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Abstract

Prompted by my lived experiences as a child born and raised in remote Laikipia county, a rural setting in Kenya this qualitative study explores the extent to which secondary school teachers and students of science in a secondary school in Kenya (Laikipia County) integrate indigenous science knowledge (ISK) and mother tongue language into the science curriculum to make science lessons more interesting and meaningful to learners. Science is an important curricular area and an area that Kenya is keen to grow and develop and yet studies show that Kenyan students fail to choose science at secondary school level. The school curriculum and teachers play a significant role in controlling what happens in classrooms in Kenya and although there is a set curriculum to be covered, teachers can decide how they will communicate to their students. While there is a focus on school science knowledge (SSK) teachers, students and policy recognise the part that indigenous science knowledge (ISK) can play in education for sustainable development. However, opportunities to include ISK are sometimes limited or thwarted by circumstances.

Qualitative data was collected through semi-structured interviews with teachers and the headteacher and focus groups for students in the school. Participants gave their insights into, and experiences of, learning and teaching in science using indigenous perspectives and languages. Students were purposively selected while due to the relatively small size of the school all science teachers took part. The science syllabus and policy documents provided information about the how and what of learning and teaching in science classrooms and provided a context for the primary data gathered from the interviews. The views of participants provided thick and in-depth narratives. The findings showed differences and similarities in participants' views, experiences and they highlight doubts, worries and practical concerns around the use of indigenous perspectives in their Kenyan science classroom. Participants showed an understanding of ISK and its problem-solving benefits at home and the significant role it could play in learning science knowledge. In this study teachers and students thought that participative methods such as

class discussions could promote creativity and innovation, and in the process create an understanding and appreciation of indigenous knowledge and its role in education for sustainability. Notwithstanding, participants also highlighted perennial issues such as poverty and a lack of resources and funding as impacting on education and in particular science education. While development since my own time in school seemed limited, there were glimmers of hope that the future could be different. The general positive view of ISK from the participants of this study suggest that it is an area of further ongoing development, particularly in regard to science education for sustainable development. The students in this study also shared important ideas about student voice and participation. Their understanding and appreciation of ISK, indigenous languages and culture in Kenyan science lessons could serve as a starting point for consideration and development of the role of ISK in sustainability and science education in rural settings.

Abbreviations

CPD – Continuous Professional Development

ECF- East Coat Fever

IMF – International Monetary Fund

IK – Indigenous Knowledge

ISK – Indigenous Science Knowledge

ITE– Initial Teacher Education

KICD-Kenya Institute of Curriculum Development

KIE-Kenya Institute of Education

KNEC-Kenya National Examination Commission

LOI- Language of Instruction

MDG – Millennium Development Goals

MOE – Ministry of Education

MOEST – Ministry of Education Science and Technology

PD- Professional Development

SSK – School Science Knowledge

SSG– Sustainable Development Goals

SSA -Sub-Saharan African

TAE-Traditional African Education

TSC-Teacher Service Commission

UN – United Nations UNCRC – United Nations Convention on the Rights of the Child

UNESCO- United Nations Educational, Scientific and Cultural Organization

UNHCR – United Nations High Commissioner for Refugees

WSK-Western Science Knowledge

X- Study school

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I dedicate this thesis to my wife, Wangui, my sons (Musa and Kibiri) and daughter (Muthoni) who inspired me to do this work.

Author’s declaration

I declare that, except where explicit reference is made to the contribution of others, that this dissertation is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution.

Signature FNG
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Chapter 1: Introduction

1.1 Background to the study

This study is prompted by my lived experiences as a child born and raised in remote Laikipia county, a rural setting in Kenya. This study has enabled me to reflect on and discover how knowledgeable and skilled my parents seem to have been in raising me and providing for me, although they themselves had not had the opportunity to enrol in any formal school. However, my home experiences were often marginalised in school. After I became a science teacher and was teaching in Scotland, these early experiences led me to investigate science teaching in Kenya particularly looking at how indigenous science knowledge (ISK) is viewed, and whether it is included and taught in science classrooms. This study focuses on finding out how secondary school teachers and students of science in Kenya (Laikipia County) integrate indigenous science knowledge (ISK) and mother tongue language into the science curriculum to make science lessons more interesting and meaningful to learners.

In Kenya, indigenous knowledges related to the natural sciences are recognised in the secondary school science curriculum implying recognition and importance; however, implementation seems often to be challenging. The study therefore explores the tensions between the push towards constructivism in policy (student-centred teaching approaches) and the behaviourism tending to be seen in practice especially as a result of the impact of the exam system, something that is not unique to Kenya.

Given the importance of science in the 21st century, it is concerning that many Kenyan students, particularly girls, fail to pick science subjects at secondary school level and, of those who do, most do not get the required grades to pursue sciences at higher levels (MoEST, 2015). The curriculum and methods of learning and teaching of science and mathematics subjects is seen to be a contributing factor in the exclusion of some students from science (MoEST, 2015). In addition, science knowledge does not seem to have been effective enough in providing self-reliance skills for young people to help themselves and communities at home (Ogunniyi, 2022). The power relationship that seems to

favour school science to the exclusion of indigenous science knowledge (ISK) and the teaching methodologies employed in schools are important aspects of this study. There is an underlying assumption in this study that science will continue to be important in the secondary school curriculum. The justification is that although in the past science education has been threatened by lack of interest by student globally and especially in the past, it has managed to survive.

In post-colonial Africa, the discourse of knowledge has been one often composed of tension between school and home knowledge, where formal education and curriculum mainly determine what is defined as knowledge, often excluding indigenous knowledge which is important in the local context (Owuor, 2007; Sillitoe, 2006). Tension between indigenous science knowledge and western scientific knowledge has existed since colonisation when Africa was forced to cede political and economic power (Maweu, 2011; Gill and Levidow, 1987 cited in Ogunniyi, 2021). In addition, a formal education system with specific goals was imposed, replacing traditional education systems that existed and had solved most everyday challenges. Colonial education policies highlighted the supremacy of the white race over non-white populations and significantly informed the development of the science curriculum particularly in Africa (Ogunniyi, 2022). According to Thiong'o (1986), language and indigenous knowledge in the form of memory gave Africans an identity before colonisation. It is this African memory that was gradually replaced by the coloniser's memory through formal western education, which was the beginning of a new enslavement.

Thiong'o (1993) argued that, although the coloniser would alienate the colonised economically, socially, politically, and psychologically, cultural alienation is more serious, because it takes away the identity of a person. Dei and Simmons (2009:30) argue that a critical African education approach would enable people to understand themselves as a people in a local context. It would help them to see how colonial history contributed to "human enslavement" and thus understand the reality of what happened and how it led to the supposed "truth" found in western academic disciplines including school science. This understanding would allow them to ask questions.

In many education institutions, abstract thinking often dominates learning and teaching with the assumption that it is the only way to solve problems, although concrete thinking being another way of solving problems in another context, could complement abstract thinking. When a student is denied experiential learning, a student may fail to connect knowledge and practice, denying the learner some survival life skills.

In later years senior students often view knowledge in a more abstract way rather than concrete, so it can be argued that learning of science knowledge is more effective when it progresses from concrete to abstract, which could be facilitated by interaction. However, some Kenyan studies (O'Hern and Nozaki, 2014; Ngasike, 2011; Gitari, 2003) show that the school science curriculum has excluded lived experiences and worldviews of the student, denying the student more ownership of their education.

1.2 Challenges for science education

Teachers and students have plenty of information about what they should be teaching/taught. According to Darling-Hammond & Oakes (2019) teachers often develop, mediate and use knowledge in the learning process. All teachers, including Kenyan teachers, are professional with required knowledge, skills and experiences that could be valuable in policy making, curriculum planning and innovative learning and teaching/pedagogical strategies. In addition, Kenyan teachers know there are 'better' ways of teaching; however, they often do not do that in practice, mainly due to education policies that determine curriculum content and pedagogy (Aikenhead, 2001). According to Gomez-Arizaga et al (2016), students could find meaning in scientific concepts through forming connections with existing prior knowledge and experiences. Kenyan secondary school science students know a lot about science in their home context; however, students are often silenced when prior knowledge (IK), indigenous language and culture is excluded in science classrooms.

Lack of adequate infrastructure that accommodates everyday experiences of marginalised students in the learning and teaching of sciences in Kenyan secondary schools may have contributed to few pupils getting the required grades to join science related courses at higher education. According to

Wambugu et al (2013), low grades in science subjects are associated with the use of inappropriate teaching approaches, which may contribute to less engaging and less interesting science lessons. A teacher-centred teaching approach is a legacy of colonialism, whose aim was to get cheap labour for the empire (Gikungu et al 2014). Orora et al (2014) suggest that the dominant teacher-led teaching approach in most Kenyan science classrooms often silences students rather than allowing them to be active participants and take more ownership of their education. When learning is passive and not meaningful, students tend not to engage and lose interest. So effective and meaningful science lessons that promote active participation of learners better prepare students for higher education and self-reliance.

According to the Republic of Kenya (2017) 60% of secondary schools at senior level should offer the STEM subjects, as a way of developing the required human capital to achieve Vision 2030 which is the foundation for national development. Available data show that the proportion of graduates in Kenyan universities from the departments of engineering, architecture, and technology in academic years 1999/2000 and 2005/2006 was 6% of all other graduates (Session Paper No. 10 of 2012). In addition, Wanyama et al (2021) note that by 2016 “science and technology clusters recorded a paltry of 29% enrolment” with enrolment in “Veterinary at 0.2%, Manufacturing 0.5%, Architecture 1.2% and Mathematics 3.3%”. As they also point out, this is in spite of these subject areas being the focus for by organisations such as the World Bank (2014). It is important that all stakeholders could scrutinize education policy and contribute towards the relevance in terms of meeting daily challenges experienced in context. The dominance of Western Science Knowledge (WSK) in Kenyan schools and subsequent societal, economic, and political problems experienced is evidence that the local context is not being respected.

There are many challenges facing science education in Kenya which include lack of adequate learning and teaching resources compared to the increased secondary school enrolments from an expanding Free Primary Education (FPE). There are few well equipped science laboratories and qualified science teachers, and it is argued that there is a lack of meaningful science lessons

through the exclusion of ISK which incorporates indigenous values and identity (O'Hern and Nozaki, 2014). Laboratories are only important in the promotion of WSK and techniques, IK does not need them. The lack of labs could help pave the way for alternative ways of doing science. It is important to find out about the perception and experience of stakeholders on the integration of ISK in the science lessons as a way of confronting persistent problems of the perceived irrelevance of school science to the local context and offer graduates alternative livelihoods through which they may retain their values and identity.

In the next section Indigenous knowledge, the means of survival for indigenous communities, is discussed, focusing on the possibility of its use in achieving school science learning outcomes.

1.2.1 Indigenous knowledge (IK)

I will define IK and briefly discuss pertinent issues. There is further detail about this is in chapter two. I have come to recognise that as a young boy growing up in a rural area of Kenya, all my experiences, listening to my parents and elders, observing elders put knowledge they learned from their parents into practice, were part of survival and were part of IK. I was living in IK and part of it. My personal experience agrees with Sutherland's (2015: 2) working definition of indigenous knowledge: "Indigenous, local or traditional knowledge are terms used to variously describe practice that is rooted in collective local community engagement with and understanding of the adjacent environment". So local knowledge is understood and conceptualised differently by people leading to the use of different terms to describe the practice that is rooted in culture and the environment. However, although there are differences between local knowledge and western science, they could complement each other (Shizha, 2011; Ogunniyi, 1988) since both knowledges aim at explaining a natural phenomenon from their own perspective. For example, the appearance of certain plants and the disappearance of certain plants and animals indicated a new season.

A high proportion of those living in Africa continue to entrust their survival to land as they did before colonisation (Emeagwali and Dei 2014). Indigenous knowledge which was the base of problem solving has collaborated with other forms of IK from societies in the process of adaptation for relevance to suit new

situations and challenges (Emeagwali and Dei 2014), although it is argued that important IK is usually excluded in the science curriculum (Ngasike, 2019; Kim, 2017).

Indigenous knowledge (IK) (discussed later in detail) is knowledge that is produced by people after living in a certain environment for a long time (Dei et al 2002; Semali and Kincheloe,1999) influenced by "ancestral voices" (Wane 2008:183). IK forms the basis of decision making to solve daily problems in a specific culture and community and especially among the poor (World Bank, 1998). Ogunniyi (2022) argues that IK enriches the worldviews of students and promotes and enhances students' confidence and sense of social identity. In addition, IK promotes caring attitudes and values which contribute to an overall sustainable development of a giving community (Ogunniyi, 2022). So, the use of IK in science classrooms can make students more confident, view science knowledge as their own and support them to take part actively in their learning.

Indigenous Knowledge is not an issue confined only to African countries. For example, in an Aboriginal context in Canada, Little Bear (2009) discusses the importance of personal experiences within their indigenous community including beliefs and thoughts. So, indigenous knowledge is based on the existing relationship in nature (living and non-living) in a complicated way and deeply embedded in spirituality. IK should be understood in a more complex way in its totality for it to make sense to an outsider, an important skill for science teachers to learn during initial teacher education and subsequent professional development, beyond the view of science knowledge as purely rational and objective.

Therefore, within this study it is argued that it is important that IK which includes African spoken histories and traditional cultures is integrated into the western disciplines as a way of challenging the dominant western centred epistemologies.

1.2.2 Indigenous science knowledge (ISK)

I now define ISK and briefly discuss issues that are relevant for this study. A more in-depth account is in chapter two. ISK is commonly associated with daily

living science practices which indigenous societies have developed through long periods of real practical investigations to solve economic social and political challenges within their homesteads (Kim 2018). ISK represents an overall experience within an indigenous community, and which may differ from other communities. ISK is an alternative to western science and complements science by using local knowledge in everyday activities including farming and fishing (Shizha, 2011; Snively & Corsiglia, 2001). Ogawa (1995) further refers to Indigenous science (IS) as how a culture helps shape reality in a certain way and transmits it through generations, although free from individual inputs. In this study diverse cultural knowledge of the young people exists and will be investigated to find out the impact in learning and teaching of science knowledge.

With reference to Indigenous science knowledge (part of IK) Dei (2014) argued that ISK is dynamic and can change to suit new situations and circumstances. The implication is that some aspects of ISK are transferable to other situations including science classrooms. However, although the inclusion of IK is important as a way of enhancing the relevance of western scientific knowledge to the local context, Sillitoe (2006) and Shizha (2008) argued that diverse African cultures made it a challenge in getting anything close to a universal Indigeneity in the African context. The lack of homogeneity in IK is thus an inevitable consequence of its being shaped by, and responsive to, local environment. In addition, although some aspects of IK practised at home have scientific principles, most of ISK is not usually recorded (Nkomwa, et al 2014; Agrawal, 1995), with implications for its use in formal education, which is based on what is codified in texts. Information or knowledge which is not written down tends to be less valued and potentially marginalised, with written information being preferred.

In an assessment of biology knowledge held by schools and the local community, Gitari (2003) found existing tensions and suggested the integration of local practices into the school curriculum as one way of making education relevant and enabling individuals to be useful in their communities, especially for pupils who terminate education at secondary level. So, an individual's cultural knowledge will be perceived differently according to the form of

science that reflects cultural traditions and the perspective of those who use it on a daily basis. It is widely accepted by several authors that learning and teaching in schools could be made more culturally inclusive through revising the existing western paradigm and implementing education reforms in Africa (Ogunniyi, 2022; Abah et al 2015). The inclusion of ISK in the Kenyan school curriculum requires a cross examination of all learning and teaching resources to ascertain their relevance in context, an undertaking that demands use of valuable resources including money, time and skilled professionals. It also demands that teachers need to be well prepared to better navigate and appropriately deal with various cultural knowledge, beliefs, meanings, morals in their classrooms (Abah et al 2015).

Indigenous science knowledge (ISK) is part of IK and forms the foundation survival knowledge which is communally owned and mostly for the benefit of all in a group. Through ISK indigenous people get to understand their environment better, work out solutions to problems and reduce poverty through appropriate socioeconomic activities. However, traditional education that provided skills for survival did not fit the colonial definition of education and was replaced by western formal education. Ogunniyi (2022; 1988) argues that a focus on a systematic social theory of change by scientific worldview against a “primitive” traditional worldview, considers both worldviews to be polar opposites, a simplistic viewpoint in that the scientific worldview is assumed to be the only way to understand nature. ISK and science have remarkably similar fundamental assumptions about how the natural world operates. However, ISK favours an inductive approach while western science favours a deductive approach, implying that both have taken distinct positions in terms of the way they understand nature. It can be argued that an increased understanding of ISK is making it more valuable (Tanyanyiwa, 2019), and therefore it could potentially be part of learning and teaching of science lessons in non-European schools.

Western science knowledge provided in schools appears not to be providing all the answers in life (and neither does ISK alone at home) especially for those students who are the majority, who due to various reasons drop out of school. According to Ogunniyi (2022) IKS have proved to be very effective in

environmental conservation and contributes to the socioeconomic growth of rural areas. So, I will argue that school science should include the sharing of lived experiences with rural students in classrooms so that they are not alienated from studying science.

1.3 My experiences with indigenous science knowledge

I grew up in the rural area of Laikipia from the late 1960s to the 1980s. During the planting season my parents seemed to have intergenerational knowledge of the ecological terrain of the land to an extent of reading natural changes including the number and direction of flying butterflies to know when rain was likely to fall. When I joined school, I embraced formal education even though my cultural knowledge continued to be the main means of survival. My teacher would sometimes punish me and others when we struggled to answer questions in the classroom, although most of it did not make sense to me. On occasions my teacher would mention local cultures in a bad way claiming they were backwards. On reflection I argue that this downplaying and undermining of ISK meant that western science was held in higher regard and therefore assumed to be of greater value. A study carried out in Canada by Little Bear (2009) found that school culture dissociated itself from Aboriginal home culture making Aboriginal children dislike school for being removed from their familiar culture, a finding that resonates with my own experience. What my parents taught me at home did not feature in any of my classroom topics which to me contributed to the lesson being less interesting.

In the rural African setting children like me have to contribute to family survival, so indigenous knowledge is important for early learning in children. According to Adeyemi & Adeyinka (2003) indigenous education promoted curiosity about the surrounding, developed an attitude of self-reliance and develop skills for survival. Similarly, I learned from my parents which seed to plant, how and when, and how to take care of it and also how to tell when rain could fall, preparing for survival in my community.

My first teachers were my family in a familiar home environment in terms of culture and language. I socialised and learned about my identity from a strong early family connection to parents, brothers and sisters, and the surrounding

community. For example, looking after family cows, my parents taught me how to tell when it was time for cow watering by the position of the sun in the sky and the length and direction of my shadow. It seems that the professionalisation of teachers in schools challenged IK views on who can teach, in what seems an aspect of colonisation.

However, I also remember the teacher introducing a topic on time saying that in school the traditional and 'backward' way of looking at the position of the sun to tell the time is never used, the modern clock is used. My school textbook focused on the modern clock and did not refer to, or show how I told time at home, assuming that watches are common knowledge, which was not the case for me. I had very little connection with the modern watch so just listened to the teacher and felt that things were done differently in school from what I knew. I learned from the teacher and textbook that IK was "backward" while school knowledge was "superior", so I began to doubt IK although it solved my problems at home. According to Gill and Levidow (1987) the hidden science curriculum has a racist agenda including the justification of the subjugation of indigenous sciences terming it inferior and superstitious. From my experience as a pupil in the classroom, teaching and learning seemed to be about imparting particular knowledge and information and so little attention seemed to be paid to connecting learning to what I experienced at home daily and I was often made to feel that local culture was not valued within the classroom.

Living in rural Laikipia county was challenging and mainly required contextual solutions. For example, my father like other local farmers and pastoralist communities did not have access to (or could not afford) veterinary services (scientific knowledge) so they used different local plant materials to treat different livestock diseases especially the fatal East Coast Fever (ECF), with a degree of success. ECF is a major livestock disease in Kenya with symptoms including swollen lymph nodes, high fever, and loss of weight due to inability to eat (Ole-Miaron, 2003). Plant material was rubbed against the inflamed, swollen lymph nodes of ECF-infected livestock to reduce the spread of infection. The Western prescribed Clexon medication for ECF was more effective and preferred but was too expensive and unaffordable. According to Emeagwali and Dei (2014) plant materials were used to treat skin and stomach

problems, and this knowledge has been used by pharmaceutical companies to make products that create huge profits, indicating potential links between ISK and SSK. Traditional indigenous knowledge forms the foundation of problem solving and many people resort to it in time of crisis.

Common ground exists in terms of the diagnoses of both ECF and anthrax in livestock between traditional and western veterinary medicine except for high fever, which is explained by lack of a traditional thermometer to measure body temperature (Ole-Miaron, 2003). My study helps me to realise the significance of African traditional knowledge and resist the colonisers' perspective who labelled them as "primitive" and "backward" (Wane 2008) and in the process argue for the significance of collaboration between school science and ISK. So, a non-European student can be taught about the diagnosis of ECF, and anthrax using ISK and then improve the diagnosis using a thermometer from western science knowledge. This is an indication of the commonalities between ISK and western science knowledge requiring collaboration in the schools without hierarchical power relations.

My interaction with my parents developed some tensions associated with school and home culture as I progressed in school. My parents did not receive formal education and so could not understand the English language and often did not know what I learned; although they supported me, the content I was learning was very different from what I learned at home. I would argue the school assumed parents could not cope with formal education content. My parents, however, were on occasions concerned with my changing behaviour that seemed to deviate from the norms at home. My parents felt that I was critical of some aspects of home culture implying they were "wrong" and what the teacher taught in classrooms was "right" which was taken as disrespect to adults. It seemed there was no link between school and home behaviour causing tension. According to Chang'ach (2013) many students behaved differently in schools and home. Parents were resisting dominant western culture which threatened the ability of students to function at home. Marianna (2010) cited in Ngasike (2019) argued that Turkana elders in Kenya were concerned with the loss of traditional culture in formally educated Turkana children. Such children acquired western knowledge; however, they did not fit within their

communities anymore. According to Ngasike (2019) such western educated youth take up western culture and a dependent mentality while developing a disrespecting attitude towards indigenous culture and languages, losing their sociocultural identity (Ogunniyi, 2011). Loss of traditional culture was a fear in my parents who always advised me that when I get formal employment and relocate to cities, I should continue to practice farming in my back garden, arguing that money can lose value, but food crops will always feed a hungry stomach. I do this today in my back garden in the UK.

I and many of my friends did not like the way learning and teaching was carried out which included sitting for long hours listening to teachers talking without anything interesting to do. I just stared most of the time or dozed off, I did not understand English, the language of instruction, and did not connect with the subject content. The class textbooks were full of things I had never seen before including combine harvesters, aeroplanes, large modern cities, modern science equipment; on the other hand, there was nothing as a contribution to the class lesson from my familiar rural setting. According to Ogunniyi (2022) the way science lessons are taught and presented in textbooks tend to ignore the contribution to knowledge to non-European students, alienating them. On several occasions I wanted to skip school like my some of my friends but feared consequences from my father. By the end of lower primary (year 3) I was proud of myself because I could speak some words in English and do a few sums, I was also accepting the reality in school that everything I learned was foreign and had no links to my lived experiences. I had to memorise knowledge to pass examinations.

Undertaking this study has encouraged me to reflect on and make sense of my experiences and practice in life leading to my belief that ISK is important in promoting relevant learning as a means of solving some challenges in local context. Thus, ISK seems to provide a holistic worldview which is important if an individual is to acquire essential life skills important for a livelihood in the local context and beyond. It is therefore important to extend the learning of science beyond the universal western worldview to enable non-European children “to facilitating subject matter learning through integration of the learner’s Indigenous knowledge system in order to transform the subject matter

knowledge into comprehensible form that the learner can grab and apply," (Abah et al 2015:669). On reflection the critical issues for me are that learning science requires a philosophy of innovation driven by critical thinking, positive attitudes and knowledge founded on local cultural background and worldview. For example, a teacher who allows student voice and agency in classroom provides the right atmosphere for creative work through the principles and practices of science in solving problems rather than rote learning for the purpose of passing exams only.

1.4 Why carry out this study?

It can be argued that the way that the curriculum is taught in schools impacts on pupils' interest in and engagement with school. Where the curriculum is deemed to be irrelevant and detached from the lived experiences of learners, this can contribute to high drop-out rates and lack of progression to tertiary education (Ngasike, 2019; Republic of Kenya, 2017). There are, of course, a number of reasons why pupils drop out of secondary school, including lack of school fees, teenage pregnancy, general poverty. For practical reasons I have avoided researching these issues. The result of this is that although formal schooling seems to offer some valuable life skills, the majority leave school with inadequate life skills, a major disadvantage especially to the majority of rural Kenyan youth who do not proceed to higher education. The use of IK in science lesson could improve interest in science lessons and provide valuable life skills for survival at home.

As African nations, including Kenya, participate on a world stage it is important that there is a well-educated population, which would include progression into further and higher education. Given the international focus on science education, it should be of concern to Kenya that only about 6.5% of all secondary school pupils progressed to higher education in 2010 (Republic of Kenya, 2017), while about 29% enrolment in the universities was in science courses (Wanyama et al (2021).

What happens in the classroom is crucial so it is important to investigate what learning and teaching approaches can be of most use in encouraging learners to engage with learning and continue in education. Listening to their thoughts and

views on this may shed light on how young people in the classroom perceive learning.

This study aims at looking at participants' science experiences which are key to giving insights into understanding different ways in which science learning outcomes could be achieved using indigenous perspectives, something discussed later in chapter 5 and 6. The overall research question of this study is to find out to what extent are indigenous science knowledge (ISK), indigenous languages, culture and pedagogical approaches currently used in the existing secondary school science curriculum in Laikipia County, and how can this information be used to support the implementation of the new education curriculum reforms?

1.5 Definition of terms

I now provide definitions for concepts that guide this study, although the definitions of terms are expanded in the literature review. In this thesis the terms western scientific knowledge (WSK), school science/curriculum, and Eurocentric are used to mean non-Indigenous science knowledge taught in schools after colonisation. The terms traditional, Indigenous science knowledge (ISK) is used to mean local science knowledge existing before colonisation. The term elders are intended to mean the elderly members of the traditional community, while western and non-western is used to refer to people for identification only. Indigenous knowledge (IK) is used for specific local knowledge and could refer to "ways of knowing." The difference between IK and ISK is not always clear since IK is often related to science issues. Most of my discussion will be with reference to ISK.

Indigenous Knowledge Systems (IKS) refers to all knowledge held by a community or its worldview which refers to thoughts/values individuals hold being in the world. Black and white in this study is used for identification only.

1.6 Outline of the thesis

In Chapter one I have identified and discussed the overall area of research, which gives way to chapter two where I review literature relevant to the issues raised in chapter one. In addition, I discuss both western science knowledge and indigenous knowledge and the context in which each was developed to solve challenges.

This discussion prepares me to investigate learning and teaching experiences of participating science teachers and their students and to clarify my more specific research questions. In chapter three I discuss methodological matters relevant to this study including justifying the use of semi-structured interviews and focus groups. I discuss the processes and criteria used in the choice of research site, design, interviews, participants and analysing data. In addition, ethical issues as an insider and outsider researcher including conducting educational research with young people in a safe way are discussed. In chapter four I present my data, focusing on the main research questions, broken down into six subsidiary research questions. In chapter five the presented data is analysed and discussed. In chapter six I draw conclusions and make recommendations based on the analysis of the data.

Chapter 2: Review of literature

In this chapter, I will explore the existing literature in a number of areas which are particularly relevant to this study. I will identify key themes and issues arising from these to establish a conceptual framework for the study, and to clarify areas in which further research could be useful. This will lead to the formulation of specific research questions.

This chapter is presented in five sections:

1. The origin of science knowledge and issues associated with science education.
2. The African context; in particular the context of Kenyan science education.
3. Relevant education theory including theories of learning and teaching.
4. Language of instruction.
5. Initial teacher education and teacher professional development in relation to science education in Africa, particularly in Kenya.

2.1 The origin of science knowledge and issues associated with science education

In this section I examine:

The origin of school science.
Characteristics of school science.
Characteristics of science as lived experiences.

2.1.1 The origins of school science

I will briefly discuss the origins of school science and its later development especially focusing on how inclusive (or not) it was of the science knowledge contributions made by natural philosophy and non-Western people. I give an overview of science knowledge from a western and indigenous perspective and see how lived experiences are (or are not) relevant to science education.

a) Natural philosophy

Between 11th and 16th centuries philosophers including Aristotle, Roger Bacon and Copernicus compiled their understandings of nature through natural

philosophy. The world was understood through observation and understanding of pattern in nature, without experimentation. The knowledge produced consisted of political, social and moral dimensions, consistent with the philosophy of nature. A recent study by Huseby & Bungum (2019) found that the concept of observation as looking was unhelpful in making sense of a double-slit experiment with electrons among pre-university physics students, demonstrating the tensions in the field of science.

Ogilvie (1986) cited in Kithinji (2000) suggested that the first science curriculum was a product of this curiosity about astronomy during both ancient Greek and Roman empires. There was curiosity into the forecast of astronomy. Kithinji (2000) argued it motivated the need for investigation into the causes of events including the earth's position and its movement in relation to other bodies in space through technical, literacy and numeracy skills previously discovered in Mesopotamia and Egypt. With new understandings in terms of more quantitatively accurate models of planetary motion, astronomers abandoned natural philosophy. A Mathematical model of the explanation of astronomy on the position and movement of bodies in space was accepted as "true" although it represented particular scientific world views, methods and ideas. I suggest that it is during the Roman/Greek era that a dominant view about the nature of the world began, marking the beginning of tensions between alternative views.

According to Ogunniyi (2022) the contribution of the theory of natural philosophy is not recognised in the development of "modern" science. In addition, Roux (2017) argued that some explanations held by natural philosophers had academic significance just like the later explanations in mechanical philosophy (discussed later). Although natural philosophy made a significant contribution to modern science, such contribution is not fully acknowledged and was often silenced by mechanical philosophy. This is important for this study in that students' lived experiences, IK and cultures are considered "unscientific" in science classrooms and so do not contribute to producing new science knowledge.

b) Mechanical philosophy

The contribution of natural philosophy to science knowledge accelerated the development of skills for practices to solve contextual challenges in 17th century Europe (Bennett, 1986), implying the contextual nature of science knowledge. According to Dyck (2020) mechanical philosophy in Europe was facilitated by changing social and cultural realities that put more value on mechanical practices for solving everyday challenges and creating material wealth. For example, the interest in sharing ancient knowledge developed by natural philosophers resulted in the development of the printing press, a contribution of natural philosophy to "modern" science. The development of rational thinking and the use of mathematics to solve physical challenges led to a more accurate description of natural phenomena including medicine and mechanics. The cause of a natural event is clearly understood in relation to progressive order and then connection is made between them in accurate quantitative terms. There were clear answers from an observed natural event leading to human control of nature in preparation of manufacturing machines that made work easier and more productive. The implication is that nature was understood in narrow terms of quantitative empirical methods tied to mathematical and mechanical explanations rather than through natural philosophy's traditional approach of understanding the world through observation and identifying patterns without experimentation. Mechanical philosophy was mainly responding to European history, social and cultural realities at that time.

Overall, the quality and complexity of European machines continued to be viewed as evidence of a higher and innovative culture (Adas, 1989) and science knowledge was publicly supported for improved life. In his book *The Origin of Species*, Charles Darwin attempted to explain the diversity of life on earth in his theory of evolution, without involving God. This was the beginning of the exclusion of alternative knowledges, beliefs, culture and spirituality from science, with implication for alternative views in science lessons in this study.

The "truths" in mechanical philosophy are mainly based on accepted mechanical ideals among mechanical philosophers only. For several decades now mechanical ideals (logical empiricism in scientific explanation) have been found to be problematic in different contexts, challenging their usefulness in

explaining scientific phenomena (Hattab, 2011; Salmon, 1989), suggesting that they can be questioned. Scientific ideas contributed to advances in scientific thinking; however, they can be challenged at any point.

If science knowledge developed in Europe was to mainly to solve local challenges, it is debatable how relevant it could be in other contexts, especially in Africa with different cultural values, and the reality of the existence of diverse knowledge (and areas of commonalities) (discussed later) that solve local problems. Overreliance on mechanical philosophy as the dominant way of interpreting the world is problematic and alternative ways of viewing the world are necessary, if science is to be available for all.

Teaching approaches of school science tend to leave out students' lived experiences in producing science knowledge while most science textbooks tend to ignore the contributions made by non-Europeans or natural philosophy to the development of modern science (Ogunniyi, 2022). In this study, the assumption that SSK is the "truth" will be questioned and be understood from students' lived experiences so that learning might be more interesting and more meaningful knowledge be produced to solve everyday life challenges.

In the next section I discuss some key characteristics of school science.

2.1.2 Characteristics of school science knowledge

a) Scientific methods

To qualify as science knowledge, certain specific steps must be followed in producing it. Barseghyan (2015) argues that there is a consensus in modern science that there is a universal way of doing science, using experimental and empirical approaches to produce "facts" and explanations about the world. According to Nola (2018) the scientific method is a systematic process that produced all scientific thinking including theories and laws as agreed upon by some privileged philosophers with assumed special understanding of knowledge. The assumption is that everybody can understand all knowledge as long as they follow the academic rules of knowing and one follows certain steps of knowing. In addition, Nola (2018) argued that scientific methods were innovative in that they contributed to the understanding of how rational thinking works in both understanding natural phenomenon and in human psychology; however, they

defined the extent and limitations of reason. So, the scientific method can be described as a specific way of acquiring knowledge about nature and social phenomena through observations, questioning, hypothesis, testing, and explanation.

Science is a knowledge system that has specific rules to be followed towards a scientific theory or "facts" about nature. However, Barseghai (2015) argues that science is dynamic in terms of theories and methods and so a simplistic view of science should be avoided. The implication is that scientific methods can be questioned, which is important for this study in terms of potentially integrating indigenous ways of thinking and practices in science lessons. Other aspects of existence and of nature that cannot be observed, questioned, hypothesised on, tested, and explained through scientific methods are at risk of exclusion from the natural science curriculum. Ogunniyi (1988) argues that modern science takes a simplistic definition of science, based on a western cultural understanding of nature ignoring traditional worldviews about science which understands nature as complex and dynamic.

b) Science knowledge as objective

From a scientism ideology perspective, science knowledge production should be "formulated through strict, rigid research methods as determined through the natural sciences, positing in a sense, objective, neutral, bias free knowledge" (Dei, 2012: 126). Scientism therefore assumes that nature must only be understood through empirical science. Such science knowledge is considered "true" because it could be validated through empirical methods excluding alternative perspectives that do not fit that criterion, impacting on the use of ISK.

However, Barseghai's (2015) argument that science always changes through the development of new ideas and methods, could be valuable for teachers in that earlier practices and understanding were transformed to give way to the present practices and understandings. Teachers could understand why we have SSK and the importance of the practices to be passed on to learners, promoting alternative thinking.

c) "Superior" in nature

As mentioned earlier Charles Darwin believed that human beings could understand diversity of species without influence of spirituality. In addition, he suggested that African perspectives including ways of knowing and culture needed to evolve towards the more "superior" white culture. It seems African culture which valued spirituality in understanding nature was "wrong", although other world cultures have their own ways of perceiving reality and solving their immediate problems through their own understandings (Snively and Corsiglia, 2000). So science depends more on multiple ways of knowing and doing.

Mudimbe (1988) suggested that Darwin's theory created a mindset of hierarchy of power, in favour of the western culture over other world cultures. Western science knowledge, language and culture is considered more valuable in science lessons, leading to a widespread belief that assumed Africans had limited intellectual capacity to hypothesise, be rational and objective compared with Europeans. Compared to other cultures, Africans were identified by Europeans, as not having made any scientific ideas besides the most primitive technology in the nineteen centuries, although according to Shizha (2016) most scholars agree that pre-colonial African societies had achieved complex functional capacities with relevant technologies that were appropriate for the needs of the communities.

Mudimbe (1988) argued that such a concept of the hierarchy of power relations concurs with the Darwin's theory of evolution and Levy-Buhl's work on anthropology. African traditional culture and ways of thinking and doing is perceived to be illogical, "primitive or "backward", and therefore in need of "civilisation". Ogunniyi (1988) argues that western and African cultural perspectives are considered to be in conflict, which is a simplistic viewpoint, since both share similar key assumptions about the reality of nature in terms of space, matter and time.

d) Science and colonisation

The development of machines in Europe paved the way towards European exploration for natural resources. According to Kelly and Altbach (1984) colonisation is a process whereby a country uses force to take control of

resources including land from other people and impose their culture. According to Nyamnjoh (2016) western culture dominated learning and teaching rather than the local culture of the African people. Local languages and IK which was unique to African people (and other indigenous people) was gradually replaced by western culture, threatening the survival of the African culture. Ogunniyi (2022) argues that colonisation has had a significant impact on the mind, personality and spirit of the colonised people for generations, and that this will continue unless dramatic actions are taken to reverse the unacceptable trend. When people were assimilated through knowledge and cultural domination, they often behaved like the colonisers. Most of the western educated people became political leaders in African countries after independence and, like colonisers, denigrated their indigenous cultures and the languages associated with them, and promoting western knowledge in education and development policy (discussed later in this chapter) with implication for indigenous knowledge, language and cultural identity.

Although Africa benefited from formal western education in terms of purely academic work, skills for reading and writing, colonisation replaced the African indigenous education structures and knowledge constructs with western education. Local culture and practices the basis of survival in indigenous communities were devalued in school disconnecting children from their home life. Written communication was also a tool for promoting the control and business interest of colonisers. However, written communication benefits former colonised people in encouraging them to engage in the global economy. It can be argued that transferring thoughts can either be verbal or non-verbal, and it is important that both have a place to accommodate the needs of all people.

According to Shizha (2005) the science curriculum in Africa became the tool of cultural and economic domination disguised as scientific progress. It appears that science knowledge and skills from a western cultural context were utilised to meet the needs of individuals in different socio-cultural contexts. Lelei & Weidman (2012) argued that the formal curricula caused tension between the colonial goal of “modernisation” of African through undermining local cultures and the African struggle to keep their traditional culture and values. It could be

argued that the tension between localism and universality, the latter associated with western science, could be linked to the need for an empire to have a competent and transferable workforce to mobilise. On the other hand, Mandikonza (2019) argues that IK is specific to a particular people and is generally empirical or related to belief systems and integrally connected to culture and practices to solve local problems, although areas of similarities exist which could provide a link between IK and SSK.

In conclusion the characteristics of western science derived from mechanical philosophy tend to alienate non-Western people's ways of understanding nature. Such characteristics are mainly a product of a historical assumption that a single "truth" existed, although such "wrong" views could be produced daily in science classrooms. Most of these "wrong" views could be the contribution of scientific method which through teaching methods are presented in a simplified way in most textbooks and seem not to represent the complex nature of natural phenomena.

In the next section I discuss science as part of what people think and do every day to solve problems at home.

2.1.3 Characteristics of science as lived experiences

a) A human activity

The history of science demonstrates that science knowledge was produced based on a particular paradigm held by the community view (Abd-El-Khalick & Lederman, 2000). So the particular cultural heritage (beliefs, practices, values, ways of life) of a community shows the history, identity and evolution of ideas for survival over time. The science or technology of a specific culture at a particular historical period is of interest in this study in that Europeans focused more on the application of the scientific (and technological) knowledge in the socio-economic activities which were influenced by western culture. So, production of western science knowledge was influenced more by culture rather than mere application of the scientific (and technological) knowledge. According to Thagard (1994, cited in Duschl & Osborne, 2002: 49) science is a product of both social and cognitive skills, commenting that "from a naturalistic perspective, we can appreciate science as a product of individual minds and as a product of complex social organisations", suggesting that

science is found in everyday social interactions and practices. It can be argued that the process of scientific knowledge production is progressive in nature and involves the natural world on one side, an individual and communal beliefs and the context on the other.

b) Cultural meaning of science

Jegede (1995) has argued that when people interact, they do so by engaging with different cultures or sub-cultures. These different cultures include home, school, science classrooms and community culture where a student belongs. According to Jegede & Aikenhead (1999) each culture has its own characteristics, so home culture and the culture of school science are different. When a student enters a science classroom, they interact with the culture of school science over and above their home culture. According to Aikenhead (2006) there is a significant gap between the culture of Eurocentric sciences and the culture of schools and the contexts of science classrooms. A student could easily understand that the science they learn in classrooms is dominated by school science culture. School science culture has its own values, norms, beliefs and standards which define effective science pedagogy with the exclusion of other traditional cultural characteristics and pedagogy. According to Aikenhead (2006) teachers struggle in their professional lives in reconciling the interests and needs of their diverse students with school science within a positivist perceived reality of understanding nature. The official culture of school science encourages teachers to follow scientific methods and positivism perspectives (Gaskell 1992), so school science is weak in linking Eurocentric science with student lived experiences (Aikenhead 2006). In modern science, Aikenhead (2006) suggests that privileged scientists holding positions of power within recognised government institutions including research and development are the only ones recognised to create scientific knowledge to benefit those bodies, although Eurocentric science significantly influence their thinking and practices, the science knowledge systems and ways of knowing.

In conclusion, the origin of science shows the complexity of paths human beings went through to solve concrete challenges while acknowledging contextual realities including culture, spirituality, social economics and politics. Western science has a context and can be critically questioned because it is assumed to

be the standard way of studying natural phenomena. The history of science shows that science has set rules which must be met by science knowledge, disadvantaging other knowledges which do not fit in, which is important for this study in terms of identifying tension between SSK and ISK.

In this study I seek to broaden the definition of science by investigating the lived experiences of students and teachers in an attempt to achieve science learning outcomes. The history of science exposes the cultural, political and economic interests in science that influenced the imposition of a valid knowledge to explain nature, transform it and control natural phenomena. In addition, the relevance of scientific knowledge in the present multicultural world is questioned by the emergence of multicultural science classrooms that require new teaching approaches by teachers so that they easily relate to students from different sociocultural backgrounds. The contribution of other cultures and practices to solve local challenges and global challenges should be acknowledged and encouraged. This study takes the position that science outcomes could be achieved by building bridges between a Eurocentric knowledge system and an indigenous knowledge system. Overall science education emphasises western culture, literacy and scientific methods.

In the next section I discuss African traditional education and practices which pass cultural knowledge and skills to young people to allow them to be active members of their communities with a view to understanding how science knowledge and pedagogy could be improved (or not) in making science lessons more interesting and meaningful in schools. I look at the place of ISK and the literature relating to how it could be incorporated in SSK in science classrooms to improve science learning for young people.

2.2 The African context; in particular the context of Kenyan science education

In this section, I examine:

Key features of the traditional African education system.

The impact of colonial education.

Education in Kenya today.

2.2.1 Key features of the traditional African education (TAE) system

Here I discuss the literature around how some aspects of this education system could be adopted into science classroom practices as a strategy for achieving science learning outcomes in a more interesting and meaningful way. Ampadu & Danso (2018) and Glasersfeld (1993) argue that learning and teaching is related to prior experiences, beliefs, cultural histories and world views. It could be argued that TAE involved each of these contexts. Omolema (2007) argues that TAE is stored in various forms and transmitted through various modes including language, culture, oral tradition, music and dance, reflecting the history and culture of the society.

In TAE, the content and how it was taught reflected the local context. According to Gumbo, (2016) elders played an important role as teachers who passed relevant knowledge to the youth through practical activities, observation and oral communication. Young people were often taught education for life through word of mouth or cultural practices leading to sustainable development including in agriculture, food preservation and health. Emeagwali and Dei (2014) argued that in pre-colonial Africa, the various ethnic communities had their own form of education based on knowledge, skills, and cultural values that served and continue to serve their needs in context today. The implication is that rural settings are rich in IK, language and culture which means students are a rich resource for indigenous perspectives. However, according to Ocitti (1973) indigenous education could not be defined as education, probably because it did not follow some set rules, although the goals, content, method and assessment are similar to formal education, implying they are broadly equivalent.

According to Tordzro (2022), telling a story in a way that is linguistically understood from the perspective of Eʋe language means describing the actual practical carving of the wood including the sound carving tools produce. To tell a story about the principles of carving the way a story is created is understood through the demonstration of the ability to innovate and make changes. According to Tordzro (2022), his Eʋe language is central to his creativity in story making and demonstrates the key role of indigenous languages in research

and contextual understanding especially in Africa. It has been suggested that new approaches to implement the school curriculum in Sub-Saharan African (SSA) are needed that identify dynamism in the local context as the starting point (Ogunniyi, 2022; Owuor, 2007).

Woolman (2001) argued that undermining African traditional culture was a significant aim of colonial education made possible through the education curriculum (discussed later in this chapter), which focused on destroying African identity, beliefs, customs and land. It can be argued that traditional education focused on passing on of knowledge from parents to children in IK and ISK, whereas western science is taught by approved professionals. The implication is that formal education is removed from the domestic context and so more divorced from a child's home culture. It can also be argued that colonisers were motivated by a need for a workforce with a known (and assessed) level of key skills and knowledge, with which they could better serve the economic and administrative machinery of the empire. It can be argued that science education is designed to mainly serve a global agenda at the expense of solving the many local challenges.

Ogunniyi (2022) argues that when people are removed from their indigenous knowledge and practices, they tend to develop a dependency attitude and a negative attitude towards their cultures and languages. It follows that when people have lost their language and culture, they often lose their identity and confidence (Ogunniyi, 2011). With regard to science education, when learners cannot relate to science content in terms of their life experiences, they tend to dislike the subject. When formal education is no longer interesting, Ogunniyi, (2022) suggests that learners allow themselves to feel "inferior" to a dominant European voice that takes away their political freedom and economic independence.

Africa has had a long struggle to develop an education curriculum that contextualises learning in terms of both content and teaching practices. However, African people's thinking and the knowledge systems and practices are always changing through diverse education experiences, language, religion and the impacts of globalisation.

I now discuss characteristics of the traditional education system that preserve African identity and sustainable development.

a) The surrounding environment is the classroom

Traditional African education is generated from the surroundings which determined the common-sense practical skills children learned so that they were well equipped to take up future roles in the community (Omolewa, 2007). For example, if the landscape had water bodies children were taught about how to catch fish, make fishing nets, types of fish, nutritional value, behaviour of fish and how to store fish and market fish. The quality of TAE was determined by the existing climate, landscape, and ecosystems in support of the subsistence economy, the context was the reference point to overall education provided. The everyday environment was the classroom while all the members of the community had teaching responsibilities in imparting valuable characteristics (Omulando & Shiundu, 1992). For example, a child had to learn about the countryside, weather pattern, the use of plants and animals found there including taboos and beliefs associated with each. It can be argued that the associated assumption that scientific knowledge is objective, externally verifiable and independent of context is at direct odds with the notion of the reality of the ever-changing local context.

The content of a traditional education system had physical, social and spiritual dimensions so that a child grew up and behaved within certain accepted norms. Johnson, et al (2016) argues that taboo practices in indigenous communities are a tool of sustainable living, although, on the other hand, taboo may act as a tool of controlling community behaviour, impacting on learning new ideas.

A study by Harris (1990) suggested that western culture believes in the power of science, while the Aborigine's world is informed by the power of spiritual and religious beliefs, implying the existence of tension between western culture and Aborigines' culture. However, Ogunniyi (1988) argues that "modern" science and traditional world views have differences which can be resolved by a well thought out science curriculum, implying that areas of convergence exist.

Traditional African education is not separated into disciplines as it is a way of life; however, disciplines replace the holistic nature of the traditional approach. For example, according to Njoki et al (2015), through changes of atmospheric pressures the youth learned details associated with the start, character and end of a season including associated plants and animals. Additionally, they gained knowledge associated with the effects of each season including the impact of amounts of water on farming and several other everyday activities. However, such activities were categorised into various disciplines including geography within formal education (Nsamenang & Tchombe, 2011). These divisions impede the teaching of context-based or problem-based science, which offers many benefits, so the divisions limit western science as well as being counter to IK.

According to Fafunwa (1982), with indigenous education, what was to be taught, the learning intentions and method of delivery were closely related to each other and not separated into compartments as in western education systems. Education practices were influenced by the environment to prepare a child to better survive in context through a lifelong education system. In addition, the social environment determined what was learned in that to retain strong communal relationships, there had to be a way of building a network of relationship that bind family, clan and community together. Children were taught how to build strong social relationships through respecting elders and taking up social responsibilities. Active participation of children in their education with elders in a familiar language and environment often offered opportunities for debate and innovation in the development of new knowledge. The assumption is that the education provided was not simplistic in focus but holistic in design and focus, which reflects a formal constructivist framework (discussed later). However, according to Nsamenang and Lamb (1994) African education did not go beyond preparing the youth for life outside the ethnic community, a challenge in the current globalised world. African education was focused more towards solving practical problems, rather than grasping the underlying theory. Like western education, traditional education seems to be aimed at solving local challenges, however, western education appears keener

on the underlying theory compared to traditional education, implying areas of similarities and differences.

b) Goals of traditional education

The purpose of TAE was mainly to produce functional individuals in a particular society. According to some authors (Adeyemi & Adeyinka, 2003; Ocitti, 1971) traditional educational practices in African societies before colonisation were mainly utilitarian, where the youth learned through repeating a task, cultural ceremonies, practices, music and dance, becoming functional and well-integrated members of their communities. The knowledge learned often solved real problems at home and methods of learning was practical involving interacting with adults and peers using familiar language in a fun way.

Fafunwa (1974, cited in Njoki et al 2015: 137) stated the following goals as important in TAE in achieving holistic all-round education", identifying how this approach impacted on all of the domains of learning:

> "1.To develop child's latent physical skills (related to a child's physical muscular participation).
>
> 2. To develop character (related to affective domain).
>
> 3. To develop intellectual skills (related to cognitive domain).
>
> 4. To acquire specific vocational training and to develop a healthy attitude towards honest labour (related to affective domain).
>
> 5. To develop a sense of belonging and to participate actively in family and community affairs (related to affective domain).
>
> 6. To understand, appreciate and promote the cultural heritage of the community at large" (related to affective domain).

Links with the cognitive, psychomotor and affective domains can also be found in formal education curriculum and pedagogical theories and practices. For example, Adeyemi & Adeyinka (2003) suggest that principles of traditional education reflect goals, contents, methods and assessment approaches featuring in formal education, although how each works is different. So,

principles of formal and traditional education have similarities which could provide relevant education for African students.

c) The conservative nature of traditional education

Jegede (1997) argued that elders were absolutely trusted and given authority to advise as they were well experienced in life through age and practices. However, in indigenous education there seemed little room for a deviation from community norms and it could be said that values, norms, culture and traditions were inculcated into the young people. So, through education most traditional African communities managed to preserve their culture and the status quo (Adeyemi & Adeyinka, 2003). The conservative nature of traditional education often gave children less freedom in making decisions about other learning interests rather than what elders determined, limiting progressive adjustment for global living. There were also gender related issues - so the voices of women and young people are marginalised. Students were discouraged from trying out things on their own without elders' permission. Ocitti (1973) argue that the conservative nature of traditional education was a contributing factor to the limitation of the development of a questioning, creative and innovative minds. However, overall children were actively involved in their education through discussion and a hands-on approach using familiar culture, language and environment, contributing to the development of critical thinking skills and innovation within a conservative environment.

African traditional education was aimed at training children to develop strong moral character, to learn and understand the world around them, to develop a 'hands on' approach, learn to be self-reliant and continuously learn skills for survival in a dynamic world at home. In addition, children learned cultural values, beliefs and worldviews that informed everyday activities. In an indigenous education system, knowledge was often learned in a more complex way being connected to both living and non-living realities for sustainability.

In the next section I discuss traditional culture, since students in this study come from different sociocultural backgrounds each with its own unique experiences, which is important for teachers to recognise to inform their practice.

d) Traditional culture

Every culture has its own form of education system clearly designed to teach the youth about what is valuable to them. According to Biko (2002: 84), "culture is essentially the society's composite answer to the varied problems of life", in terms of thinking and practices. Culture is an expression of a way of being and a way of knowing, which is factored into everyday practices, and in the expression of a community identity. Culture significantly contributes to how people view reality and also determines how they view themselves and the world around. As noted earlier, TAE is stored in culture in the form of knowledge, practices, customs, music and dance. According to Emeagwali and Dei (2014) African culture and identity is dynamic and is negotiated to suit emerging realities within a context, implying that this makes it flexible and accommodative of other cultures. Mitsuko (2009) argues that traditional and western cultures are not pure but rather could have same or similar ways of understanding natural events. In an African traditional setting, cultural practices were the backbone of survival, although colonisers dismissed them as superstitious and with no "scientific" foundation. However, several pieces of research (for example, Ogunniyi, 1987, 1988) based on anthropological, philosophical literature and participant observation found that some traditional beliefs and customs have scientific reasoning. Some traditional cultural knowledge and practices could be used in African classrooms. Through TAE, children learn to appreciate their history, language, customs and values, an attribute of cultural heritage which western education aimed at denying African children (Kelly, 1991).

So, when forms of traditional culture are used in formal education then traditional education effectively becomes part of learning, valuing student's identity and also connecting formal learning with students' lived experiences. Learning becomes more interesting as students become active participants contributing their cultural experiences in achieving formal learning intentions.

However, according to Ogunniyi (1988), the traditional African worldview, a product of traditional culture, is rational and valid within specific context; however, it is necessary that a worldview is clearly understood for it to be valid. It is only then that the ideas and customs make sense and, in the process,

one can understand why people hold those values. So, this study will consider whether teacher education and teacher professional development could empower teachers by providing necessary knowledge and skills to make sense of local culture and use it in science lessons. In addition, lack of tangible documentation of traditional cultural knowledge is a challenge, since vital centuries old indigenous knowledge and skills are lost (Bishop, 1990).

Dei et al (2002) argue that there is no universal indigenous knowledge or culture, so there are diverse experiences, practices and settings where ISK emerges. Since ISK is considered complex and dynamic, then serious debate is needed to successfully implement the integration of IK in science classrooms. However, although indigenous knowledge systems are specific to a culture of people, the goals of education often have some similarities. According to Sillitoe (2006) some aspects of indigenous knowledge are common among diverse communities, although slight differences may exist, for example, the process of making traditional liquor. The differences amongst cultural and lived experiences across different groups does not mean that these diverse knowledge systems cannot be used in science education.

In conclusion traditional education had a strong focus on community requiring members to follow set rules, develop practical skills, regulation and culture of the group. Individual needs were less of a concern; rather, community needs and survival mattered more.

In the next section I discuss indigenous knowledge and indigenous science knowledge as the foundation of survival within specific socio-cultural rural setting especially in colonised people and explore if they are an obstacle (or not) to learning school science.

e) Indigenous knowledge (IK)

Indigenous knowledge (IK) is used for specific local knowledge and could refer to “ways of knowing”. Indigenous knowledge is a complicated term to define, however for this study it is defined in terms of a worldview of people in relation to land and their place in it. Indigenous people have a pragmatic and clear understanding of the interconnection of all living and non-living parts of nature in their context.

Some writers (Emeagwali & Shizha; 2016; Dei et al 2002; Semali & Kincheloe, 1999) considered IK as knowledge that is produced by people after living in a certain environment for a long time and, influenced by "ancestral voices" (Wane 2008: 183), in form of local culture, beliefs and spirituality of the people. According to the World Bank (1998), IK forms the basis of decision making to solve daily problems in a specific culture and community and especially among the poor. So, IK forms the backbone of survival among indigenous communities especially in rural areas. It is owned by all people in the community and represents shared experiences which are passed on to the youth as community wisdom. Shizha (2014) argued that IK was determined by a variety of considerations including beliefs, existing opinions about the natural environment and how their survival in this environment would be guaranteed. So, IK usually makes more sense in context.

The history of science highlights issues of some philosophers criticising the work of others mainly through misunderstanding of that work. However, Popper (1935 [1959]) and his adherents (see for example, Maxwell (2017) claim that it is the refutability of knowledge that makes it science, so criticism may rest on an improved understanding rather than a misunderstanding. According to Little Bear (2009:7), IK knowledge needs to be viewed through local context so that it can be better understood in practice. Little Bear argued that,

"Knowledge is a methodology. A methodology is a validation process. It speaks to how we validate sensory intake so that a person can claim, "I know." Knowing is represented in the Aboriginal context as multiple and diverse processes and includes other ways of knowing, i.e. dreams, visions, insights and teachings that validate one's sensory intake".

To Aborigines, IK embraces a complicated list of personal experiences within their indigenous community including beliefs and thoughts. So, indigenous knowledge is based on the existing relationship in nature (living and non-living) in a complicated way and deeply embedded in spirituality. IK should be understood in a more complex way in its totality for it to make sense to an outsider. It would be important to find out how the teachers in my study might view the issue.

According to Dei, Hall & Rosenberg (2002), knowledge has no rigid features, experiences, and social practices. In addition, Wane (2002) suggest that IK is evolving all the time and over time accumulated forms of IK determine aspects of cultures, so in the process of learning one knowledge, new knowledge is created. This is the same with western science which relies on existing knowledge being challenged and 'disproved' with new understanding developing all the time.

Therefore, IK is complicated and could present a challenge incorporating it in formal education curriculum. However, there are some common indigenous knowledge and practices related to land among different Africa ethnic communities which form the foundation of unifying indigenous knowledges. After all, Emeagwali and Dei (2014) argues that IK which was the base of problem solving has for centuries collaborated with other forms of IK from other societies in the process of adaptation for relevance to suit new situations and challenges.

Indigenous knowledge as the main source of solving rural problems could be the foundation of learning more meaningful knowledge in school. According to Ogunniyi (2022) indigenous knowledge (IK) can contribute to the socioeconomic development and food security especially in rural areas, so IK could provide a significant contribution to poverty reduction in post-colonial Africa. Oghebor (2011) cited in Ogunniyi (2022) argues IK is effective in conservation and development efforts of natural environment; it can provide students with the frameworks for understanding their world around and provide students with effective problem-solving skills. Ogunniyi (2022) suggested that IK make students more confident, proud and aware of their social identity. In addition, IK is social capital that could be adopted and adapted to effectively used elsewhere, which make integration of IK into science knowledge in this study possible.

f) Indigenous science knowledge (ISK)

In this study ISK is linked to cultural customs and indigenous knowledge that solve a peoples' problems in a particular context that includes farming, fishing, hunting, and land management. According to Ogawa (1995) Indigenous science

knowledge (ISK) is commonly passed from parents to children and is integrated into culture which indigenous societies have developed through long periods of real practical investigations to solve economic social and political challenges at home. In addition, Abah, Mashebe, & Denuga (2015) suggest that ISK is unique, local and contextual knowledge whose production is influenced by spiritual experiences and informal investigations and symbolic understanding of nature. Shizha (2015) argues that community beliefs, cultural perspective and needs often determined how community knowledge and practices developed. According to Emeagwali & Shizha (2016) most African communities had their own cultural knowledge that was embedded into the local cultures and everyday practices. This implies that indigenous science is the way knowledge is produced, practiced, and passed on to African young people within their own culture. This knowledge, Dei (2014) argued, still exists today and has been dynamic over time, being adapted to suit new community challenges. Although ISK is diverse in different cultures, the ISK in one community has interacted with other ISK in other communities and formed knowledge systems that are similar in terms of "principles, concepts, and ideas behind their knowledge" (Dei, 2014: ix), so there is potential for its use in Kenyan formal education.

However, Adyanga (2014) casts doubts on the success of the inclusion of ISK into the science curriculum based on the existing colonial legacy of the dominant western education in the contemporary African education system. In addition, Zinyeka (2013) argues that since traditional beliefs are local and based on unique knowledge and culture which cannot be clearly proven, this makes ISK fail the scientific criteria, impacting on its use in science classrooms. Handayani et al (2019) argue that school science (discussed later) and ISK have similarities which could be developed to produce a complementary body of knowledge that could be used effectively by students in science classrooms.

Indigenous knowledge systems are based on anthropomorphic worldview (Ogunniyi, 1988) and the holistic approach which emphasized flexible meanings, living in harmony with the environment, explanation and prediction, taboos, cultural aspects of respect for living and non-living.

I now argue that African people had their own knowledge and ways of understanding their world and solving their problem in a scientific way. For centuries Africa was able adequately to understand the world around and to sustain itself through developing problem-solving knowledge and practices. According to Emeagwali and Shizha (2016) many scientific innovations supported by indigenous knowledge have for centuries enabled African people to live harmoniously with the environment. They had excellent knowledge and skills related to hunting animals for food and fruit gathering and to the use of efficient shaped stone tools for hunting and defence. The discovery of the earliest fire- making process ever known at Wonderwerk Cave South Africa in 2012 (Emeagwali & Dei, 2014) implies that the earliest basic innovative knowledge started in Africa. African indigenous sciences and technological advances including iron making was, however, disrupted by the slave trade and colonisation (discussed later), disrupting African pace in competing with the modern technology (Emeagwali & Shizha, 2016). It can be argued that the massive political power of western countries driven by economic interest disrupted indigenous science and technology. Shizha (2013) argues that globalisation has replaced centuries of political oppression in Africa through commercialisation of knowledge where ISK is alienated over western science knowledge.

g) Other modes of communication

Indigenous science knowledge and information was widespread in other communities in a range of forms including stories and narratives performed in everyday life as rites and rituals, stories, idioms, drama, art, symbols, graphics, songs, dance (Ogunniyi, 2022; Tordzro, 2018). Solomon et al (2022) argue that body movement and dance as embodied interaction is a potential cultural resource for engaging and expanding ways of making science lessons more interesting and meaningful for learners especially for marginalised learners. However, although body movement may be useful in all classrooms, not much is known about it as a creative and cultural resource (Solomon et al 2022); this poses a challenge for teachers who might want to use it in classrooms. The importance of movement and dance needs to be considered both as a device that supports western science education but also one that supports “modern”

countries in participating in the global economy. It would be good to explore the multiple consequences of standardised body movement and dance as a teaching resource, particularly in reference to science education for all.

At a global scale, learning and teaching of science in and out of classrooms is or could be facilitated by incorporating dancing which potentially makes a link between abstract concepts and concrete knowledge easily available to learners. According to some authors (Solomon et al 2022; Fattal & An, 2019; Najami et al 2019) dance and movement can link abstract concepts to life experiences within the principles of chemistry and physics including atoms and subatomic particles; acids and bases; genetics; photosynthesis and human body systems. According to Solomon et al (2022) the way physics is taught is disconnected from learner's bodies and kinaesthetic experiences, making it less meaningful to learners. When teachers allow movement as a learning resource, lessons are often more interesting, something relevant for this study if more students in Kenya (and globally) are to take science courses as Kenyan government wants.

Another study by Burke (2009) investigated chemical bonding and reactions through data collected from a chemistry teacher in a rural school and who had collaborated with an experienced dancer. According to one student a lack of interest in chemistry was a common feature among students before dance and movement was introduced. Another student commented that since atoms could not be seen, it made more sense when the body represented atoms and dance represented reactions and relationships. These findings show that through dance students developed more interest in learning chemistry and this helped link content to everyday life. They also gained a deeper understanding of the content and were more interested than they were before dance was involved. In the Burke (2009) study, folk songs and dances which learners learn from home and enjoy could provide an interesting learning approach in science lessons.

Research was conducted by Majalia (2011) into the education of secondary and primary school students about HIV/AIDS through the experiential Ngoma a Taita, an ethnic group cultural performance in Kenya that often focuses on

dance, song and singing. The aim of the research was to allow young peoples' voice and agency in a school-based HIV/AIDS intervention program and for them to take ownership of the fight against HIV/AIDS. Although HIV/AIDS is a serious health concern in Kenya and globally, it is a particular challenge for the youth in Kenya because of a cultural taboo associated with discussing sex, making the encouragement of safe sex problematic in Kenya (Majalia, 2011). School-based HIV/AIDS intervention programs in Kenya had some success by creating more awareness, however, limited adoption and change of practices among the young people was observed. Significant resistance from religious organisations made things complicated for the school programs. Topics associated with reproductive health and HIV/AIDS are culturally sensitive and involve feelings which often create a gap between the teacher and young people, limiting effective communication in the process. In addition, HIV/AIDS interventions for youth required an appropriate language that could reflect the perception of reality by young people. It is important that form of communication should bring a shared understanding and meanings between teachers and young people. Through Ngoma, people air their views, listen to others and come to consensus in non-threatening ways (Gunderson and Barz 2000). Similar to many other cultural performances in Africa, Ngoma often represents the complexity of everyday life. Through indigenous oral languages, Ngoma represents much knowledge and many practices with the purpose of engaging the people in solving a problem; it contains a mosaic of information and skills "entertainment in the sense of involved enjoyment; it is moral instructions; it is also a matter of life and death and communal survival" (Thiong'o 1986:23). Findings from this participatory research project show that experiential ngoma has great potential as a communication tool that respects local culture and empowers the youth to take ownership of the HIV/AIDS challenge rather than view it as an imposed problem, encouraging them to initiate their own change, both individually and collectively.

In conclusion the implication for my research is that finding ways to link to the cultural knowledge and practices held by students may be key to providing relevant, interesting and engaging science lessons. It will be interesting to

consider whether (or how) any similar approaches could be incorporated into science teaching in the context of the study.

h) Interaction with the environment

In this section I examine how literature and research has considered ways in which traditional science education was closely linked to the environment. As noted earlier, for centuries before the arrival of Europeans, Africa had its own form of education which mostly through the word of mouth passed of knowledge, skills and attitudes to the youth. The knowledge transmitted to the youth was mainly to enable the youth to understand the reality of the world. According to Sunal (1998) the knowledge acquired was necessary to enable members of the society to be effective problem solvers. Although there were no formal documents in African education Ocitti (1973) argues that pedagogically African education included both instructional and non-instructional models of learning.

The curriculum in the traditional education system was founded on the local context (physical, social and spiritual realities) that existed in indigenous societies, as in other global societies (Adeyemi & Adeyinka, 2002). The content of the curriculum was influenced by the existing physical environment with the intention of preparing the youth to adjust and adapt to the surrounding environment and benefit from it in a more sustainable way. According to Castle (1966:40), "Whether the child's habitat was dominated by mountain, plain, river or tropical forest, he had to learn to combat its dangers and to use its fertility". For sustainable living, the youth were expected to understand the physical environment including landscape, weather, and both plant and animal life. A child became aware of the use of plants and animals around, including any associated taboos. The spiritual environment also influenced the content of traditional curriculum (Adeyemi & Adeyinka, 2002). The youth was made aware of the need to appease the spirits to avert such disasters as drought, ill health and death, thus encouraging sustainable living with the local environment. For example, events like drought and floods were explained in terms of their spiritual importance influencing the process of learning and teaching to provide knowledge and skills to mitigate such disasters. Ocitti (1973) argues that the spiritual aspect of the African education system brought the whole community

together in terms of abiding within socially acceptable values and norms, promoting survival.

According to Adeyemi & Adeyinka (2002) the home environment of a child determined what practical skills were needed for future survival of the child. For example, if the surrounding setting had rivers, then several skills were needed including fishing, canoe making, fish preservation, fishing, net manufacture and repair skills. Therefore, the knowledge and skills the youth learned at home aligned with the physical environment so that they effectively reaped benefit from that environment. However, formal education changed African ways of learning through word of mouth to mostly written form. It also changed what was learned as well as how. Boateng (1985) argued that formal education interrupted the way African people transmitted knowledge, although African people benefitted from the development of literacy skills.

In conclusion the African education system focuses on the perpetuation of a community culture; is holistic in its approaches, community based and builds relationship with living and non-living things in context.

2.2.2 The impact of colonial education in Africa/Kenya

I now discuss how colonial, political and economic interest influenced the education system and school curriculum to serve those interests.

African communities lost power and freedom through erosion of their cultures in formal education during colonisation and later through globalisation. The location of settlers and missionaries determined the extent of the spread of Christianity and particularly western culture and formal education. According to Sifuna (2005) missionary work, which included the starting of formal schools, concentrated in agriculturally rich areas along with settled communities which favoured the development of formal education. However, rural areas with less fertile lands tended to be neglected because of poor economic returns and were “left behind” in the development of formal education, in terms of resources, infrastructure and access to western culture (Eshiwani, 1985). This is important for this study because rural schools in remote settings are disadvantaged from a historical perspective, posing a significant challenge to successfully implementing the science curriculum.

Most education commissions recommending reforms during the colonial era were based on redefining what colonial government thought was good for Africans (Lelei & Weidman, 2012) and not on Africans' needs. According to a report by Beecher of 1948, the African education system was poorly organised and lacking in structure (Oketch & Rolleston, 2007). The report recommended Christian religious education to be taught in schools to create a moral society at all levels. In addition, there was a formal exam leading to graduation and certification, a western culture to replace African culture in formal education. This created structures and standard practices as we see them today where prescribed knowledge, pedagogy and exams are used to provide a narrow perspective on specifically defined areas of learning.

The 1900 land ordinance by the British administration, allowed settlers to take land from local Kenyan owners for settlement. According to Gikungu et al (2014), colonial interest was the basis of an education curriculum that provided required labour. So, the school curriculum was mainly focused on religion, basic gardening, and carpentry (Alyw & Schech, 2004) so it retained some local 'content' in addition to religion. However, although formal education provided local children with numeracy and literacy skills, the problem was that most of the knowledges and skills benefited colonisers rather than local communities as was the case with traditional indigenous education.

Worldwide, colonial education policy statements and reports have always been based on the supremacy of western culture over non-white cultures. According to Agbo (2004) the residential schools introduced by Canadian government in the education of First Nations children was meant to exclude them from their indigenous knowledge, indigenous languages, culture and beliefs. Maina (2003) suggests that the curricula of a colonial education system did not reflect specific cultural needs of local communities but reflected colonial interest through "an individualistic Euro-centric value system" (Woolman, 2001 :29) against tradition/practice as well as values. The colonial government used power to impose their own worldviews on the locals and denied them creativity through their knowledge and cultural expression. Western culture was a tool of limiting and controlling knowledge production through the church and school.

Somerset (2007) presents evidence that the British colonial administration in Kenya financially supplemented education disproportionally through racial structures based on segregated schools for Africans, Europeans, Arabs, and Asians. According to Eshiwani (1990) as of 1950, an African child received £1, European £56, and Asian £8.3 per capita, which meant that fewer resources and facilities were available to the African children who were the majority in the population (97%) compared to the minority Europeans and Asians (3%). It can be argued that fewer learning resources for non-white youth meant they were being prepared for the unskilled labour market, so lack of fair funding in all schools may mean high disparity in the quality of education. The low investment in the education of the African child, Chege (2001) argued, was a Pan-African problem and had serious impact in terms of implementing learning outcomes in formal curriculum especially in rural areas where majority of poor children learn.

Ogunniyi (2022) suggests that although colonial education systems encouraged the development of literacy skills, literature and research in Africa, the disconnect with local culture which persists today may have contributed towards a limited feeling of ownership of education among learners and hindered the development of problem-solving skills. In addition, there was a strong emphasis on exams (a global factor) in the Kenyan education system at all levels and these were administered in the English language and often determined progression (or not) to the next education level. Effective teachers were assumed to be those whose students achieve the best grades. However, exams were often associated with a narrow academic approach to learning including memorisation rather than deep understanding (O'Hern & Nozaki, 2014; Lillis, 1985). Teachers often teach what is to be tested using English as the language of instruction, although teachers often value home languages in their personal lives and use it when linking disciplinary content to students' prior learning. According to Thiong'o, (1986) African classrooms are key sites where linguistic oppression occurs with teachers the major players owing to the power and authority they hold. Thiong'o (1986:111) argues that the colonial government subjugated the home language of students in school, and in particular disconnected home language from classrooms. So, "the language of

my education was no longer the language of my culture" (Thiong'o,1986:111). In schools, teachers played a significant role in silencing, shaming, and discouraging the linguistic and cultural practices of the home in an attempt to teach prescribed knowledge using English the language of instruction, considered to be the "knowledge and language of power" (Thiong'o,1986:111).

The colonial perception of a well-paying job was the promise given to students and communities if they remained silent. When other languages are used in classrooms those cultures and histories about the people who use them are accommodated and this can potentially encourage learners to take more ownership of learning and teaching. It can be argued that subjugation tactics of colonisation are active in teacher pedagogies and teachers are often gatekeepers to the oppressed indigenous languages. In reference to colonisation Thiong'o (1986: 9) commented, "the bullet was the means of physical subjugation. Language was the means of spiritual subjugation", disrespecting what Africans represented in terms of culture and identity. It can be argued that the impact of colonisation in formal education led to alienating African children from themselves, since it is challenging to transmit culture through a "foreign" language. In addition, local language may be a cultural resource which help children process things into a deeper level.

With reference to Kenya, Eshiwani (1993) explains how the country imported a colonial curriculum because they had limited human and financial resources to design a more relevant curriculum that could serve the needs of Kenyans. In particular, this ignored the effects of the child's first language in learning and the use of English as the language of instruction often affected pupil's self-confidence (Ogunniyi, 2022; Jepkemei,2020). Graduates gradually began to despise their languages and cultures and to speak ill of their own culture doubting the culture of their ancestors which had guided them for centuries and made it possible for them to exist (Ngasike, 2019). It can be argued that African graduates of western education began to think of themselves as "superior" and possess white logic and thus devalue their own culture as barbaric, a western perspective on African culture.

Schools in Africa have taken in a western competitive approach to education at a global level regardless of local needs and interests, putting pressure on teachers to conform to global view dominated by exams (Halvorsen, 2018). According to Halvorsen (2018) public policy and governance in most African countries is significantly influenced by colonial legacy and the impact of globalisation. It can be argued that when the LOI is English, white students whose first language is English have a cultural context to draw from to make sense of classroom content. However, students whose first language is not English learn at a superficial level mainly due to translation challenges into their culture because they have been removed from their culture. Learning goes beyond subject content to ways of thinking and innovation, which undermine creative films in African languages (Halvorsen,2018). Colonial education impacts on the use of African languages as an everyday means of communication, LOI and being innovative. It can be argued that western education tends to take away African children's identity, culture, language and people contributing to loss of self-confidence.

In conclusion, the colonial education system was designed by "experts" to make children respect authority, learn basic skills for specific labour needs and consumer culture. They learned what to think and not how to think, including how to reproduce knowledge taught by a teacher, a reason why and how the education system in Europe was developed. Education policies represent a racist agenda of "superior" Europeans over non-Europeans. According to Lillis (1985: 80) African colonial governments transferred, "frameworks, paradigms, concepts, methodologies, and techniques from metropolitan countries to colonies" for their own social, political and economic interest, in disregard of local cultural context and needs of the colonised people. This posed many challenges in relation to a relevant school curriculum, education facilities, language and culture and pedagogical issues.

In the next section I discuss the Kenyan education system and why ISK is not seen as important and how that could be mitigated so that science classrooms are more inclusive to both ISK and western science and give students a good science experience. I discuss the Kenyan attempts to decolonise science education to suit local cultures, the persistence of traditional instructions and

exams and the effects of delinking (or not) of a scientific worldview to the worldview of the majority of students especially rural students.

2.3 Education in Kenya today

In this section, I look at the current situation in Kenyan's education system. I consider:

a) Initial changes following independence.
b) The impact of globalisation and move towards universal education.
c) The current Kenyan education structure.
d) Post-colonial Africa science education.

a) Initial changes following independence

After independence in 1963 Kenya proposed to indigenise formal education curriculum by reforming syllabi to reflect diverse cultures and ways of knowing as a way of empowering citizens. According to Eshiwani (1990) political freedom was seen as the time to reclaim the African identity and cultural heritage through education by ensuring that formal education was relevant to local needs. The Ominde Report of 1964 is among about a dozen government and stakeholders funded education reviews following Independence, an indication of the commitment to get the optimum policy framework that would produce the right strategy for education that would serve the needs of the nation. These reforms included: the report of the National Committee on Education Objectives and Policies (Gachathi Report, 1976); the report of the Presidential Working Party on the Second University in Kenya (Mackay Report, 1981); the report of the Presidential Working Party on Education Manpower and Training for the next Decade and Beyond (Kamunge Report, 1988) the Commission of Inquiry into the Education System of Kenya (Koech Report, 2000). However, despite these, it can be argued that since independence the government has struggled to come up with a form of educational curriculum that would integrate diverse indigenous cultural knowledge and practices, promote social change and empower individuals (Ndegwa Report, 1971; Ominde Report, 1964). The outcome of indigenisation education policies in Kenya was relatively minor and did not result in radical change towards indigenous education becoming the foundation of learning and teaching. So trivial changes

were made in education without structural changes in the colonial education system to give African education prominence.

According to Lillis (1985) foreign teachers and curriculum developers appointed to provide advice to the Kenyan government after independence posed a huge challenge to the integration of the indigenous knowledge into the formal school curriculum, since they were lacking in indigenous knowledge, or were serving colonial, political and economic interests. The smooth political and economic transition left the British colonial education structure and content largely intact; although the people in charge of education after independence were mostly Kenyans by birth, the Kenyan education system copied the British curriculum in schools (Woods, Dunn & Mutuku, 2008). It can be argued that western educated Kenyan leaders valued western culture more than local cultures, so had little commitment to indigenise formal education. On the other hand, the elite could be under global influences (discussed in the next section).

Formal education was used by the new Kenyan state as the bridge between diverse cultures, particularly hoping to develop a new national culture, recognising the need for a more global culture. According to the Ominde Education Commission Report of 1964 cited in Gikungu et al (2014) Kenya decided that the country's education reforms should be guided by the industrialised world's approach based on socio-economic development. To promote educational access and western approach to development, the Kenyan government restructured education through bureaucratic state agencies including the Ministry of Education (MOE) and the Kenya Institute of Education (KIE) (Currently the Kenya Institute of Curriculum Development (KICD)). To achieve this goal, O'Hern & Nozaki (2014) argued that the Kenyan school science curriculum was under firm government control in terms of the official western science knowledge, language of instruction and pedagogy, impacting on the use of ISK. Western curriculum, culture and pedagogical practices have persistently neutralised indigenous voices with serious consequences in terms of preparing youth for employment.

In 1984, The Mackay Report of 1981 recommended that Kenyan education system was to change to the current 8-4-4 system, a North American model (8

years of primary education; 4 years of secondary education and 4 years of university education). This was a borrowed foreign education system, impacting on the use of ISK. The 8-4-4 education was aimed at improving quality of education in all stages by ensuring the youth acquired self-reliance skills that would prepare them for employment (MOE 2008; MOE,1988). However, according to Murichu and Changash (2013), the 8-4-4 education system was immediately resisted by both teachers and parents because of a lack of stakeholder consultation and its forced implementation without adequate physical and human resources.

Most African countries, Kenya included, prioritised formal education as the pillar for political and economic development (World Bank 2009), an industrial approach to economic development. The aim of the independent Kenyan education policy was to expand education access to all Kenyans as a means of combating illiteracy and accelerating national development. Free basic education became a popular Kenyan education policy, which encouraged expanded education and enrolment (MoEST, 2015). High enrolment in Kenyan schools put undue pressure on learning resources including learning supplies and appropriate infrastructure making the process of learning and teaching problematic for teachers (Abuya, et al 2015). According to the Global Monitoring Report 2016, (UNESCO, 2016) the physical infrastructure of education remains poor in most SSA countries including Kenya. In Kenya some schools lack adequate classrooms despite the government disbursing infrastructure grants to both public primary and secondary schools. Special grants that were offered to secondary school helped set up teaching and learning facilities including science laboratories; however, these were still inadequate. Problems of inadequate learning materials are compounded by the inadequate number and quality of science teachers for the increasing student roll. Inadequate learning materials and human resources have a serious impact on learning and teaching to achieve set learning intentions (UNESCO, 2016).

In conclusion, many of the structures of a colonial education system and educational curriculum that served colonial political and economic interests continue to exist in Africa today. So, Kenya has a weak strategy for an education that might better serve the needs of the nation. Science classrooms

in Kenya lack science knowledge, skills and pedagogy needed for national development.

I now discuss how the open market policy under globalisation has influenced formal education with significant impact especially for young people's voices and agency in schools.

b) The impact of globalisation and the move towards universal education

Globalisation has been described as a new form of colonisation where soft power replaces hard power to impose new values on the less powerful countries and people. According to some authors (for example, Wanjing et al 2012; Escobar, 2007) globalisation is a European concept through which modernity is imposed on other countries. Globalisation integrates world economies and more traditional culture into a "modern" culture, where the world is ordered, rationalised and predictable. Through globalisation, western culture has come to dominate other cultures in education and development in a (Escobar, 2007).

Globalisation has brought prosperity to some countries and to individuals within countries. For example, with growing recognition of the 'knowledge economy', competence in English language is an empowerment tool in the very competitive world market-driven economy where salaries are better compared to local jobs. In addition, western science knowledge as presented in globalisation has some benefits since all knowledges or cultures are dynamic and often complement each other to improve understanding of natural phenomena.

The high cost of education and non-performing economies in the 80's and 90's forced many African countries including Kenya to abandon their free education policy, reducing previous gains made in this area. African countries needed money to support their economies. The International Monetary Fund (IMF) and the World Bank demanded that the Kenyan government adopt Structural Adjustment Programmes (SAP) policies in order to manage better the declining economy and control increasing national debt. Generally, donor conditions required the government to reduce education funding by freezing teacher employment which led to teacher shortages; and through education cost sharing with parents which the majority of parents could not afford (World

Bank, 2009). The quality of education provided was so low because of poor implementation of education programmes that target inequality (World Bank, 2009). Many students were forced out of school especially the most vulnerable and poor in rural areas (World Bank, 2009), the shortage of teachers forced school committees to request parents to meet the cost of employing cheap untrained teachers (Duflo, et al (2014) impacting on the quality of education in mainly rural areas. According to World Bank (2009) the Gross Enrolment Rates (GER) in primary schools before SAP was 105% and 88.2% during SAP before the introduction of Free Primary Education (FPE) in 2002. SAP increased inequality by making education unaffordable and less resourced especially to the poor.

In addition, the IMF and World Bank dominated educational reform policies that were meant to serve the needs of local people and replaced them with their market economy agenda. Koosimile & Suping (2015) argue that globalisation has turned schools into sites where learners gain values that prepare them for global duties and challenges. Similarly, Shizha (2013) argued that neoliberal policies contribute to the subjugation of ISK and domination of the western science where knowledge is a commodity for sale. According to Al'Abri (2011) donors promoted a global agenda on commodification of knowledge, standardised tests, global school curricula, and English as the global language of instruction. Western knowledge continued to dominate the school curriculum, marginalising local communities (Dei and Simmons, 2009). To Dei et al (2002), silenced voices need to be heard and acted upon to reduce the effects of commodification of science knowledge, promoted by ill-informed policies and scientific practices. The majority of African students did not connect with western science and lacked ownership, so they lost interest.

As part of national and global commitments, the Kenyan government introduced Universal Primary Education in 2003 and free day secondary school in 2008. Under international pressure many "developing countries" including Kenya agreed to comply with the world Conference on Education for All (EFA) held at Jomtien, Thailand, 1990 and revised in Dakar Conference in 2000. According to Torres (1999), "developing countries" were required to actualise basic education. School fees were abolished, and the Kenyan government introduced capitation grants to ensure access, quality, equity and relevance of

school education. However, free education has hidden costs. According to Obha (2009) these include school uniform, meals, boarding fees, motivation fees, stationery and books which parents were expected to meet.

The Increased enrolment caused problems of teacher shortages, lack of adequate classrooms and teaching and learning resources. This increasing access to education raised some concerns in terms of overall quality of education provided because the physical and human resources did not equally expand as well. Similarly, most secondary schools are always under pressure from the Kenyan government to increase enrolment and at the same time comply with the Ministry of Education science and technology guidance on school fees. Through a Gazette Notice No. 1555 of March 2015 all public secondary schools were required to charge fees as follows: day secondary schools 9,374 Kenya shillings (about 90 British pounds) while students in boarding schools 53,553 Kenya shillings and in each case the government was to subsidise each student with 12,860 Kenya shillings (about 100 British pounds) per year (MoEST Press statement by cabinet minister March 10, 2015). However, the cost of education is higher than government estimates. Most parents, especially in rural areas, find education costs unaffordable, due to high rates of poverty. According to Mutegi (2018) the cost was the reason many primary school graduates did not proceed to secondary school. The introduction of Free Day secondary school education (FDSE) in 2008 by the government was expected to solve the problem of access. The government pays a significant percent of education costs including recurrent social costs; development social costs; teacher wages; tuition fees; national examination registration fees and school infrastructure development. However, the cost of education remains high. In addition, some parents think that the education provided was elitism and often lacked relevance with life in rural areas. According to the Republic of Kenya (2016: vii), “The graduates at secondary school level did not acquire adequate entrepreneurial skills for self-reliance” leading to high unemployment rates, building a case for the integration of local knowledge and culture in science education.

In conclusion globalisation has brought prosperity to some countries, however western culture has remained dominant. Educational reform policies align more

with the market economy agenda of prescribed content knowledge and pedagogy of teaching, so in Kenya, the science knowledge and pedagogy of teaching is delinked from lived experiences of students potentially contributing to less interesting and meaningful education.

c) The current Kenyan education structure

To understand the context of this research it is important to understand the interplay between the arm of government through various agencies (in the form of school administration, school curriculum and assessment) and school practices. The school structure is designed to facilitate implementation of what the government thinks is good knowledge and how it is to be taught and assessed.

In independent Kenya, the new education system borrowed significantly from the colonial education system. All education and training matters in Kenya have been governed by the Education Acts of 1968 and Acts of Parliament, which were replaced by Section 66 of the Basic Education Act (2013) which required the Ministry of Education to develop and review the standards of education and training. The legislative goals of education are aligned with several international laws (discussed earlier in this chapter) that require provision of free and universal basic education.

While all Kenyan young people had different education experiences and opportunities within the colonial education system, today the Kenyan education system assumes a standardised approach. The Ministry of Education (MOE) was established to run all aspects of education including the provision of education at all levels, policy formulation and implementation through a range of education agencies.

The Kenya Teachers Service Commission (TSC) has a firm hold on teacher behaviour within schools in terms of curriculum content, pedagogy and length of courses and is responsible for teacher training. The Kenya National Examinations Council (KNEC) is responsible for the development and administration of both the Kenya Certificate of Primary Education (KCPE) and the Kenya Certificate of Secondary Education (KCSE) examinations (MoEST, 2015). In Kenya, as in many countries, exam grades are often used to judge not

only the overall performance of individual students, but also teachers, headteachers and the school. In addition, the promotion of Kenyan teachers and headteachers is mainly pegged on grades achieved by students they teach. According to Lillis (1985) high stakes examination leads to the dominance of a teacher-centred teaching and learning process where memorisation of facts by student is more important than learning for deeper understanding through more interactive practical activities. In addition, O'Hern & Nozaki (2014) argue that exam grades are often misleading and give little indication as to how the Kenyan education system could be improved.

The Kenya Institute of Curriculum Development (KICD) (formally Kenya Institute of Education, KIE) plays an important role in conducting education research and in producing relevant teaching and learning resources needed for supporting the implementation of school curriculum (KIE, 2009). KICD approves official subject textbooks, writing and publishing school textbooks, teacher guides and other supporting materials used in delivering the curriculum. A key consideration in official textbooks is the overall coverage of the national syllabus and ensuring that all areas which will be tested in national examination have been covered. According to O'Hern & Nozaki (2014) KICD on its own and without consulting other stakeholders determines the official knowledge, how it is learned and the specific period to cover it. The overall structure of education indicates a bureaucratic arrangement that is driven by standards and power and which may not be conducive to accepting alternative views.

However, with the rapid expansion of free formal education in Kenya, serious challenges exist in relation to funding. At secondary school level, schools are stratified into national, provincial and district schools (O'Hern & Nozaki,2014), a colonial education legacy based on social economic interest which extended to education development (Lillis, 1985). Most national secondary schools have a colonial history in their origin. National schools are well-resourced with an adequate teaching force, well equipped science laboratories and developed infrastructure. District schools provide for the majority of students who are poor and these schools are often poorly resourced and are mostly day schools. There are also few privately funded secondary schools mainly located in urban areas, where the rich and some middle-class individuals can afford the high

fees charged. Public primary and secondary schools are funded by the Ministry of Education in terms of both the human and physical resources necessary for learning to take place. Capitation grants supplement the government funding effort and are provided to public secondary schools while parents are required to make financial contributions, including uniform, boarding fees where required, and food. However, government funding does not consider regional resource disparity, disadvantaging rural schools with poorly developed infrastructure, a colonial legacy. Several authors (Rollnick, 2014; Woolman, 2001) have suggested that globally, and especially in Africa including Kenya, rural schools often received less funding from the government than urban schools. Many rural schools end up with limited resource allocation, poor infrastructural development, less political voice and representations impacting on learning and teaching in such schools. It can be argued that fair allocation of funding should respect contextual factors. Cumming & William (2008) argue that a rural poor child would require more support to attain a better learning outcome because of a complex package of disadvantages in existence at home and school. So, a funding formula that provide funds based on school context could allow all students have relatively similar opportunities to achieve learning outcomes.

Public education expenditure in Kenya is deemed to be inadequate (MoEST, 2015), impacting on quality of learning and teaching. Increased number of students enrolled public schools has implications for quality education in terms of too few teachers, demotivated teachers, inadequate learning material resources and lack of professional development opportunities for teachers. When less funding was available for education, the quality of education provided was low because of poor implementation of education programmes that target inequality (World Bank, 2009). Teachers' pay takes a significant part of Kenya's public education funds, leaving less for education resources; for example in the period 2004-2014, 74.83% of Kenyan education expenditure was allocated to teachers' salaries (MoEST, 2015). Adequate learning resources often broaden learning experiences, leading to achieving learning outcomes and more meaningful learning. For example, the availability of relevant teacher professional development opportunities could provide teaching skills that

reduce the gap between student experiences and science knowledge. This study will consider whether this is a factor in developing effective science education in a rural area.

In the next section I look at the challenges of integrating indigenous knowledge into formal education within post-colonial African and Kenyan contexts. I discuss the universalisation of education policies in Africa and the increasing poverty-ridden communities, lack of interest in education, lack of basic self-reliance skills to survive and loss of sociocultural identity.

d) Post-Colonial African science education

At independence, many African countries had acknowledged the global dimension of school science and wanted to take their place at a global level through training more doctors, engineers and other professionals to fill positions left by colonial staff (Lilies, 1985). The leaders believed that western science knowledge was the road to industrialisation and the solution to the socio-economic problems the new countries were experiencing. So, the effects of colonial education in Africa are alive today in terms of education system including knowledge and teaching pedagogy. Although the African education system existed and transmitted knowledge, skills, or cultural values to the youth, it was not written but oral and therefore from a colonial perspective it did not exist.

Persistent domination of western knowledge in the Kenyan school curriculum is complicated. At independence, Kenyan leaders made promises of designing a relevant school curriculum that incorporated indigenous knowledge as the foundation of economic development. Mwalimu Julius Nyerere of Tanzania through Azimio la Arusha la 1967 (Arusha Declaration of 1967) declared a move towards indigenised education with a policy on “Education for Self- Reliance”, which Nyerere (1967) suggested should be relevant to Tanzanian citizens. However, lacking in an original school curriculum, most of these African countries retained the colonial education curriculum and structure with some modifications to reflect African needs through a series of education reforms. The resulting science curriculum has not solved high unemployment problems among the youth in Africa despite several changes and massive expenditures.

Research by a range of science education writers, discussed below, suggests that African children have been learning an irrelevant science curriculum for more than three decades into the post-colonial period and the problem remains into the 21st century. According to Ogunniyi (1986), at primary school level, African pupils learned basic scientific knowledge and skills using unfamiliar foreign language, a barrier to solving local challenges, achieving learning outcomes and development of critical thinking skills. Therefore, for an African child to cope with allegedly 'difficult' western science, knowledge had to be memorized (Jegede, 1997; Ogunniyi, 1986) from a textbook and through teacher-led pedagogy. Students have little ownership of their learning when IK, language and practices are excluded from the production of new knowledge.

School science is taught and presented in textbooks in a way that often alienates non-western students in terms of their lived experiences. So, the contributions of students' lived experiences are often missing in producing science knowledge in classrooms. Ogunniyi (2022) argued that when African students perceive science as foreign to their experiences, they lose interest and only study it to pass exams. According to Gwekerere (2016) rote learning is an obstacle to science learning in the 21st century because the knowledge acquired is not practical and makes little sense to student experiences. So, when a student memorises knowledge, it often fails to link to what he/she already knows and is less interesting and meaningful at home. In addition, Ogunniyi (2022) argues that national exams have taken a central role in African education system, a significant challenge to the integration of science and indigenous knowledge in classrooms. However, Gwekwerere (2016) suggested that there is a similarity to IK in the way SSK is presented through experimentation, observation supported by possible patterns, leading to a conclusion, and thus there is a possibility of integration of ISK into school science. Therefore, skilled teachers could link IK and SSK.

Kenya, like other countries, finds many ethnic communities living side by side with each other, leading to multicultural classrooms. In reference to South Africa, Ogunniyi (2022) argues that multicultural science classrooms have emerged, a significant challenge for most teachers. Students come from different sociocultural backgrounds and require teachers to apply new

instructional strategies to effectively connect students' lived experiences in science lessons and achieve science learning outcomes. The assumption is that teachers have the necessary knowledge and instructional skills to effectively integrate students' lived experiences in their classrooms. The training and staffing of the education sector within Africans did not result in indigenisation, but instead western science knowledge was perpetuated through the foreign trainers and curriculum (Ogunniyi, 2015). The colonial staffing model and courses remained (Ogunniyi, 2011; 1995; Lillis, 1985), and little has changed decades later impacting on the use of ISK (Ogunniyi, 2015). The colonial education infrastructure continued to dominate and control the entire post-colonial education system after Africa's independence.

I now discuss how the way school science is taught in science classrooms and presented in textbooks may contribute to the alienation of the role indigenous people played in the development of modern science, the main source of tension between IK and SSK. Science education in Africa takes the assumption that science is culturally and politically neutral. According to Ogunniyi (2022) the hidden agenda of the science curriculum is mainly to advance the economic interest of the west, enhance the ideology of white supremacy and to justify the subjugation of IK and practices by labelling Indigenous science as primitive and superstitious. According to Battiste (2002), IK was rejected because, like socio- political or cultural aspects, it did not fit into the "universal" Eurocentric thinking. IK was considered unsystematic and incapable of serving "modern" needs.

However, based on a variety of "rational" methodological and contextual criteria, IK is perceived to be different from scientific knowledge (Agrawal, 2002; Battiste 2002). For example, IK is mainly orally stored and transmitted while western scientific knowledge is in written words. Indigenous Knowledge, ways of thinking and transmission did not conform to western standards, thinking and practices. The genesis of tensions between IK and SSK is mainly the universalisation of science with a perceived dominant western science worldview, and exclusion of the existing multiple worldviews, cultures, and sciences.

In the next section I look at policy formulation and implementation to find out how study of science as a discipline is understood.

2.4 Education policy
a) Policy formulation in Kenya

According to Grindle (1980: 6) policy is "a broad statement of goals, objectives and means". So, education policy could be stated in the form of instructions, texts and legislation whose aim is to frame and constitute changing teaching practices in a country by improving education practices.

According to Abuya et al (2015), there are two important approaches that define the processes and issues that influence the implementation of policy- 'top-down', and 'bottom up'. The 'top-down' approach is centrally planned and firmly controlled by the state, which fits the Kenyan situation. A more comprehensive definition of policy process which is also important for this study is by Dunn (1995) where he described policy making as a political process. Dei (2014) argues that the curriculum represents the social values of those in power, who often resist an education change that does not serve their interest, impacting on the use of ISK. Gikungu et al (2014) argue that changes in Kenyan education policy and curriculum development were a top-down approach intended to solve societal social and economic problems, which is implicit in practice in Kenyan classrooms. However, communities are complex and experience complex local challenges which require different local solutions guided by historical and social realities, and so one way of solving contextual problems is likely to fail. In policy adoption, policy is legalised through government authority. Although IK is acknowledged in policy text and legislation, it only offers political capital to government and it seems that it receives no political backing for its implementation.

Shizha (2013) argues that western educated policy makers often prioritise their internalised colonial ideas which in turn influence education policy through the policy making process. However, Sifuna & Otiende (2006) argues that Kenya's policy makers lack the skills needed to reform curriculum and pedagogy to reflect the local context, thus proliferating postcolonial contradictions. The top-down approach appears to reduce the role that teachers play in the policy process and teacher understanding and ownership of education policy. Teachers also have their own ideas about their job and standard beliefs which

Kelchtermans (2005) argues are left out of curriculum change, impacting on teacher ownership of the school curriculum. According to Bantwini & King-McKenzie (2011) if a new curriculum introduces conflicting normative beliefs, teachers often resist the changes.

b) Policy implementation

According to some authors (Bergen & While 2005; McLaughlin, 1987) policy implementation is complex and difficult process, mainly because there is a disconnect between policy requirement and practice. Teachers play an important role in the implementation of curriculum reforms (Alsubaie, 2016), and their readiness to adopt (or not) curriculum reforms often means the success or failure of the intended curriculum change (Lee, Yin, Zhang & Jin, 2011).

The science curriculum presented to teachers in Kenya appears to be a directive, which is implemented using the top-down model with apparently little teachers' voice in the policy formulation. A behaviourism approach through top-down planning fits the requirements of the science curriculum; however, the experiences of teachers and students, especially those in rural areas are missed out, impacting on the use of ISK. Brown (2015) argues that there is usually a gap between teachers' practice and requirement of policy, because teachers often implement only what best suits the needs of their individual contexts. According to Carl (2005: 223) teachers' voice need to be heard throughout the process of curriculum reform to actual implementation.

In a bottom-up approach the implementation of policy involves continuous communication with implementors, to allow discretionary decisions to be made for effective implementation. The science curriculum in Kenya seems ambiguous on how to include students' lived experiences and also assumes that teachers have skills to plan inclusive lessons. The consequence of ambiguous policy intentions is that implementors exercise discretion rather than clear policy for effective practices. Pressman & Wildavsky (1984) as quoted in McLaughlin (1987: 162) argue that it is often very challenging to make even the most ambitious policy achieve the intended goals, because what most counts is the "will, or the attitudes, motivation, and beliefs… (which) are less amenable

to policy intervention". In addition, teachers could be turned into implementors of a school curriculum that they had an input in a bottom-up approach, which give them more ownership of the document in terms of what they teach.

c) Challenges in policy implementation

Like many African countries, Kenya faces teacher shortages at all levels of education. According to Evoh (2007) the shortage of mathematics and science teachers in South African secondary schools was so bad that a school of about 900 pupils usually had one or two teachers and most of them were unqualified. Significant shortages of qualified science teachers in many African countries still exist (Ogunniyi, 2015). Secondary school teachers in Kenya are working in a context where the recommended teacher student ratio in Kenyan public schools by 2020 was 1:35. The national ratio was lower at 1:29, however notable disparities in the student-teacher ratio (STR) among Kenyan counties existed particularly in rural areas (Republic of Kenya, 2020). Teachers, especially in rural areas, are seemingly under significant pressure. Learners come to school with complex needs which require individual attention by teachers to allow students to participate in classroom activities and take more ownership of their learning. In addition, according to the Global Monitoring Report 2016, (UNESCO, 2016) the shortage of other learning resources including textbooks and school laboratory services in Kenya is alarming, impacting on teachers' ability to provide effective learning experiences for all learners.

Studies (Inyiega et al 2021; Ogunniyi, 2015; Republic of Kenya, 2010; Mckenzie & Santiago, 2004) have suggested that most SSA countries provide low quality teacher training programmes that do not reflect the needs of students, a situation that remains today. In addition, a lack of in-service training has denied Kenyan teachers opportunities to enhance teaching skills (Andiema, 2017; Republic of Kenya, 2013), impacting on the use of ISK. According to the Republic of Kenya, (2012a), appropriate child-centred approaches including active learning in teaching are essential in ensuring quality learning and motivation as opposed to passive learning. However, according to Ogunniyi (2015) most independent African countries including Kenya depended on former colonial government science teachers using traditional teaching methods,

impacting on how science education was experienced by those going through the system and on the use of ISK in classroom. Most Kenyan secondary school teachers are trained in western knowledge, language and culture and pedagogical approaches, so they face challenges of integrating science with students' indigenous knowledge (IK) in multicultural classrooms using innovative instructional strategies. It can be argued that the Kenyan government views active learning from a western perspective rather than from local students' lived experiences and practices.

In the next section I discuss educational theory and how it is linked to the syllabus. I discuss a range of relevant education theory which can be used as a lens to interrogate learning and teaching and consider how these relate to the specific socio-cultural context of this study, given the fact that I am investigating both the perspective of learning the content of the syllabus in classroom and learning that takes place at home. I briefly define curriculum as a concept and then discuss relevant models of curriculum design and the different ways of how they are conceptualised and implemented in different communities.

2.5 Educational theory

In this section I consider the literature relating to educational theories relevant to this study which inform the construction of the research and my understanding and analysis of the data:

Theories of curriculum.

Theories of learning.

2.5.1 Theories of curriculum

I briefly discuss the origin of curriculum as a concept, curriculum theories and the way they are understood in different societies. Important to this study is that with the existence of a structured and rigid science curriculum and teaching pedagogy, students' lived experiences are likely to be left out of science lessons.

The definition of curriculum is a contested field because of the diversity of experiences and beliefs held by responsible researchers, so a broad perspective will be taken. According to Kelly (2009: 8),

> "an educational curriculum at all levels should be concerned to provide a liberating experience by focusing on such things as the promotion of freedom and independence of thought, of social and political empowerment, of respect for the freedom of others, of an acceptance of variety of opinion, and of the enrichment of the life of every individual in that society, regardless of class, race or creed".

So, in this view, cultural knowledge and practices held by students should be part of the formal curriculum. To ensure that a curriculum serves its purpose in providing relevant quality learning appropriately, it needs the necessary reforms to address any raised concerns as a means of improvement (White, 2004) and could include student voice and agency. Kelly (2009) argued that besides stating 'official' knowledge a curriculum should go further and specify the reason behind the choice of knowledge and expected outcome on pupils' lives. The implication of this is that in any curriculum framework, pupil needs should be the guiding principle in the choice of content and pedagogy. However, many world curricula including the Kenyan science curriculum contain prescribed knowledge and skills which children are expected to know, while students' lived experiences are not formally acknowledged. In addition, the emphasis on exams that only test prescribed knowledge often marginalises alternative perspectives with implication on the application of knowledge at home. It can be argued that a focus of industrialisation for economic growth in Africa impacts on education and curriculum. Kelly's view on a curriculum that also includes student's lived experiences is relevant for this study. In addition, Grundy (1987: 115) suggested that a curriculum,

> "as praxis is a conceptualization of curriculum derived from an orientation towards human well-being and which makes an explicit commitment to emancipation of the human spirit. It is a process which takes the experiences of both the learner and the teacher and, through dialogue and negotiation, recognises them both as problematic".

So if a curriculum is more realistically an organised set of a group of people's learning experiences and practices as a reflection of the society guiding principles and drivers, it is subject to reform to suit new situation. Following

this view, the science curriculum and pedagogy in rural Kenya should respond to reality as perceived by students at home.

Kelly (2009) suggests that there are a number of ways of conceptualising curriculum:

i) Curriculum as a body of knowledge

Sometimes the curriculum is defined in terms of the content contained in a disciplinary subject, which can be referred to as a body of knowledge. The Kenyan science curriculum in Kenya could fit into a curriculum model that was concerned with a specific body of knowledge per discipline which students must master in each school level before assessment. The content in the syllabus is arranged systematically into specific areas which may be assessed; for example, the course title, explanation, teaching method, topic objectives, course topics and dates, textbooks and required material resources, grading plan, course validation and remarks. Such traditional thinking considers a curriculum to be a group of subjects which are prescribed in a rigid syllabus and through teacher instructions. What all this means is that teachers should transmit prescribed knowledge to students using an appropriate teaching method (Blenkin et al 1992); teachers are dissociated from the process of making the policy and are restricted to being disseminators of knowledge (Kelly, 2009). It can be argued that curriculum as knowledge is less inclusive and often silences other voices in classrooms.

ii) Curriculum as a process

The weakness in the curriculum as knowledge including rote learning and learning for the test, motivated the drive to find a curriculum model that was more inclusive in terms of linking classroom activities with life out with classrooms. Students' experiences, knowledge, and culture formed the starting point of classroom learning with the intention of producing meaningful knowledge through critical thinking, engagement and improved interest. Stenhouse (1975) argued that this model gave learners a voice in terms of the way they learned through interacting with teachers, the curriculum, and learning material resources. The problem is that examination particularly in "developing countries" is the focus over subject matter, potentially diluting the

quality of learning. Stenhouse argues that pupils could still be examined as they pursued other aspirations like sports, although it could be a challenge especially for low ability students to be examined. Considering how curriculum might be conceptualised as a process is relevant for this study because this type of curriculum model would take account of home experiences and be related to more creative learning strategies, going beyond subjects and including broader learning experiences and individual reflection.

iii) Curriculum as praxis

This theoretical perspective often leads towards a wider perspective of educational practice in society. The focus goes beyond individuals or groups to how both create understandings and practices. According to Grundy (1987) curriculum as praxis incorporates planned activities that prioritise human interactions, values, and attitudes within a teamwork setting. This perspective seemingly embraces critical pedagogy that emphasis production of knowledge through teamworking in solving local challenges. Such a curriculum often respects existing diversity in people towards survival skills. Teachers and students seated together could share experiences and dialogue together in solving a problem. In multicultural classrooms every student is considered to make significant contribution to group objectives.

Curriculum as praxis according to Carr & Kemmis (1986) is a practice that results from a well-informed educator through an emphasis of a contextualised reality paying attention to existing social and historical factors. So, there is a readiness to embrace societal changes and new challenges; however, it assumes that teachers are well trained and experienced to enable them create conditions to democratise learning spaces. In addition, teachers should have more freedom to teach their classes as per children needs using innovative pedagogies. Further, practices and reflection should guide the process of curriculum and not just presenting textual instructions for implementation by practitioners (Yek & Dawn (2006). In this study praxis creates opportunities for individual student and group voices within the teaching and learning context. Student's voice and agency has a role in determining new knowledge and how it is produced.

it can be argued that curriculum theories are useful; however, theories do not actually represent classroom practices (McCutcheon, 1985). So, most teachers tend to ignore theories and seek solution elsewhere to classroom challenges. Curriculum theories also help to understand how a curriculum is conceptualised so that it becomes easier to understand whether and how IK might be incorporated into science education and the best approaches and limitations of education reform.

The account of school science as reflected in the curriculum is an audit of opportunities to integrate ISK into SSK teaching which I now turn to in the next section.

2.5.1.1 The curriculum theories of Dewey and Freire

The Kenyan government seems to have a firm grip on the science curriculum especially through the requirements of the national examination. Education policies and syllabi in place are also intended to address important social issues including inequality, democracy, unity and social justice. In order to envisage a relevant science lesson in a Kenyan rural setting, one that has equal spaces for IK and SSK, it is important to be guided by theories that capitalise on curricular and pedagogical issues. John Dewey's curriculum theory and Freire's critical pedagogy of a critical transformative role of education can be used to consider how science lessons might be organised in different ways. How is the relationship between the teacher and the learner conceptualised?

I) DEWEY AND THE EXPERIENTIAL CURRICULUM

John Dewey is one of the progressive educators who advocated for an education that emphasised learning by doing a pragmatic approach of experiencing reality as perceived by students. Dewey (1938) believed that a student's experiences, culture, and interests are very important factors in producing meaningful knowledge which solves immediate challenges. Dewey (1916: 305) advocated a formal education that was contextual and not one that was based on abstraction, categorisation and rationalised to prepare a student for employment.

Dewey suggested that a curriculum should reflect the local experiences and reality as perceived by the students and should focus on students' historical reality as understood at home which could allow them to connect new knowledge to what they already know. In addition, Dewey argued that prescribed knowledge did not accommodate students' lived experiences as democratic schools should. To Dewey, ideas and interests of learner are the guide towards an active learning and teaching process in classrooms. So, to Dewey, teachers should not be delivery systems for knowledge content and students the consumers or end products. Although education goals should be defined by an economic infrastructure including a focus on education curriculum, it does not mean all focus is on this. Dewey argued that students should learn to be critical thinkers and innovators to improve their survival skills in a complex world.

There are some similarities between African education systems and Dewey's theory of learning in that although traditional education did not have a formal curriculum, the way learning and teaching progressed reflects Dewey's ideas about student active participation, interest and culture in delivering formal curriculum.

On the other hand, it could be argued that the Kenyan science curriculum fails to conform with Dewey's idea of the usefulness of students' experiences in construction of meaningful knowledge. In science lessons, the science syllabus and textbooks are considered paramount in producing knowledge for career and national development rather than educating whole persons for lifelong growth. Practical work and theory together could promote personal growth, community and quality of life.

II) FREIRE - CRITICAL PEDAGOGY

Paulo Freire, a native of Brazil, is well-known 20th century philosopher of education whose practice of critical pedagogy has been adopted on many continents. Most of Freire's thinking and work went to improving life for oppressed people. Freire believed in a critical and transformative role for education where learning should not aim to "integrate" learners into an oppressive system of education but rather change the education system so that learner could become "beings for themselves" (1970: 74). Freire examined

traditional ways of organising learning and described what he saw as a "banking" approach where the teacher "deposits" knowledge on a student's "empty" mind.

Students are assumed to know nothing in a classroom where a teacher is assumed to know everything. The performance of a teacher is often determined by how skilled they are at depositing knowledge in student's mind while the best student is the one who is best at reproducing what has been deposited at exams. Students are pushed to be passive learners in classrooms, so for Freire the education system become a tool of oppression and government who run it are the oppressors. From an African perspective, the 'banking' approach does not seem to acknowledge reality as perceived by Africans nor provide an opportunity to engage with that reality.

Freire (1970) disapproved of a teacher-centred education that perceived students as containers to be filled with knowledge. Teachers are considered to have authority over knowledge which is perceived as worthy knowledge by the powerful elite rather than the cultural knowledge that lived experiences of students which is systematically subordinated. Freire believed that education could either encourage oppression or transform towards freedom. Although Freire did not specifically mention science education, he advocated for learning and teaching approaches that accommodated dialogue or questioning the relationship we have with the natural world. A democratic education often gives all students from diverse backgrounds an opportunity to work together in a team, and in the process could transform the inequalities of their diverse lives. Freire advocated for classrooms where teachers and students are in a dialogue that promotes learning that leads to deeper understanding of how the world around and about really works. In such a classroom a student is continuously facing questions about themselves and their world in a more challenging learning environment that seeks to transform their world. From Freire's perspective, Kenyan science classrooms should be places where Kenyan students are allowed to critically look at their world through their own lens and question it in their own way.

However, Freire's approach to learning is often time-consuming leaving less time to cover all learning material required for exam preparation within the specified time. There is also a problem of adequately trained teachers and time for the teacher's attention for all students. Freire's concern for science lessons could be to impact on students critical thinking skills, so that they could prepared for local and global challenges where capitalism is presenting new global challenges at a regular basis.

In the next section I discuss theories of learning that are relevant to this study with a view to understanding how science in Kenya might be taught better using ISK as part of the experience.

2.5.2 Theories of learning

Some authors (Romiszowski, 2016; Halttunen, 2011) suggest that each learning theory highlights teaching and learning approaches that fit a context in terms of resources, teaching ideas and values which potentially facilitate meaningful learning. Through different teaching styles teachers could make learning more meaningful to students. I will base my discussions on the views of Merriam, Caffarella, & Baumgartner (2007) who believed that students acquire knowledge in many types of settings, formal, informal and culturally based, implying that contextual perspective and alternative knowledge could be valuable in cognitive development. Teachers could adopt learning theories and adapt their practices to suit their student's needs rather than wholly adopting them with potential conflict in context. Hiebert & Grouws (2007: 373) argue that learning theories only provides "facts" about teaching, which, "do not translate directly into theories of teaching", implying that innovative teaching that align with students' need is necessary.

I now discuss behaviourism and constructivism perspectives in relation to learning and teaching that provides a more inclusive learning experiences for science students.

2.5.2.1 Behaviourism theory

The work of Thorndike (1911), Pavlov (1927) and Skinner (1957) resulted in a view of learning called behaviourism, a concept which dominated education for decades. The main idea was that learning was more likely to develop using a scientifically proven theory of stimulus-response and classical and operant

conditioning. Stimulus-response associations, encouraged by consistent positive reinforcement could lead to learners making observable changes in behaviour. Behaviourism is seen in the reinforcement of certain practices using reward and punishment (Lerman, 2014). This curriculum content is often transmitted to learners in a systematic way without learner engagement or interaction. Assessment is often exam-oriented and high stake with no teacher input in terms of contextualising what and how questions are framed or constructed to suit the needs of their students. The pedagogic approaches associated with a behaviourist approach are mainly lecturing, teacher demonstration, class notes, rote learning, memorisation, and repetition. On the other hand, social learning theory seems to challenge behaviourism based on the understanding that children are known to learn through observation (Bandura, 1977) implying that students are knowledge producers. Further, behaviourism is criticised for the narrow nature of the knowledge acquired and its disregard of difference in learning styles of students.

My next discussion is about the principles of constructivism and how they could be adopted and adapted to suit socio-cultural reality, and in the process, I will attempt to find a link between constructivism theories and the interactive nature of a traditional education system.

2.5.2.2 Constructivism theories

As noted earlier, African traditional education has a focus on active learning where parents and children interact in producing knowledge and use practices that solve immediate challenges. In the 20th century, behaviourists' objective approaches to learning were questioned from the perspective of other emerging theories including those of Piaget and Vygotsky (Weegar & Pacis, 2012), who had an alternative view on how knowledge is constructed. From their constructivism perspective, people are capable of interpreting their own experiences and understand their world well (Ertmer & Newby, 2013). So, through the learning process, an individual can produce new knowledge based on prior knowledge (Weegar & Pacis, 2012) rather than acquiring knowledge through teacher-led pedagogy. So, students' lived experiences could be used to actively produce new more meaningful science knowledge in science classrooms which links to how African children actively learn at home. However, a well

skilled teacher is more likely to succeed in creating a classroom environment that helps a student to produce new knowledge within a group.

I) PIAGET'S COGNITIVE CONSTRUCTIVIST THEORY

According to Piaget's (1978) cognitive constructivist perspective, learning can be explained in terms of a two-staged process. In the first stage, some skills and abilities needed for formal education will naturally develop as a child grows. Next is the stage of social interaction which facilitate learning of formal concepts. When their thinking develops, children often learn as they engage with the immediate physical environment. Piaget believed that development preceded learning, implying that children could not learn certain things until they had reached a certain developmental stage, which is how we have ended up with systems which have clear 'steps' and stages in learning. His theory suggests that there are four stages in acquiring knowledge including sensory motor, preoperational, concrete operational and formal operational. This implies that acquiring knowledge is a systematic process which means that a child must acquire knowledge from one stage before proceeding to the next. So, thoughts that a child already stores in their mind could help in solving a new problem, which is important in this study in that schemas could be the foundation of our knowledge about learning science knowledge.

II) VYGOTSKY'S SOCIO-CONSTRUCTIVIST LEARNING THEORY

Vygotsky (1978) suggested that learners actively constructed their own knowledge from other knowledgeable people around them including peers. Learning is an interactive process, which Vygotsky described as the development of higher psychological functions or higher thinking capacity. Through the idea of the zone of proximal development (ZPD) Vygotsky highlighted the connection between social interaction, learning of concepts and development of tools: "we propose that an essential feature of learning is that it creates the zone of proximal development; that is, learning awakens a variety of developmental processes that are able to operate only when the child is interacting with people in his environment and in collaboration with his peers" (Vygostky, 1978: 90). Vygostky argued that students often face harder tasks beyond what they can easily handle by themselves, so this is the zone where learning happens with support from others. Teachers should guide, extend and evaluate children's learning processes to encourage them to engage

more with their learning. Daniel (2008) argues that team working promotes the sharing of thought and supports the development of learning.

Vygotsky (1986) argued that a child acquires psychological tools (language) which are important for learning through social interaction. Vygotsky argued that individuals did not just respond to the natural dictate of their situation but were active participants in producing situations that facilitated the development of knowledge and skills for survival. During this learning process children may develop confidence and take more ownership of their learning. In addition, children may develop creativity including literacy and numeracy knowledge, which is possible when a teacher is flexible in the teaching process.

However, Vygotsky's ideas could be implemented if teachers are trained in teaching in group settings. Although a student's culture is key to promoting active participation in learning and teaching process, the curriculum should be culturally relevant if it is to be integrated into existing mathematics curriculum (Rosa & Orey, 2011) and by extension the science subjects which are academically closely related to mathematics.

In conclusion, taking a constructivist view, Vygotsky suggested that children are not limited by age/stage; successful learning is about having the right support from the educator. Children often learn from others in a social situation and children have significant knowledge and experiences to solve problems at their age; student's experiences, culture, and interest are very important factors in producing meaningful knowledge which solve immediate challenges; and learning and teaching approaches that accommodate dialogue in understanding world around.

The traditional African community approach to problem solving and social constructivist theories of learning demonstrates that children can do better than what is "expected" of them at their age in school system. What children need is support and guidance from teachers including peers as they actively participate and take ownership of their learning. The current educational theory deconstruct the colonial thinking of a "good" western education and a "bad" traditional education. Vygotsky posits the importance of language in

promoting learning, which links to the next section on the Language of Instruction (LOI).

2.6 Language of instruction (LOI)

According to some authors (Fenn & Perullo, 2000) the Kiswahili language became the language of colonial communication in Kenya after British colonisation. Jepkemei (2020) notes that the United Missionary Conference of 1909 held in Kenya decided that mother tongue was to be the language of instruction in primary school in grade one and two while Kiswahili language was used in grade three and four. The aim was to pass on the Christian culture in a language that could be understood. In 1910, through a segregation education policy Kiswahili became the "lingua franca" of the Kenya colony. Therefore, colonial powers were instrumental in influencing the spread of the Kiswahili language in Kenya and Tanzania before independence. Interest in changing to support English as the language of instruction in schools began after independence.

According to Dlodlo (1999), western Europeans with political and economic power determine which language is in use in African education, with the excuse that foreign languages are more scientific compared to African languages. The language issue in Africa which is guided by power of colonial language over indigenous language is complicated, contributing to significant challenges for language and learning in schools. The language policy says one thing while teachers and students often use the language (s) that suits the needs of their learners. In addition, language of instruction in school could determine the "death" of African cultural heritage, intercultural understanding and African nationalism (Woolman, 2001).

After independence, despite Africa countries being multi-lingual, decisions on language policy assumed that national unity could be achieved by retaining colonial languages as culturally neutral means of communication. In Kenya, English as language of instruction was favoured by Kenyans after independence over mother tongue, which was the favoured colonial language of instruction, which appears contradictory (Jepkemei, 2020). English language was assumed to be the key to empowerment and advancement, which seems true for the few who get jobs. However, many African countries have made some effort after

independence to allow the use of African languages particularly in lower primary school.

Policy is not just a school academic matter, but a social and cultural phenomenon which could be linked to local culture for more meaningful learning. Prah (2009) is emphatic that the persistent use of foreign languages as LOI and marginalisation of indigenous languages in African schools is the main contributor to underachievement and poor attainment in students, leading to high dropout rates, poor examination grades and unemployment. It seems no good explanation is provided for this continued practice especially when tiny countries in Europe use their local languages as LOI in schools. Prah (2009) argued that it was impossible to transform majority of African people into speaking and working in foreign languages, thus promoting the idea of empowering Africans through local languages and knowledge contained. Promoting local languages as origin of knowledge construction and duplication is most likely to lead to liberation and modernity.

A study in South Africa by Mavuru & Ramnarain (2020) investigated secondary school science teachers' experiences when utilising learners' home languages in teaching grade 9 students. They found that integrating local languages with the language of instruction made understanding of scientific concepts better and through code-switching students were more confident debating issues. However, teachers had pedagogical challenges in integrating local languages in science lessons. In addition, teachers had limited choice of words in local languages for scientific terminologies so translation from one language to another was a challenge. Finally, the study found that students who got used to learning science using code-switching found English written test a challenge. So, teacher education on how to teach science by integrating local languages could allow students to take more ownership of their learning and achieve learning outcomes in a more confident way.

A study by Mwinsheikhe (2009) conducted in Tanzania secondary schools found that English language as a medium of instruction posed a significant barrier to teaching and learning. In Tanzania, the majority use Kiswahili language in their everyday activities while only a tiny minority could speak the English language.

In the Tanzania study, secondary school biology students (year one and two) and their teachers were interviewed and observed to determine their competence in English language and how they coped with the challenge in the teaching and learning process. The study found that a majority of students and teachers admitted that English language posed a challenge to achieving the set learning intentions. Most teachers and students were incompetent in the use of English language leading to tense moments and little meaningful learning and teaching. Low English language proficiency forced both teachers and students to resort to coping strategies including code-switching, safe talk, and negative reinforcement. When Kiswahili language was used the classrooms were jovial and friendly, difficult concepts were easily understood through dialogue. The student performance in tests conducted demonstrated that using the Kiswahili language reduced inequality between student scores while using English language increased inequality.

In another study involving Haitian and Hispanic children, the learning of science was curtailed by the complications of simultaneously understanding English language (Lee & Fradd, 1999). This study confirmed that when English was used in an ethnically diverse science classroom, pupils whose first language is not English were disadvantaged. In this study the language of instruction was a third language to all students, so they were disadvantaged when unfamiliar language was used as language of science. The Haitian study is relevant in Kenya where English the language of instruction is either second or third language of the students impacting on learning and teaching of science. To ensure fairness in science education, the culture and language of marginalized groups need to be considered. So there is a motivation for the use of a meaningful language of science instruction for home and school environment. According to Fang (2006) the language of science is a major problem in learning science and Henderson and Wellington, (1998) note that even those learners whose first language is English struggle to cope with scientific terminologies and language demands and assumptions made by science teachers and textbooks.

According to Waliaula (2019) the struggle for freedom in Kenya and Tanzania used Kiswahili language to unite indigenous peoples, something that heavily

influenced the elevation of the language as a national language in both countries, implying that development and use of a language is determined by defined interests. In last decade, the African Union endorsed Kiswahili as one of the languages of communication, a source of power. In addition, the East African Community (EAC) have legislated Kiswahili as the official language of the Community. The elevation of the status of Kiswahili in Africa has attracted many African countries and abroad to include it in the education curriculum.

More recently (Khumalo, 2020) South Africa and Zimbabwe added Kiswahili in their primary school curricula for 2020. Kiswahili has displaced many other tribal languages in the same way it happened through colonial powers when they pushed for the spread of Kiswahili in East Africa. According to Waliaula (2019) people of East Africa are competent enough to express themselves verbally and in reading and writing in the Kiswahili language, since it is the only language that adequately stores their knowledge, culture and practices. It is through mother tongue that African people express their thoughts and develop a relationship with the immediate environment, so the culture of people is expressed in mother tongue which is a cultural heritage (Jepkemei, 2020).

According to Feza (2016) referring to mathematics, learning and teaching need to use mother tongue and not a foreign language as LOI to improve understanding of mathematical knowledge; however, the complexity of the language is challenging. Balancing of power between languages improves confidence, self-expression, reasoning in students since all languages are equally scientific. It can be argued that from the research that science learning becomes meaningful when enquiry originates from a child's natural experiences and the teacher's ability to negotiate and align those experiences with science content. The learning process becomes more fascinating when the pupil's language becomes the medium of communication of science experiences and findings. This science learning continues uninhibited by language as the child develops academic language, thus helping to bridge the learning gap initiated by a foreign language. When code-switching is used in science lessons, there is a balancing power between the two languages improving confidence in students as those local languages are also scientific.

Indigenous languages can improve literacy skills outcomes at primary schools especially in "developing countries", with implication for my study in terms of developing scientific literacy. Research was conducted by Piper, et al (2016) in Kenya assessing oral reading fluency and reading comprehension among 2000 children in English, Kiswahili and one of two mother tongues (Dholuo or Gikuyu). Findings showed that many children were more fluent in English language than the other languages; however, their reading comprehension was significantly higher in Kiswahili, Dholuo or Gikuyu than in English. Research by Piper et al (2016) shows that Kenya's national language policy which require the use of mother tongue in lower primary school is very limited in practice.

Piper et al's study implies that when mother tongue is used in science lessons, students can understand much more owing to their respective requisite vocabulary, although their fluency in mother tongue is more challenging than in English language. An area of interest for my study will be whether when English language dominates science textbooks and classroom instructions, students can readily recognise English words. However, students may have limited requisite vocabulary, comprehension and understanding to enable them appropriately to respond to questions.

In the next section I discuss teacher education and professional development and consider how these impact on Kenyan teachers' classroom practice in relation to ISK.

2.7 Initial teacher education and teacher professional development in relation to science education in Africa, particularly in Kenya

2.7.1 Initial teacher education

For decades a lot of work on general education reform and teacher education in Africa has been undertaken (Ogunniyi, 2015), although less research is available in science teacher education (Ogunniyi,1986), a situation which has not changed much today, to my knowledge.

In most Sub Saharan African (SSA) countries, teachers must meet specific minimum requirements to qualify to teach, although some unqualified teachers fill teacher gaps in some countries (Schotgues, 2022). Entry into teacher education programmes varies but one must have a minimum of secondary education to higher education. The teaching degree is either Bachelor of

Education (B.Ed) or Bachelor of Science in education (BSc Ed). Teacher professional course and degree programmes can run concurrently and vary in most African countries from one to three years. Holders of a B.Ed will have studied disciplinary content knowledge, science methods courses, professional education courses and teaching practice (Miheso-O'Connor Khakasa, 2016). There is generally a 40-day period of teaching practice in classrooms under the supervision of experienced teachers and university teachers. It is only when a student meets the minimum qualification standards mainly through standardised tests that a teacher is deemed qualified, although it is not certain the teacher will teach effectively, especially given the complex needs of students in rural areas.

For decades, science teacher education in Africa has experienced several challenges including teacher shortages, inadequate resources, English as language of instruction, education policies, irrelevant science curriculum and examinations (Ogunniyi and Rollnick, 2015; Ogunniyi, 1995, 2000, 2011). For example, an increased overall student roll in most African schools has contributed to teacher shortages, putting pressure on teacher education to train more teachers, including science teachers, impacting on teacher quality (Schotgues, 2022).

Several authors (Shizha, 2007; Nashon, 2005; Blanton et al 2003) argue that teacher education has a significant influence on the way teachers teach and the shaping of teacher attitude towards the teaching of science. Teacher preparation is critical for providing relevant school lessons related to students' lived experiences and especially when combined with support through relevant profession development (discussed later) for teachers in active service. In the 21st century formal education is facing a paradigm shift from the banking concept (Freire, 1972) teaching approaches to student-centred teaching. So, teacher education and professional development should shift from teaching to learning within the constructivist perspective where teacher is a guide, while learners take more ownership of their own learning in achieving learning outcomes. To allow (or not) student voice and agency in achieving science learning outcomes could depend mainly on teacher education.

Ogunniyi & Rollnick (2015) have argued that the trajectory of science teacher education in Africa has been significantly influenced by colonial powers and infrastructure, so the science content and the way it is taught takes a western perspective potentially contributing to disconnecting students' lived experiences, and so most students lack interest.

According to Dembe'le' & Miaro-II, (2013) science teachers should be well prepared to teach using more innovative teaching approaches and more inclusive pedagogy. Research suggests (Westbrook et al 2013) that in addition to being competent in the use of groupwork, familiar local languages and students' social and cultural experiences, teachers need to be competent in the use of IK in the classroom. The use of IK within science teaching is a very specific pedagogical strategy and it cannot be assumed that student teachers will learn this strategy without specific discussion of this during their ITE programme.

Ogunniyi (2015: 65) argues that science teachers need to have adequate science knowledge and knowledge of pedagogy to successfully implement the science curriculum. Science teachers especially in rural areas need to be well trained and confident teaching science lessons using IK, culture, language and lived experiences of the student including developing skills in preparing appropriate lesson plans. For example (Ogunniyi, 2021, 2000) in South Africa science teachers faced serious challenges teaching in multicultural science classrooms where students came from diverse socio-cultural backgrounds. Such teacher challenges exist around the world including Kenya where multicultural classrooms are the norm especially in rural areas. So " border crossing" (Aikenhead & Jegede, 1999) should be facilitated by teachers so that students' lived experiences become the foundation for learning meaningful science knowledge.

Content knowledge is considered a measure of how well a teacher can teach their subject, although it is not a guarantee that a teacher with adequate content knowledge can provide effective instructions to students and better learning outcomes (Schotgues, 2022; Ball, 2000). However, it can be argued that better teacher subject knowledge improves teacher confidence to enter

unfamiliar territory including incorporating indigenous perspectives. Some authors (Rollnick, Bennett, Rhemtula, Dharsey & Ndlovu, 2008) have concerns regarding teacher science content knowledge in SSA, although some countries provide professional development opportunities to upgrade their knowledge. Many teachers in SSA face challenges of content knowledge of their subjects and pedagogical skills for effective instructions and student activities in classrooms.

Teacher education programmes often take on political dimensions, where the government decides the minimum qualification standards for teachers, through a top-down approach delinking it to science curriculum with implications at implementation. According to Ogunniyi and Rollnick (2015) most pre-service teacher preparation programmes in Africa focus on education theories for all teachers and science content and methods for science teachers only. Although, there is no known best practice on how student teachers should be prepared, science knowledge, and the way to teach it, is a concern in preservice course in Africa teacher preparation institutions. Passing a standard test could mean only meeting the minimum requirement of the course (Schotgues, 2022) and not effective teaching.

There are concerns raised in South Africa about the suitability of teaching science content in the science department or taught within the education department where content could be merged with appropriate pedagogy to suit the school curriculum (Ogunniyi and Rollnick, 2015). The implication is that teachers are presented with a science curriculum which is a new experience to them in terms of both science content and pedagogy. It can be argued that pre-service teacher education curriculum in Africa is less linked to science curriculum taught in schools, so there should be a link between teacher education and the science curriculum. Although in most African countries teachers take part in teaching practice as part of their teaching qualification, that period is inadequate in light of the wide gap between the teacher education curriculum and the school science curriculum.

Ogunniyi (2015:75) argues that the science content in most teacher programmes is rigid and “a closed book”. Science content is insulated from questioning,

impacting on the use of ISK. According to Banu and Abdullahi (2014) pre-service teachers learn that active construction of knowledge should be done within the confine of scientific methods. However, a study by Ogunniyi (2004, 2005) in South Africa found that the inclusion of IK in the pre-service teacher preparation could lead to innovative teaching. When teacher education programmes disregard cultural knowledge readily available especially in rural areas, teachers are denied pedagogical skills for incorporating indigenous science in the formal curriculum. Although teachers are advised to use the surrounding environment in classrooms, teachers are often less skilled to actualise diverse ways of understanding natural phenomenon that would involving students' lived experiences in a more complex way.

A research study (Mandikonza, 2019:1) was conducted in a Zimbabwean University to find out if IK and practices could lead to meaningful learning of scientific concepts in a secondary school syllabus among university student teachers during a micro teaching session. It was found that student teachers used innovative teaching pedagogy through every day familiar IK and practices for meaningful learning in a micro teaching session. IK can be an effective resource for meaningful learning especially by skilled teachers.

Ogunniyi (2015) argues that for teachers to provide meaningful science lessons that take note of cultural diversity, pre-service teacher programmes should focus on providing continuing professional development programmes and in-service for serving teachers.

2.7.2 Teacher professional development

Professional development for teachers in service is important in updating their teaching skills to cope with changing student learning needs. In particular, Adedeji and Olaniyan (2011) argue that teacher quality in rural areas of Africa, where the majority of the population live, needs to improve. According to some authors (Gathumbi, Mungai & Hintze, 2013; Hardman et al 2011) teacher education programmes in Kenya have been criticised for producing teachers deficient in teaching skills required meet the learning needs of their students. Teachers often need support to mitigate this skill gap.

Most teachers worldwide including Africa receive professional development support for teacher promotion and to improve instruction in classrooms (Schotgues, 2022). Professional development to improve and monitor learning is often carried out by school inspectors who visit schools to provide support and offer advice. However, professional development opportunities are rare due to lack of teacher trainers, lack of funds and distance, especially for rural schools. Establishing a functional CPD system is a challenge for many African countries and each has their own answers to the problem. For example, Kenya established education resource centres where trainers are located and travel to schools to offer curriculum and pedagogical support (Schotgues, 2022). In Benin professional development courses for secondary school teachers were conducted by subject specialist based on national agenda. In Mozambique teachers received additional instruction including teachers sharing ideas and good practice, which can be argued is a more teacher-centred PD course and beneficial for sharing contextual experiences and potential coping ideas. In Zambia professional development courses were conducted mainly in urban centres. It can be argued that where PD is available it mainly focusses on national curriculum and is limited to urban centres. So, PD in Africa is mainly focused on the national thinking and urban centres, often marginalising the experiences of rural areas and setting, impacting on their usefulness for rural teachers.

The new code for Kenyan teachers (TSC, 2020) makes it compulsory for all teachers to update their teaching skills. According to Teachers Service Commission (TSC) Act, 2012 (TSC, 2020: 6), “every registered teacher (is required) to comply with the teaching standards prescribed and also undertake career progression and professional development programmes”. In-service programmes are usually presented formally or informally, although training opportunities are rare in Kenya (Lowe & Prout, 2019). Available professional development programmes are mainly theoretical with little relevance for classroom practice (Lowe & Prout, 2019). According to Wanzare & Ward (2000) quoted in Lowe & Prout (2019) funding challenges force the Kenyan government to provide professional development opportunities mainly to teachers in urban centres, marginalising many rural teachers. In addition, professional

development programmes often fail to connect with what individual teachers and school context require. According to Namunga & Otunga (2012) CPD programmes that align more with school context and experiences have the potential to change teacher practice. So in-service training could be guided by real classroom setting and practices, based on what works in classroom and is more important for learning and teaching.

Through continuous professional development (CPD) teachers are more likely to continue to provide effective instructions to students and acquire necessary skills and competence to improve learning outcomes (Schotgues, 2022, Hassel, 1999). Professional development for teachers is often used by government through policy to highlight thinking, convey critical ideas and guide teachers towards a prescribed learning goal.

According to Hardman et al (2017), in Kenya and Tanzania CPD is often of low quality and does not always fit the classroom situation. The CPD focuses more on content than methodologies of teaching and does not reach the teachers most in need of in-servicing in the rural areas. When a government decides on CPD course content, then this contributes to the exclusion of teacher's classroom experiences which could be the focus to improve teacher practices and help teacher cope better. Darling-Hammond et al (2009) consider a bottom-up approach where teachers as professionals come up with diverse pedagogical strategies which inform classroom practices. Although Darling-Hammond and others focus on higher education their argument could be extended to secondary school teachers in deciding on what content and how that content is presented. In such a CPD teachers have the opportunity to work together in a team, planning learning instructions, sharing good practices, informing curriculum development by researching the outcomes of some classroom practices, evaluation and professional classroom decisions. Relevant PD support could provide skills to integrate IK in classrooms. According to Hardman et al (2017), some selected Key Resource Teachers (KRTs) who were trained to lead subject related school-based professional development in Kenya were expected to perform their new role together with the usual full teaching timetable, a significant challenge while the headteacher was expected to

provide school-based training and support, over and above other administrative duties.

Hardman et al (2012) argue that CPD which is often available in urban centres and rare in rural areas, is usually unplanned and offers no support at classroom level. In Australia, The Education Queensland, Department of Education, Training and Employment (DETE) delegated to schools the role of implementing education curriculum including professional developments which turned out to be an expensive and time-consuming undertaking (Lowe & Appleton, 2014). Teachers implementing the Australian curriculum received little school support during a time of implementing a new curriculum. Findings in the Australian study resonate with the situation in Kenya where funding of professional development programmes has been a challenge contributing to inadequate training opportunities especially in rural areas where rate of poverty is relatively higher.

In conclusion, research suggests that there are concerns in Kenya and in Africa in general about teachers lacking necessary knowledge and teaching skills to implement an inclusive curriculum and therefore there is a need to intervene to make learning and teaching more interesting to students. Adequate funding for professional development improves opportunities for training for all teachers. Professional development programmes that relate to classroom situations are identified as more effective in changing teacher practice. Effective teacher education programmes provide a key opportunity to prepare teachers with knowledge and instructional skills to make learning and teaching a more enjoyable experience for all students. So besides focusing on better disciplinary science knowledge and pedagogical content knowledge, teacher education programmes could also learn to acknowledge ISK and how to integrate it in science lessons.

2.8 Summary

In conclusion, the cited literature shows that it is what people experience on a daily basis that constitutes knowledge. This knowledge makes sense in societal context where it is constructed and used. So, the existing IK and beliefs of Kenyan people should be examined since they are key to changing the social and economic system of the people. The literature cited in this chapter shows

that there are debates about the role of IK in schools where children of indigenous communities around the world, and particularly in Kenya, learn science. There are ideas put forward that position ISK and SSK as separate while exploring areas where some ISK could supplement SSK in science classrooms. However, lacking from such debates is how curriculum insights could be used to understand the link between ISK and SSK. There is a growing body of writing which reminds us that education is not neutral and should provide an enabling discourse where scientific knowledge is understood as being a product of culture and reflects the social diversity that exist today.

Policy and legislation suggest that the Kenyan government have significant control over science curriculum content and how science lessons are taught. Within a western dominant perspective of education and especially science education, the assumed gap between SSK and IK is reinforced. There is a clear call for social justice and national unity within education policies and initiatives but there is a danger that these remain more rhetorical than real, thus having little effect in closing the gap of the disparities existing in education. With perceived alignment of rural students with ISK while a western perspective aligns with SSK, the gap is likely to persist.

Having examined the existing literature, this study aims to investigate IK, ISK and SSK in terms of the voices of both teachers and students through talking with them and examining in daily classroom practices, to see how far existing policies are having an impact on classrooms. In Chapter 3, I explain the approach which I took in preparing for this research.

Chapter 3: Methodology

3.1 Introduction

In this chapter I establish the main research question (and subsidiary questions), discuss the paradigm in which the study is set, the methods that were used to gather data from students and science teachers and the principles underpinning the data analysis to address the main research question. This study investigates current practice in science teaching, with particular reference to ISK, considering the relationship between policy and practice. Thus, the relationship between teachers' views about what the science curriculum guides them to do and what they do in practice is significant. Student classroom (and school) experiences and practices are also important in this study and appropriate methods for gathering relevant data are vital.

All the sections discussed in this chapter relate to the preparation for addressing the main research question as follows:

"To what extent are indigenous science knowledge (ISK), indigenous languages, culture and pedagogical approaches used in the existing secondary school science curriculum in Laikipia County, and how can this information be used to support the implementation of the new education curriculum reforms".

To enable me to answer this broad research question, I created 6 subsidiary research questions:

1) What education policies are responsible for learning and teaching of secondary school science in Kenya?

2) What is the meaning of "science" and indigenous knowledge (IK) from the perspective of teachers and students?

3) What are the teachers' and students' sources of knowledge?

4) What do teachers and students think of the role of home culture in supporting understanding during science lessons?

5) How do teachers/students and students/students interact with each other in science lessons?

6) What are teachers and students' observations and concerns about integrating IK, indigenous language and culture in science lessons?

According to Morse and Richards (2002) the aim, research questions and methods of study should be interconnected and interrelated giving it a cohesive approach, so the sections in this chapter strive to align with aim of the study.

3.2 Research approach

This study started from an assumption that the process of investigating learning and teaching, including the implementation of a government education policy, involved complicated responsibilities that requires researchers to develop and practise good listening skills to enable them to understand the intricacies involved. This study takes a constructivist research approach that strives to give a voice to and empower participants and allow multiple dimensions of views and approaches within a blurred research paradigm (discussed later).

In the next section, the term 'research paradigm' is defined, followed by discussion of these in relation to this study.

3.3 Research paradigms

Guba (1990: 17) argued that a paradigm is "a basic set of beliefs" that determine what action is taken. These beliefs held by the researcher may determine his/her view of the nature of reality, how and what data is collected

and analysed. The choice of a paradigm usually depends on a researcher's beliefs and the topic under investigation. However, according to Lincoln, Lynham & Guba (2018) the boundary between paradigms is blurred; each has strengths and weaknesses, meaning that no paradigm provides all answers to a problem, and therefore compromises are important. There are two key paradigms in the world of research: the positivist research paradigm and the interpretivist paradigm. Each paradigm has a different ontology, epistemology, methodology and methods. I first define ontology and epistemology and show my own view of each and how these guide my study. In this study, I echo Jackson & Mazzei's (2018:732) view of theory which focuses less on the concepts but more on "how they work, what they do, what they allow, and perhaps what they hide". The implication is that I rigorously engage with theory with an open mind to allow for new ways of thinking.

i) Ontology

According to Schwandt (2007) cited in Lincoln, Lynham & Guba, 2018; Denzin et al (2018) ontology refers to the worldviews, personal opinions or beliefs about reality which a researcher holds as they seek new knowledge through a research process. In social science, ontology acknowledges the existence of multiple realities; this influences epistemology, the choice of the research question(s) and the methodologies. In this study, I take the perspective of multiple realities and that a single reality which is "the truth" does not exist. The implication is that themes are reported showing different perspectives in the findings.

ii) Epistemology

Writers (Lynham & Webb-Johnson, 2008 cited in Lincoln, Lynham & Guba, 2018; Creswell, 2007; Guba & Lincoln, 2005) define epistemology as the way a researcher engages participants in the process of learning about the truth (or not) in the world of the participant, by giving them a voice to talk about their perceived reality.

According to Gray (2009) objectivist epistemology takes the view that there is an objective reality waiting to be discovered, through scientific methods. The positivism perspective, which is associated with objectivism, considers the

social phenomenon to be independent of social factors. A researcher and participants seem not to have a role in knowledge produced or in the understanding of a social reality.

On the other hand, a constructivist/relativist epistemological research approach strives to give a voice to participants in the belief that reality is complex and socially constructed. Finding meaning in a social phenomenon is a product of an active engagement between the researcher and participants. The researcher quotes from participants including collaborating evidence, interacts with participants and becomes an "insider. The researcher takes a subjective role in the interpretation and analysing of collected data.

Before I discuss the methodological approach, I first consider what might be an appropriate paradigm for the study.

3.3.1 The positivism paradigm

A positivism paradigm takes the view that knowledge is a universal, objective truth, and is there waiting to be discovered and verified (Denzin & Lincoln, 2018; Guba & Lincoln, 1994, 2005; Denzin & Lincoln 1994). Knowledge is assumed to originate from somewhere, through direct or indirect observation including the measurement of a phenomenon. Positivists seem not to value the relationship of the researcher to knowledge or participants, suggesting the relationship is independent or dualistic and holding that what is more important is the scientific rigour and validity of findings. Denzin and Lincoln (2018: 98) referring to Lincoln, Lynham and Guba's perspectives, argued that positivists do not ascribe to the important issues of "voice, empowerment or praxis".

According to Svend (2018), in education research, a positivism paradigm usually uses relatively structured interviews in the assumption that predictable and objective knowledge existed ready to be discovered. The set questions are in the same order, often in the form of a questionnaire and are used to give thoughts without expanding on them, possibly leaving out important information. Denzin and Lincoln (2018) warned that positivists are attempting to introduce scientific methods into qualitative research approaches through neoliberal discourses in educational research. Albert Einstein (1915), quoted in Bruno (1987: 6) said that "it is the theory that determines what we can

observe" suggesting that the positivist researcher shapes reality rather than the voice of the participants.

3.3.2 Constructivist/interpretivist paradigm

According to Denzin and Lincoln (2018) the interpretivist paradigm considers the individual's personal subjective experiences of the world in context as what constitutes reality for them. Such a paradigm holds that knowledge is subjective and socially constructed in context allowing for multiple, socially constructed realities to be held by individual participants. In this paradigm, people have beliefs and feelings about their world through which they construct reality at both personal and communal levels. Creswell (1998) suggest that qualitative research can allow the development of a complex understanding of a problem by introducing multiple perspectives and identifying various factors at play and demonstrating a broader reality. There are multiple constructed realities which are equally important, so researchers need to interact with participants in the research process so that they gain more insight about reality from participants' perspectives. A reality seems to be co-constructed when participants attempt to understand their own world and the researcher attempts to understand the nature of participants' objective experiences at the same time.

An interpretivist researcher is expected to go to the field without making judgement, learn through interviewing, attending events and writing about their understanding of people's perspectives on a phenomenon. It is assumed that people are capable of accounting for their thoughts and actions and can explain in clear logical manner which is easily understood by a researcher. However, discerning the multiple meanings provided by participants needs significant time for summarising information; it is also important to include minority meanings as a way of understanding a complex phenomenon.

In the interpretivist paradigm, the subjective experiences of participants and researcher are generally moulded by the historical, social and situational context in which they occur. The researcher will hold certain values and views about a phenomenon, which may pose difficulties trying to understand what people are telling them, particularly if alternative views from the researcher's own views emerge. The interpretivist researcher is expected to be reflexive

about the subjective beliefs and values which they hold and be open about them, and also to take into consideration the specific context where people live and interactions they experience.

Denzin & Lincoln (2018:20) argue that "The constructivist paradigm assumes a relativist ontology (there are multiple realities), a subjectivist epistemology (knower and respondent co-create understandings), and a naturalistic (in the natural world) set of methodological procedures". To arrive at an in-depth insight, a constructivist-interpretive paradigm seem appropriate especially when information provided is subjective.

However, the positivists argue that interpretive paradigm is too subjective, focusing more on the researcher's perspectives and, without a theory as a starting point, is too dependent on the research process to verify findings. In addition, positivists with a focus on "universal truth" do not encourage production of local knowledge without global relevance.

In the next section I outline the rationale for choosing the interpretivist paradigm in this study.

3. 4 The paradigm for this study

This study starts from the assumption, based on my own ontological approach which accepts the existence of multiple realities, that the learning and teaching process is complex and involves, amongst other issues, interpretation of policy wording, hopes of different stakeholders, deliberations and disagreements. Faced with such an environment, I recognise that each person interprets the outcomes, and explanations for such outcomes, differently depending on their individual expectations of the learning and teaching process. It is therefore important to gain deeper insight into people's perspectives and thus it is important to select a fitting research approach that makes it possible to explore such subjective social constructions of reality. This study requires in depth investigation into how teachers and students perceive school science (SS). The following key issues identify why an interpretivist approach is the most appropriate.

3.4.1 Potential for dealing with complex situations

According to Lincoln, Lynham & Guba (2018) an interpretive paradigm researcher is interested in better understanding how people perceive a phenomenon within a social environment. The paradigm emphasis on the complexity of social construction of knowledge, where individuals' past experiences and cultural background influence their own understanding of reality. Teachers and students have different lived experiences based on various factors including ethnicity and location which are likely to influence the way each interprets and make sense of scientific knowledge. Interviews and focus group are important research techniques that are considered appropriate to collect subjective thoughts of participants in this study. The paradigm considers collected data and evidence to be important; however, the constructing of meaning and including interpretation, is of paramount importance as the basis of deeper understanding of the concept under investigation. According to Guba & Lincoln (2005) the understanding of phenomena from the understanding of people's lived experiences helps inform praxis. In this regard (Guba & Lincoln, 2005:195) critical theory consider reality to be a product of social, economic, political, cultural, ethnic and gender values. For this study, participants' perspectives and how they are shaped by societal perspectives are considered important in giving a voice to participants.

3.4.2 Relevance of context

The interpretive approach often produces data in the form of opinions, beliefs, experiences, feelings, thoughts, and responses that take priority over descriptive factual data. An interpretivist paradigm strives to understand participants' perception of reality in their natural setting, their own specific physical and cultural location. Teachers usually possess scientific knowledge which they strive to make relevant to students through student's lived experiences. However, the scientific knowledge is subject to different interpretations based on the specific cultural views of teachers and students. In this study, the paradigm promotes an active interaction with people in charge of policy, teachers and students in their own specific context. The study attempts to investigate how teachers in a rural secondary school in Kenya understand 'scientific knowledge' and then how and whether they utilise indigenous perspectives to make it more relevant to student's lived

experiences. The findings are specific to this context and not expected to be generalised, however, findings may reflect reality in many rural secondary schools in post-colonial sub-Saharan Africa.

From a positivism perspective, a traditional quantitative approach would consider participants' subjective perspectives irrelevant and of no consequence within context. However, such subjective perspectives are important for this study's perspective that people have different perceptions about reality based on their previous experiences and cultural orientation. The focus in this study is to gather insights and experiences of participants which shape reality. Qualitative research methods, which are appropriate to the interpretivist paradigm, are relevant in this study.

I am aware that I have my own perspectives and beliefs which are mostly a product of my past experiences and these may impact on what participants tell me. The danger is that my own experiences could overshadow participants' actual meaning so it is important for me to listen carefully to what they are telling me and not to what I think participants are saying. This also has relevance for the discussion of data analysis (see later in the chapter).

In the next section I discuss the methodology that will shape the research design and answer the research question. I outline qualitative research tools and offer a critique of interview and focus group techniques.

3. 5 Methodological approach

This study is investigating, amongst other issues, the possibility of the integration of indigenous science knowledge (ISK) into school science knowledge (SSK). The relationship between science curriculum guidelines and teacher practices is important in answering the research question. In addition, the potential gap between teachers' views and practices is considered important. ISK is a dynamic and complex phenomenon which is usually rooted into individual subjective experiences, social and cultural context. More familiar language seems important in making sense of ISK in this study. SSK is also a dynamic phenomenon whose aim is to meet certain specific goals set by a dominant force, depending on who the target group is, desired needs and contexts. SSK and science practices are often dependent on the culture and

social context in which they operate. Research suggests (see chapter 2) that a dominant school culture in terms of SSK and pedagogy often marginalises ISK. SSK represents the perspectives of a particular culture with its own language, values and rules. ISK and SSK would be well understood using a research approach that brings the researcher and the researched into a closer engagement in order that more contextual and cultural insights are obtained as a way of understanding the complex ISK and SSK issues.

This study takes a qualitative methodological approach mainly because of my epistemological and ontological position as an interpretivist. Taking a qualitative research approach enables me to understand reality from the participants' perspectives. My constructivist ontological perspectives view participants as individuals who construct their own realities which are usually influenced by the existing social structures. Therefore, my ontological position is guided by my epistemological assumptions which in turn influence the research methodology and choice of research methods.

According to Schwandt (2007) cited in Lincoln, Lynham & Guba (2018) through methodology a researcher can explore the appropriate data collection techniques with a view to understand the meaning of reality in context. A natural setting would allow participants to volunteer insights in a free and secure way and provide data that closely reflect a holistic account of a phenomenon under study. According to Verma et al (1999), qualitative researchers consider human experiences and emotions which are complex social issues, usually depending on many other factors including beliefs, time and context. In qualitative approach, data collection method allows more insight into the participant's own world and there is an increased possibility of getting sensitive data.

Pedroni (2007) argues that the qualitative research approach in educational research has provided more insight into how the local and global forces interact with each other and in the process produce important knowledge about how social and cultural forces influence local practices. With particular focus on the area of my research, O'Hern & Nozaki (2014) argue that although scientific knowledge has been identified as important in national development,

educational research has tended to ignore the study of the perspectives of all stakeholders about SSK and relevant policies. They argue that qualitative research is appropriate for uncovering the existing tension between ISK, the SSK curriculum, education policies and practices in relation to local and global survival.

A qualitative research approach differs from the statistical measurement of external variables (frequency or quality) in a quantitative research approach, where a researcher has very little contact with participants. According to Flick (2013) in a quantitative approach, the researcher would have a minor role to play (if any), because participants act independently. Denzin & Lincoln (2018) stated that qualitative research findings were criticised and labelled unscientific, exploratory or subjective. The main concern was lack of a systematic and scientific method of data collection, a reflection of the previously dominant positivist approach. The most common criticisms (Bryman, 2001), are that the qualitative approach is very subjective, depending too much on researcher's views; it has no approach to inquiry for replication; it cannot be generalised, and it lacks transparency for the actions taken. This qualitative study does not intend to generate a theory or generalise the findings, even within Kenya. This study aims at understanding participants' perceptions about utilising indigenous perspectives in school science classrooms. This study emphasises highlighting participant's experiences as opposed to collecting 'evidence'. Thus, although qualitative research has some disadvantages, the benefits of using a qualitative research approach in answering this particular research question outweigh the disadvantages.

3. 6 Research methods

The discussion of the interpretivist paradigm leads to consideration of methods and a process of data collection which offers flexibility and allows a clear understanding of participants' experiences in their natural environment. Methodological approaches rely on an inductive approach which means that instead of a study being driven by theory, theory develops through the study, because the aim is to understand the complex nature of participants' subjective experiences, where data collection and analysis offer interpretation(s) of phenomena under study. These research techniques include

semi-structured interviews, focus groups and document analysis, which are considered appropriate to collect subjective thoughts of participants in this study.

According to Svend (2018), there are three forms of interviews, relatively structured, relatively unstructured and semi-structured. However, Parker (2005) argues that distinct interview models do not exist because it is not easy to confine what people say within the interview structure. Relatively structured interviews may be used in the positivist paradigm; where it assumes that "true" knowledge exists and can be discovered. Participants using questionnaires or answering several set questions asked in the same order, with minimal interaction with the researcher, may give opinions without thinking too hard about the answers. Unstructured interviews are more about gathering narrated life stories where a few specific questions prompt a longer conversation revealing opinions and attitudes. Semi-structured interviews are useful because they potentially put the respondents at the centre of consideration of their views, which is important for this study and is explained in the next section. However, I briefly discuss language issues in data collection.

Within research and multilingual context, the interviewee should be allowed to use a mixture of languages to express themselves in a more competent way including the use of song and dance. Although the use of a mixture of languages may offer researchers potential solution to the many challenges posed by linguistic challenges within multilingual contexts, it does not solve all challenges.

Translation is very important and is tied to getting very precise understandings of what people mean which is key in this kind of research. According to Warr (2005) it is very important to pay maximum attention to the language used, so that information provided is clearly understood and meaning of reality is represented as intended. Jepkemei (2020) argued that using unfamiliar language hindered free expression of ideas within a group, while familiar language made children more confident. When a second language is used a speaker usually translates the first language into the second language, with potential loss of some information. In this study, discussion involved instances

of translations, rendering it less natural than would be expected in everyday conversation, however clarification was sought if anything was unclear.

During the focus groups and interviews, I made it clear that the research process was not tied to school rules, so students were free to use any language or mixture of languages they were comfortable in expressing their ideas fully. Discussion proceeded mostly through the less understood official English language with interludes of Kiswahili language and mother tongue, all of which are understood by the researcher.

Data collection and description of science experiences in science was done in English. In this study, all participants were encouraged to use a language they were most competent in to describe a concept. When I told participants they were free to use their own local language, I had expected them to use this when describing their science experiences to me. However, a mixture of local and English languages were used which confused me and made me wonder if they had understood me in the first place. Maybe they did not know how to tell me about their experiences in local languages or they had simply ignored me. They were willing to talk about lots of detailed experiences hopping from one language to the other which I did not think would clearly answer my questions. I gave up and allowed them to talk, without caring if the information would add up to answer my questions, only to realise later in data analysis they had in fact provided adequate data, although they had not done what I was expecting. I applied an interpersonal reflexivity which acknowledged and valued participants' unique knowledge and thoughts and respected their impact on the research process. Using researcher reflexivity, I accepted responsibility for my personal opinion and mitigated swaying the outcome of my study to suit me. The action of participants demonstrated a need to fit in the colonial designed "world" by switching from local to using colonial language.

I now discuss research methods for this study.

3.6.1 Semi-structured interview

Svend (2018) suggests that the semi-structured interview is the most popular technique in social science research. According to Brinkmann & Kvale (2015: 6) the semi-structured interview, "is defined as an interview with the purpose of

obtaining descriptions of the life world of the interviewee to interpret the meaning of the described phenomena". Semi-structured interview questions are pre- prepared, open-ended questions already intended to provide some focus but also to allow a free discussion of an issue of interest at length. The researcher should provide a platform during the interview where people can accurately reveal their thoughts about the world.

The interview questions to the interviewee are often flexible allowing at some points a change of interview structure so that a participant may emphasise things they think are more important. Such an approach is important in this study because it allows participants to "put together (their) own personal reality" (Guba & Lincoln, 1985: 73) through the issues they choose to give priority to, in their responses. According to Svend (2018) the interviewer can make use of non-verbal information including facial expressions to tell him/her something about participants' thoughts. This information can be used to guide the interviewer through a face-to-face interview, allowing him/her to spot discomfort (or comfort) and take appropriate action to reduce harm. The researcher needs to be aware of potential harm to participants and know how to reduce it, especially when participants may give too much information, some of it personal or contradicting the official position. The researcher may decide to abandon a specific topic under discussion or let them withdraw if high emotion sets in. The school emotional support mechanisms may be called in if needed.

Note-taking during the interview is important to ensure more insight is noted for instance body language and remembered, which is important during the data analysis stage. However, in some cases note taking during interview becomes problematic as the researcher may not be able to write down all important details. Some participants may be wary of notetaking as this deviate from their experience of a "normal" conversation. Sound recording of interview is important as an accurate account of what was said and how. According to Brymen (2004), sound recording in qualitative interview improves retention of all information possible, which is important for this study. Note-taking and recorded data may act as a fall back if a potential participant is uncomfortable with either.

In a semi-structured interview like in this study, which involves additional questions being asked in order to probe further or tease out additional information, there is a danger that participants may feel pressured to provide more information. However, the benefits derived are important for the study because the alternative of a structured interview would not offer the opportunity to clarify some unclear answers given or negotiation on questions.

Svend (2018) argued that researchers need to have adequate skills to interpret participants' experiences and practices through information acquired during the interviews. Flexibility often allows the cross checking of information provided at various point of interview. The participant may seek clarification of unclear questions, and the interviewer may also seek clarification of answers provided. Interviews are modified and made more flexible by changing the kind of questions and how they are asked. Parker (2005) suggests that interviewers should actively involve participants by creating a good relationship so that participants can freely give more information.

According to Paradiso de Sayu and Chanmugam (2016) it is important for the interviewer to use active listening skills (paraphrasing, clarifying questions, asking the meaning of words or content) so that more insight information is acquired through the resulting expanded responses. Paradiso de Sayu and Chanmugam (2016) argued that the same questions may be asked in different ways across interviews, which is important for data analysis focussed on determining participant thoughts about empowerment. The researcher will practice active listening, rephrase the questions if need arises so that it is clear to interviewee and seek clarification on unclear answers and words used. The study will also observe cultural protocol as a way of building a trusting relationship which is important in quality data collection.

When the interviewer directs and controls the direction of interview through questioning, it reflects the potentially exploitative nature of interviewing. To reduce the danger of exploiting participants this study emphasises the importance of cultural sensitivities and complying with ethical requirements when dealing with participants. Observing Indigenous protocol and reciprocity are important for good relationship based on power balance between

researcher and interviewee in this study. Working collaboratively with participants and discussing the interview process, suitable location and time for the interview is important, because understanding of local culture requires a researcher to respect social constructs including the concept of voice, silence and speaking. According to Patton (2002) listening to how people speak is important in revealing their feelings, experiences and thoughts. In this study, body language, silence, the level of voice among others forms of communication will be important in data collection.

Having planned an interview guide, aiming for some consistency, as suggested by Krauss, et al (2009), I conducted a pilot interview with an experienced science teacher working in Scotland. This allowed me to adjust the interview guide accordingly as advised by Harding (2013) before carrying out the interviews in Kenya. This interview was conducted in the teacher's house. A consent form was signed and the interview was recorded on a digital recorder. The interview took about 40 minutes. I had arranged to ask the questions as they appeared on paper; however, I ended up following the flow of discussion instead, since some questions were being addressed within the answers to others. I learned to be prepared to be more flexible, to encourage the flow of conversation and to probe key areas which arose from the answers.

3.6.2 Focus group

According to some researchers (Kamberelis et al, 2018; Kamberelis and Dimitriads, 2013) focus groups are becoming increasingly popular in social science because of their flexibility and opportunities for the sharing of power between participants and researcher as participants reveal their experiences and practices. Focus groups are generally formed from participants who share a lived experience and are flexible in the way a specific question is asked and responded to by individuals in the group. Kamberelis et al (2018) states that researchers need to be very alert around what goes on in a focus group and seek clarifications so that important information is not missed. Sensitive issues are identified through the taking of notes and responding to "subtexts" and "breakdowns" (Kamberelis et al 2018:705). So, during focus group discussion, students will sometimes make some comments that helps explore background information or clarify issues including confirming something. In other cases,

how the group reacts to an issue could help better understand the issue, process and patterns.

Such comments may provide knowledge about bigger problems. As a secondary school science teacher myself for about two decades, the focus group approach mirrors my teaching practice of interacting with students during the learning process where listening and clarification of ideas is important as students' own and group views are used to understand how meaning is created about a phenomenon.

This study utilised a focus group for students from each level of a secondary school, because this provided a wider knowledge base within a familiar environment where group members could interact and share experiences in relation to a phenomenon. This study recognises that young people have a central role to play in school science which is largely neglected and seeks to empower them at least to some extent through focus group discussion. Students were chosen by the researcher with the science teachers' help across all levels of secondary school representing gender, age, ethnicity and experiences. According to Kamberelis et al (2018), mixed groups usually approach discussions in a dynamic way, through the way they interact, negotiate and understand each other resulting in very important and rich data. On the other hand, I am aware that there is the potential for some voices not to be heard because of that very mixture of age and gender differences. However, because of the small number of students involved I decided to utilise the indigenous custom of relatedness where the community need is more important than individual and hoped that the older students would ensure younger students have an opportunity to speak, irrespective of gender. Participants may influence each other in focus groups, so that the views are shaped by what the others are saying, while some quiet participants may be overshadowed and dominated by extroverts, losing important views. It was important for this study to mediate such possibilities and encourage the less confident to share their views through a rotational sharing basis so that all have an opportunity of contributing if they want. Observation of students' cultural protocol and reciprocity helps build a trusting relationship that balances power between students and researcher. Traditional greetings and sharing of food may help in building relationships.

However, schools as a formal institution with hierarchy of power relationships have the potential to prevent students from speaking openly. I attempted to reduce this by reassuring students of the confidentiality of what they said and conducting the discussion in a less formal way that included using languages they understand well and are comfortable with. I informed students that I was not there as a teacher, but as someone who wanted to listen to their lived experiences and give them a voice in learning and teaching of SSK. The students were both orally and through the participant information sheet reminded about their responsibility to keep group information confidential and not to disclose any information without consultation with the group members.

In the next section I discuss how I went about examining and analysing science documents.

3.6.3 Official science documents

Different documents give policy direction in relation to the implementation of the science curriculum sometimes in a less interactive way when compared to other forms of qualitative data like interviews and focus groups. It was my expectation that the documents I found would provide information about opportunities for the inclusion (or not) of ISK, languages and culture in science classrooms and in general school system in Kenya. The types of documents utilised were also determined by the research questions and circumstances of the study. According to Morse (1994) data from available documentary resources potentially provide answers to at least some elements of the research questions.

Available documents were scrutinised to determine the detailed government information on education policy and on the aims and objectives in the learning and teaching of secondary school science in Kenya. I was aware that some documents could be out of date, so checked with participants that they were current while gathering data. The policy documents which were most useful in this study were the science curriculum documents (specifically the science syllabus), official science textbooks, teacher planned documents (schemes of work and lesson plans) and history of the school policy document. The science curriculum documents, lesson plans, schemes of work, official textbooks, and laboratory equipment show the official science knowledge and pedagogical

approaches that teachers must use to implement the Kenyan science curriculum, which could give some insight into teacher practices.

The choice of records and documents that I made turned out to be rich sources of qualitative data for my study. According to Paradiso de Sayu et al (2016), documents provide holistic background information about a research issue in a broader context, especially where interviews are utilised in collecting data. Brymen (2004) argued that secondary documents are important because they are not produced in response to a research study, so are impartial in the information they contain. Bogdan & Bilklen (2003) suggest that documents are mainly used to provide secondary supplementary data in qualitative research.

However, According to Inokuchi & Nozaki, (2010) documents have been used as a source of primary data in naturalistic research including cultural studies. Document analysis provides comprehensive original policy information which may not be easily available from busy teachers and head teachers. However, Brymen (2004) argues that most documents are not objective and cannot be viewed as a true reflection of such institutions. Further, the information contained in government documents cannot be considered as a reflection of what happens in practice. According to Van de Ven and Johnson (2006) practitioners face challenges of adopting research findings in practice, mainly because the form of knowledge cannot be easily practiced in context of practice. When preparing for data collection I recognised that it would be interesting to see how information in official documents and teacher interviews is reflected (or not) in classroom practice. This study takes a critical approach in revealing the disconnect when analysing the written text.

In this study the inclusion of the science syllabus and teacher and student textbooks were necessary to supplement the data I gathered through focus group and interviews, two research methods I considered effective in collecting subjective thoughts of participants to answer the main research question. Official documents provided evidence for my study showing the extent to which indigenous knowledge and languages were expected to be used in classrooms before this study. Official documents also highlighted key information on government policy, aims and objectives in secondary school science classrooms

in Kenya. Textbooks were mainly used in this study to understand how they contributed to learning and teaching rather than determining the science content.

In summary, official government and school documents provide information about what is expected in the policy; the textbooks may contain appropriate materials, or not, but whether or not they have been used will be entirely up to the teachers. This study aimed to investigate theory in documents and what happens in practice.

3.6.4 Auto-ethnography

Auto-ethnography as a qualitative research method gives researchers an opportunity to include their personal experiences in an attempt to have a broader understanding of a specific phenomenon in the context of a scientific subject (Ellis & Bochner, 1996).

According to Cann & DeMeulenaere, (2012) the way a researcher writes often encourages emotional expressions and personal and subjective views. It can be argued that the use of personalised writing in autoethnography which is often in first person voice encourages a rich description of cultural norms, events and people. Autoethnography as a research method often acknowledges the complex relationship between a person and culture and allows a non-conventional form of research and expression (Wall, 2006), which allows the researcher's life experiences to be my outward voice in the research. In this study I have included my personal experiences to express my voice. Wall (2006) suggests that through autoethnography, a researcher may challenge a dominant perspective through sharing of subjective personal experiences which may contribute to a deeper understanding of the social world around us and provide an opportunity of reflection on what could be different after listening to the other. Many researchers take the perspective that a study can be neutral and objective an assumption which is often questionable, a position shared by this study, that objective knowledge does not exist.

Criticisms of autoethnography include that it might privilege the dominant voice of those who assume to determine what is legitimate knowledge and how to arrive at it. According to Alvesson (2003) autoethnography emphasises more the

life experiences of the researcher, than those of participants. In addition, Poerwandari (2021) argues that autoethnography often takes the perspective and worldview of people in power. Although autoethnography considers the researcher's experience as data to broaden understanding of a topic under investigation, analysis of data could potentially focus more on the researcher's, life experiences narrowing its conclusions. However, Bochner and Ellis (1996:24) disagree arguing that, "If culture circulates through all of us, how can autoethnography be free of connection to a world beyond the self?" Writing about personal life experiences, thoughts and feelings takes away the privacy of a researcher who is expected to be honest and willing to tell it all (Mariza, 2013). Consequently, many ethical issues arise beyond the initial comprehension of the researcher, classifying autoethnography as a complicated research method.

In autoethnography, where both researcher and participants are subject of research, a researcher may want to give an account that he/she wants to be the determinant to the conclusion (Poerwandari (2021). In the process private information that a researcher provides for broader understanding also becomes public knowledge, something that may not have been intended, but necessary. Therefore, a researcher telling a story could intentionally (on not) make a biased conclusion. In this study I am aware of the position of power I hold as a researcher and work hard to avoid privileging my own experiences over those of participants. I have decided to include autoethnography method so that my rich background in the ISK in Kenya and my personal experiences can strengthen (or not) emerging themes and potentially arrive at new ways of thinking and feeling.

There is an ongoing debate about the possibility of decolonising research paradigms within colonial Eurocentric paradigms (e.g. Chalmers, 2017). According to Held (2019), "…academia has almost exclusively been focusing on Western paradigms and approaches to research… This manifestation of ontological oppression is a result of Western science being exported around the globe from Europe alongside imperialistic and colonial attitudes". As an African researcher I acknowledge and resist the epistemic oppression supported by colonial history and knowledge systems. In this study, I have consciously taken a

reflexive engagement of my assumptions and interpretations, towards prioritising open dialog as way of sharing power and privilege, in achieving interesting science lessons for all learners in this study. Participants have potential safe opportunities to discuss issues of concern to them in an honest environment. This study is in solidarity with oppressed science students in their everyday struggle against a dominant SSK towards science lessons for all.

In the next section I look at the study site to understand the social and cultural context under which teachers and students are exposed to as they interacted in science lessons. This is important for data analysis and interpretation later.

3. 7 Research site

This research was conducted in one Kenyan secondary school which is categorised as a district Day school by the Ministry of Education. It will be referred to as X Secondary School. Another head teacher from a neighbouring school was identified to give a broader view on policy implementation. My justification of school choice is informed by Denzin and Lincoln (1994: 202), "They [researchers] seek out groups, settings and individuals where... the processes being studied are most likely to occur". Most rural schools in Kenya are located in areas where the survival of communities is tied to IK and local languages, so the choice of a rural school was based on this understanding.

X Secondary School is a day school which enrols both boys and girls. The school, like many others in Laikipia county, was a product of a local community initiative that was meant to make secondary school education more accessible to community children who walked long distances to surrounding schools (X Secondary School, 2019). The initiative was mooted and agreed upon by local primary school stakeholders in 2010 to start a secondary school. The community contributed resources to start the school in 2011, and in February the same year, 18 students joined form one (first year in Scotland) class and four more students later in the year. The local councillor assisted to get well-wishers who made mainly financial contributions. For example, Rumuruti County Council made significant financial contributions (X Secondary School, 2019). In 2012 the school hired the services of a matron. In June 2012 fund raising was organised to pay teacher salaries. In the same month the Ministry of Education officially registered the school and posted the first principal, following by appointment

of board of management which replaced the initial committee which run the school. A Parent Teacher Association (PTA) was appointed. In late 2012, the Teacher Service Commission (TSC) appointed the first trained teacher followed shortly by the appointment of a deputy headteacher. The school would later get money to purchase more land from Community Development Fund (CDF) which funds community projects.

In 2014 the first English teacher was appointed by TSC and sent to the school. The school expanded and enrolled the first double stream. The first form four students sat for national examination in the same year and achieved a mean score of 4.1 against the highest mean of 9.0 (X Secondary School, 2019). The school participates in annual music festivals where students participate to show their skills in traditional cultural dances, songs and drama, which according to the headteacher the school did very well. By 2019 there were 267 students enrolled (137 boys and 132 girls) with 7 teachers appointed by the government. Most science teachers are posted by Teacher Service Commission and few employed by the school. At the time of visiting the school a range of subjects were taught in the school curriculum with science subjects a combination of Biology, Chemistry, Physics, Mathematics and Agriculture. The school is small with a total of 17 teachers including headteacher and his deputy on the staff.

At the time of visiting, although the school comprised a library, classrooms, staffroom, school office, science laboratories, the school lacked adequate facilities (Table 3.1). For example, there was a small makeshift library structure made of iron sheets in which was made of rough ground and had a table and four plastic chairs. There were dusty shelves with a few old torn textbooks and old newspapers on them. I often used this room for preparation, but it was rarely used by students during my time there. Water and sanitation were poor, and they had no electricity.

TABLE 3.1 CHALLENGES IN THE SCHOOL

Education resource	**Available resources**	**Resources required**
Tuition		
Science laboratories	1 (incomplete)	1
Science equipment	Limited	Severe shortage
Classroom	8	11
Library	0	1
Welfare		
Kitchen	Temporary	1
Sanitation		
Boys	3	3
Girls	3	3
Administration		
Principal's office	Temporary	1

3.8 Plan for data collection

Here I summarise how data was collected in this study. Table 3.2 is constructed in relation to my own data collection, drawing on the work of Kamberelis et al 2018; Svend, 2018; Brymen, 2004.

TABLE 3.2 AN EXPLANATION OF DATA COLLECTION

Technique	**Main feature**	**Why is it important?**	**What are the drawbacks?**	**Why is it the good choice for this study**?
Face-to-face semi-structured Interviews	There are 4 science teachers and head teachers(s) in a one-to-one interview in private.	Deeper insight information is provided, and sometimes divergent information emerges which is important for broader understanding.	The researcher takes the role of deciding and designing research question and interview questions.	More understandings and comprehensive data.
Focus group discussion	There are 8 students involved.	The data provided is cross-checked for accuracy/ clarification. Adequate data is collected within a short time, and there is group security so that students air their views freely.	Sensitive and confidential information may be held back because of fear for information leaking. Extroverts may dominate, and introverts may be overshadowed.	Is useful with students, because they often like working in groups where they feel more secure that in one-to-one interview where they may feel intimidated.
Documentary analysis	Government documents (policies, textbooks),	It provides information that some busy participants who are also policy	Some information may be out of date, unavailable in	Provides ground for understanding reality as

	news paper cutting reports, school policies.	implementers, cannot provide or cannot easily remember comprehensive original policy information.	printed forms or missing.	constructed by participants.

The following table outlines sources of data and related issues that impact on data collection that link to the 6 minor research questions.

TABLE 3.3 LINKING THE SOURCES OF DATA TO THE 5 MINOR RESEARCH QUESTIONS. Adapted from Khupe and Keane (2017).

Edited subsidiary research question.	**How is data collected?**	**What are the challenges?**	**How are challenges reduced in this study?**
1.What is the meaning of "science"?	Interview and focus group.	Misunderstanding of the questions by participants. Language barriers.	Rephrase the question. Allow language of participant's choice.
2. What is teachers' source of knowledge?	Interview, science syllabus.	Language barriers. Fear associated with possible leak of sensitive information to "others".	Allow language of participant's choice.
3. What are teachers and student's	Interview and focus group.	Developing, maintaining and ending relationships is challenging.	Reassuring participants that no one would know what

classroom experiences?	Science syllabus.	Language barriers. Fear associated with possible leak of sensitive information to "others". Language barriers.	they said except me and my supervisors. Allow language of participant's choice.
4. How does the inclusion of student's home experiences affect learning outcome?	Interview and focus group.	Developing, maintaining and ending relationships is challenging. Language barriers. Fear associated with possible leak of sensitive information to "others". Language barriers.	Relationship: Bringing a gift and sharing food with the interviewee and providing a ritual moment for requesting spiritual permission prior, during and after the interview/focus group. Allow language of participant's choice.
5. What education policies mandate or prevent the incorporation of IK/ ISK into the school's practices?	Interview and syllabus.	Developing, maintaining and ending relationships is challenging.	Relationship: Bringing a gift and sharing food with the interviewee and providing a ritual moment for requesting spiritual permission prior, during and after the interview/focus group.
6. What are teachers and students' experiences	Interview and focus group.	Developing, maintaining and ending relationships is challenging.	Relationship: Bringing a gift and sharing food with the interviewee and providing a ritual

and fears about integrating IK in science lessons?		Language barriers. Fear associated with possible leak of sensitive information to "others". Language barriers.	moment for requesting spiritual permission prior, during and after the interview/focus group. Allow language of participant's choice.

The following pseudonyms are used, titles for teachers are omitted to mask identity.

- Mr. Njoroh- headteacher, Jebi secondary school.
- Mr. Bute-headteacher neighbouring Makenji secondary school.
- Science teachers are G., ND., W., K., B., KA.

3.8.1 Selection of participants

Participants (teachers/head teachers and students) were purposively selected. Lincoln, Lynham and Guba, (2018) argued that most qualitative researchers utilise the purposive sampling method and not random sampling because they know the most resourceful people where required data is most likely to be found. In this study, the number of science teachers in the school was small to select only some and so all were asked to participate, while teachers selected the most resourceful participant students to their knowledge. All the teachers who participated were Kenyan university graduates in education and all were educated in Kenyan secondary schools. The selection of student participants through teachers may lead to a sense of coercion on students to participate (Miller & Kreiner, 2008), or of students wanting to please their teacher or the researcher, making the research appear a less voluntary activity. However, the researcher and teachers worked together, and everyone was reminded about the ethical requirements of free participation. For this study the criteria for participants were:

Teachers.

- Trained science teacher and actively teaching.
- Over 18 years of age.

Head teacher(s)/deputy head teacher(s)

- Over 18 years of age.
- Heading the study school or a local secondary school.

Students.

- Science students from year one to four.
- Be between 11-17 years old.

The small sample size in this study had various age ranges, gender and experiences (table 3.4 and 3.5 below), which was helpful as this could provide more insight into the experiences and practices of school science. The sample is not intended to be representative of the population but only to produce subjective insights and knowledge in understanding the phenomenon studied. I recognised that a relatively small sample would make this study more feasible with manageable transcripts. Further, a small sample aligns well with the methodological approach in supporting the interpretivist argument, which disagrees with positivist stance that implies that, greater objectivity and reliability is obtained with a large sample. In the event, this study collected data from six science classroom teachers, eight students and two head teachers, both of whom had good experience in the science curriculum and policy.

TABLE 3.4 THE AGE RANGE, EDUCATION AND TEACHING EXPERIENCE OF TEACHERS

Teacher name (pseudonym)	Age range	Education level attained	Subject Taught	Teaching Experience (years)	Terms of service
KA	25-30	Bachelor of Education	Chemistry/ mathematics.	4	Temporary
B	25-30	Bachelor of Education	Maths/Physics	5	Permanent
ND	25-30	Bachelor of Education	Biology/Chemistry	4	Permanent
W	40-45	Bachelor of Education	Biology/Chemistry	14	Permanent
G	45-50	Bachelor of Education	Maths/Physics	21	Permanent
K	50-55	Bachelor of Education	Biology/Agriculture	28	Permanent
Njoroh H/T	55-60	Diploma in Education	Kiswahili	31	Permanent
Bute H/T	55-60	Bachelor of Education	Kiswahili	32	Permanent

The number of female teachers was significantly lower than male, however in order to maintain anonymity within a small group of participants I decided not to identify their gender. The gender differential in teaching experiences was also significant (4 to 5 years for female; 4 to 28 years for male). The data implies another reality on rural secondary school science teaching force, that

female teachers are underrepresented. It is not obvious why males were more overrepresented than females, but it is worth asking what happens to female science students as they progress along the education system. This is an issue that is not the focus of this study and is not explored further but could be considered in future.

TABLE 3.5 THE STUDENT AGE, GENDER, AND SCHOOL SCIENCE LEVEL

Pseudonyms	Expected age at school level	Participant School level	Participant age (years)	Gender-Male (M)/Female (F)
MW	14	1	14	M
BM	14	1	14	F
NW	15	2	15	M
EM	15	2	16	F
AG	16	3	17	F
SE	16	3	17	M
SM	17	4	17	F
MN	17	4	17	F

The expected ages varied with actual age in some levels, explained mainly by a common practice in Kenyan schools where a student may repeat a class or start school later at primary school. My ethical clearance permitted me to work with this group of young people aged 14-17 years.

In the next section, I will discuss the researcher and participants interactions within the research process and the consequences of this interaction to the participants.

3.8.2 Ethical conduct of research

Ethical considerations play a key role in the conduct of all research involving human subjects. According to Holloway & Biley (2011) emphasis on ethical consideration is the key in producing trustworthy research. Ethical approval (Appendix A) for this study was granted by Glasgow university ethical committee which is the body entrusted to approve a research plan if they believe it is rigorously ethical. Moule & Hek (2010) argued that ethical

committees are bound by the key ethical features of justice, fidelity, respect and beneficence. My research plan adhered to such principles and was approved.

Potential participants were made aware through University of Glasgow research ethics documents about the specific process of the interview and focus group discussion, including the time each would take. Besides the document information, continuous dialogue would make participants more comfortable, which is important for participants to take ownership of the research process and outcome.

I made my research permit application to the Kenya National Science Council towards end of March 2019, which was processed quickly through an official letter. I proceeded to the Laikipia County director of education who with little delay wrote another letter (Appendix B) authorising me to conduct the research in my chosen school in Laikipia county.

Although the University ethical research approval and government letters were significant steps towards achieving my research goals, the participants did not have a duty to work with me. Closely working with the head teacher who is a respected and accepted person in the school community facilitated links for me to teachers and students. My family connection in the area also improved my acceptability. The introduction to the teachers and students was important because it implies that I was trusted by the highest office which in a way makes it easier for teachers and students to work with me, although this could potentially have made some teachers and students feel that they had to participate to please the headteacher or myself. The signing of a consent form implies a participant has allowed me into their "world".

The signing of documents should also signify a willingness to participate. However, I am aware that most rural culture in post-colonial Africa are oral in nature, meaning verbal agreements reached are important, followed by document signing. I also had a duty to making sure teachers did not feel "invaded while doing their jobs" and the students were not being unduly influenced. Teachers' advice on time and place was sought in arranging focus groups with students to avoid interrupting normal school programmes and

demonstrate the researcher's willingness to fit into the researched daily activities (Briggs & Sharp, 2004). Similarly, research in its very nature creates a power imbalance between the participants and researcher especially in previously colonised peoples. It is advisable for a researcher to mainly act as a facilitator and one who makes effort to power balance (Goebel, 1998), especially where people are the subject. Teachers and students needed to be comfortable with a common understanding that the aim of our conversation was on integration of indigenous perspectives into the school science.

Being a PhD student and working abroad especially in Europe was perceived by participants as a source of power in the local context. I was aware that I was regarded as one wielding "more" power than participants. This made me re-examine my interaction with participants in a continuous manner. For example, my presence was always treated with "more" respect and honour to an extent that at times participants wanted to reschedule school times to align with mine. I reminded them that the emphasis was for me to fit in and not the other way round. School and family are institutions representing power, where teachers had relatively "more" power in school while parents wielded "more" power at home. This power dynamic could present a challenge for student participants who wanted to refuse to participate. However, I always tried to remind all participants about their right to withdraw from the study at any time without notice and no penalty.

As I reflect on this study, I am aware of my relationship with the topic as a science teacher in Kenya and before that as a science pupil in a Kenyan secondary school. I feel I am an insider to the experiences, although I recognised that I could not assume that my experiences were the same as those of the participants. I appreciated that a large country like Kenya had many people, of different ethnic groups and experiences. Therefore, my personal experiences of issues related to the topic may influence my understanding of Indigenous Science Knowledge and Western Science Knowledge, about which I was cautious. However, the aim of this study is clear and is to question the domination of a single "story" identified in my literature review (chapter two) that western science knowledge was seen to be the dominant knowledge over Indigenous science knowledge in the school natural science curriculum.

According to Rouney (2005) interviews are important especially for insider researchers because it allows them to listen to participants' experiences. I am constantly aware of my own experiences; however, the focus must be on participant experiences. As an insider, I was aware that with a shared background I would probably find it fairly easy to interact with participants and in the process, they might open up to me more than to an outsider interviewer. Trust might be more easily established with me compared to an outsider interviewer. I also planned to engage genuinely with my participants' experiences which Seidman (2013) suggested is important during the conduct of an interview. I was aware of the information provided through body language and the way the language is used. However, a participant might assume that I know what they mean without saying it or explaining and I was aware that I would need to check for meaning regularly. There is an ethical responsibility to represent the information gathered in a way which does not create 'meanings' which are not 'correct'. This study takes the views of participants seriously and offers them flexibility to follow their own thoughts during semi-structured interviews and focus group, which in a way of demonstrating accountability (McKinnon, 2006).

Kovash (2018) argued that ethical research is important to reassure and regain confidence and trust of formerly colonised (vulnerable) communities so that their voice is heard in the research process. This study considered participant teachers and especially participant students to be marginalised within science education through silence and wanted to give them a voice in focus group. Familiar ISK and language was encouraged in the focus group to support participants to move from silence to speech.

This research involved gathering data from young people around their experiences of science learning. Informed consent was given by both young people and their parents/carers and they were also made aware of their right to withdraw at any time.

Students are a particularly vulnerable group. While the nature of this study is unlikely to cause any physical harm, I was aware that when students take part in research, there could be some anxiety created or the research activity could

exacerbate existing stress, for example, if science is a subject which they do not enjoy or if questions about school or home experiences cause embarrassment or trigger troubling memories or thoughts. In addition, ethical vulnerability may be heightened by cultural views on elders and authority figures, of whom I might be seen as one. I attempted to mitigate this by involving participant students in the decision-making process including appropriate time of focus group meeting. They may also be concerned about being identified in the study or about their participation affecting their relationship with teachers. Such potential risk was reduced by reassuring the young people about the procedures around confidentiality, both when collecting data and when presenting it in later written reports. According to Kimmel (1988) there should be no clue left in the data that could uncover a participant's identity. Further Kvale (1996) argued that the name of the participant should be left out during the analysis of findings to protect privacy of participants. Students were made aware of a relevant staff member who could be contacted if they wished to discuss any areas of worry or concern, and the researcher would have referred any pupil to this person if it appeared that there was some distress which was not necessarily communicated overtly by the student.

In summary it is at the methodological level that care needs to be taken so that good relationships and ethical conduct of research is practiced. In the next section I discuss some of the key philosophical and practical issues related to data analysis.

3.8.3 Actual conduct of data collection

The study school is a relatively small Kenyan school with few teachers to choose from. Being new to the school and not knowing learners well, I had little choice in the selection of participants so I made contact and requested all science teachers to participate. For students, teachers played a significant role in "purposeful selection" of students so all school levels and backgrounds were represented.

During my first day in the study school I held a meeting in the headteacher's office where I explained to the headteacher the purpose of the study, how it was to be conducted, what contributions I was hoping to get from participants

and how the findings would be used. I explained that I hoped that the study would benefit all participants and the community and that it was unlikely to cause any harm to participants. I encouraged him to ask any questions or add to what I had said. He confirmed his willingness to participate and signed the required information and consent forms. Frankfort-Nachmias and Nachmias (2008) argued that through the informed consent form, participants can have a clear understanding of the aim of the study including the research process. However, Eisner (1991) had argued that the overall practical usefulness of the informed consent in practice is debatable; a problem that Mueller and Instone, (2008) said needed dialogue during the study. The information sheet clearly informed the participants about the aim and objectives, including the data collection techniques, and was repeated orally when appropriate, during the duration of the research process.

I made effort to provide appropriate and sufficient information about this study, although that could affect his response to interview setting. I wanted him to understand that there were no right or wrong answers in my study, and that view was clearly stated on the information sheet. I repeated the process with each teacher. Students signed the plain language statement information sheet for students (appendix C) and parents/ guardian signed the consent forms on their behalf. Parents also signed the parent information sheet.

I also endeavoured to ensure confidentiality and anonymity to avoid potential embarrassment or harm to participants. I made it clear this was a voluntary task that one could exit at any time without notice and with no consequences. Only willing students and teachers took part since a good relationship between me and participant could improve the success of the research process, which was key to data collection in this study. My research topic and methodology were not too sensitive to cause any harm especially to students. Participants had the freedom to take part and I established good rapport with them so that they trusted me. A relationship build on trust and equal partnership is key to a successful research process. All participants worked on an environment of honest conversation, willingness and frankness. I engage genuinely with my participants' experiences which Seidman (2013) suggested is important during the conduct of an interview.

To have a complete record of what participants said during the interview and focus group I digitally recorded and transcribed the interviews and focus group conversations rather than making potentially incomplete and inaccurate notes and memories of the conversation. Sound recording also allowed me more flexibility in the analysis and representation of the data. I was aware that transcribing spoken words into written form changes an oral setting into written words, so it was necessary to retain the original aspects including pauses to improve understanding and interpretation (Silverman, 2001). Data was in the form of sound recorded transcripts which was later transcribed into separate word-processed documents. Data in Kiswahili language was translated into English language and put in brackets. The data in word format was then copied into NVivo© software for easier analysis.

During the data collection process, I gave interpretation to the observed body language, facial expression and tone of voice. The most comprehensive insight on data was obtained when I listened many times to the sound recorded data and transcribed it. My presence in the school site also helped me understand the school setting under which teachers and students developed their perceptions. As the researcher (who has experienced issues under this study) I understand reality in my own way, assumptions which can influence my understanding of participants' teaching and learning experiences in secondary school science. According to Rouney (2005) interviews are important especially for insider researchers because it allows them to listen to participants' experiences. I listened more to reduce the influence of my beliefs and perspectives in data interpretation. During data collection conversations, I was aware of Morse's (1994) suggestion on the importance of the hermeneutic process. I did not allow my initial thoughts to be rigid but went back and forth between data collections in a bid to arrive at more comprehensive understanding of the data. There is an ethical responsibility to represent the information gathered in a way which does not create 'meanings' which are not 'correct'. This study takes the views of participants seriously and offers them flexibility to follow their own thoughts during semi-structured interviews and focus group, which in a way of demonstrating accountability (McKinnon, 2006).

In both interview and focus group I put the question to participant(s) and actively listened to the story, sought clarification or re-directed participant(s). Teacher interviews were planned to be 40 minutes but lasted between 30 minutes to more than 1 hour. Focus group lasted around the planned hour.

3. 9 Data Processing and Analysis

Most of the data collection process started with audio recordings. The data collected was then transcribed and analysed to answer the main research question; however, for easier analysis data was analysed to answer six subsidiary research which emanated from the main research questions. Gathered data was recorded, transcribed and translated into a word document and secured on my laptop using a password only known to me. My initial thoughts, based on having relatively few participants, was to code the data manually; however, after consultation with my supervisors, the use of NVivo software (Richards, 2005) was considered preferable as it could provide a more detailed analysis. To work effectively with the software, I benefited from a Nvivo software training from Glasgow University, support from my supervisors and colleagues PhD students.

NVivo (Richards, 2005) was helpful in finding common patterns and repeating themes in both teacher's and student's answers to questions put to them in the transcripts. Each transcript was fed into the software separately, read and reread to look for persistent themes. Participant answers to questions were categorised into "nodes". Once I had read and reread gathered data I came up with some temporary lists of possible key repeated themes, which was improved by categorising answers using NVivo software. To reduce the chances of ignoring some important issues that I may not be aware of, I kept an open mind to issues that were continuously emerging at the same time focusing on the research question(s). Each sentence or statement in the transcript that was of interest was highlighted (free nodes) and then coded with a specific name for example "Language of instruction"(Appendix D). The coding process involved making several changes to clearly reflect the content of the answers. These changes allowed me to evaluate if there was consistency (or not) and also potentially identify emerging surprises in the data. This process of categorisation allowed reorganisation of themes and subthemes including

addition and rejection of some themes. Potential themes that emerged were also considered. The names of some themes were sometimes broken down into separate themes or merged into one theme, for example “language of instruction” was subdivided into “advantages of mother tongue” and “disadvantages of mother tongue”. In addition, some gathered data (statement or sentence) could be coded in two or more nodes. The final themes are presented in chapter 5 and arranged per subsidiary research question; however, reaching this stage required several reorganisations and reviews of my initial thoughts about the connections between themes and research question. According to Kaefer, Roper & Singha (2015) the use of a software helps in coding which is a complicated process taking place in several levels. My predictions of what might be the key issues was often overshadowed by issues which I never thought could feature much in the data collection stage. My analysis and interpretation reflected this reality of my findings which challenged my initial thoughts. It is important for me to rethink why my initial understanding of the issue was different (discussed in chapter 5). Any notes I made during data collection were left out of the software analysis since they were only needed to seek clarification of issues with participants during interview.

My epistemological position agrees with constructivism. Data interpretation is aligned with constructivist theories which provide a strong theoretical framework for analysis and discussion. In particular Dewey and his concept of the experiential curriculum would link to broadening out to issues of effective learning and teaching. In addition, aspects of Freire’s work could give depth to discussions in analysis. It is important to see how constructivist theory relates to the use of indigenous science knowledge (ISK) in SSK. However, according to Patton (2002) the inductive approach disregards theoretical perspectives, so the priority is the analysis of available data leading to surprising (or not) findings. This study does not strive to prove anything or produce a new theory; the focus is to answer the research question based on the subjective views of participants. According to Perakyla and Ruusuvuori (2018) data analysis should reflect the cultural context of the participant’s location, a key focus in this study.

In the next data presentation chapter, I identify themes which will help me start to structure the analysis section by linking themes to the subsidiary research questions.

Chapter 4: Presentation of Data

4. 1 Introduction

In chapter 3, I outlined the methodology and methods which I used to gather data to answer my overall research questions: To what extent are indigenous science knowledge (ISK), indigenous languages, culture and pedagogical approaches currently used in the existing secondary school science curriculum in Laikipia County, and how can this information be used to support the implementation of the new education curriculum reforms. In this chapter, I will now present the data and emerging themes. A brief list of pseudonyms for headteachers and teachers could help the reader identify them.

- Teachers- G., B., ND., KA., W., K.
- Mr. Njoroh- headteacher Jebi secondary school.
- Mr. Bute-headteacher Makenji secondary school (neighbouring school).

4. 2 Themes arising from the data

The data is organised and presented in this chapter according to the themes that I identified from the data. The themes were selected and the data was sorted and organised using NVivo software (Appendix E), as described in Chapter 3.

When presenting my data, I could have reported the findings from teachers interviews first and set the scene from an adults' perspective to show the existing teachers' thinking and practice in science classroom. At the organisation stage of this study, some comments by teachers showed that potential diverse views in terms of beliefs, perceptions and practices in science classrooms would emerge. To a reader this would have provided a background to then read students' views in the focus group, in the process placing students' views in the context of adults' views. However, I decided to discuss the views of the two sets of participants together, which to me gives the accounts of each group of participants equal weight. I was trying to put the students' views on an equivalent footing to the views of the staff, particularly as I have mentioned that other research has not always taken account of their views. I

have taken the perspective that on the one hand, if something comes up as an issue for many participants, clearly this is an important thing to look at, on the other hand if something is only mentioned by one person, it can still be an important issue and cannot be ignored simply because only one person mentions it. This structure served to clearly identify the similarities and differences between teachers' and students' accounts.

Using this approach, I was able to put the views of both sets of participants, and to discuss any differences and the implications of the differences.

Since this constructivist-interpretive investigation is aligned with the principles and practices of qualitative research, I have used inductive analysis to make sense of data. The principles and practices of inferential statistics are not involved. The social and cultural context and setting of this study informed the initial data analysis and interpretation as this allowed me better to understand the context within which teachers and students interacted in science classrooms. For example, Mr. Bute suggested that "some of these homes are technically very poor" implying that participants of this study are from a low-income group in Kenya and are mainly peasants. The rural location is therefore likely to influence the school culture including language and how teachers view ISK held by learners.

Being in the school setting enabled me to make some early analysis and interpretations from the events in school. For example when some students were sent home for lunch money, this gave an indication of a low-income group with limited learning and physical resources. According to Sarantakos (1998) data analysis should be a continuous process; however, in my study, data analysis was limited to key events and information from my conversations with participants. The findings of this study are presented in a way that align to the 6 subsidiary research questions. The analysis was organised into 6 sections. To study the extent to which IK is used in science classrooms in the study school the sources of data included official curriculum documents (science syllabus, teacher's guide, and learner's book); teacher-planned documents (schemes and lesson plans); local newspapers, formal semi-structured teacher interviews and focus groups for students. For clarity I organised emerging themes from the

science curriculum separately from those of teachers and students. The science curriculum document clearly spelt out the aims and objectives of science education in secondary school and also suggested learning activities and learning materials including the LOI and language to be used in exams. For example, the Ministry of Education in Sessional Paper No. 1 of 2005 prescribes English as the LOI in secondary school, a policy Mr. Bute described as silencing student voice and agency in classrooms.

My themes emerged from a categorical analysis of codes and categories of processed data from official documents, teacher interview and focus group for students. The coding process borrowed some ideas from the grounded theory (Patton, 2002) and evaluative analysis. What teachers and students said happened in practice in the science classroom helped my understanding of the gap between what curriculum documents required to happen and what was happening. Curriculum documents, interviews and focus group provided more evidence in support of each theme. As informed by McCulloch (2009) I personally developed my own potential initial important and persistent themes (see Appendix D), categorising the answers with the use of Nvivo software and watching out for any new issues that consistently arose (see Appendix E). This allowed me to focus on the 6 subsidiary research questions and at the same time be open minded about potentially important things I had not thought about. The text of the interview and focus group was coded (highlighted text of interest) and then I coded them with a specific name; for example “The syllabus is the guide in everything for a teacher” comes under” “language of instruction” and “Source of school knowledge” (see Appendix D). During the period of coding process, categories were edited and reviewed many times so that they clearly reflected the content of the answers. Some categories were improved by developing new themes from them; for example “language of instruction” became “advantages of LOI” and “disadvantages of LOI”.

Development of themes was a tedious, but necessary, task with many interactions among raw data, theory, research questions, reflection during data collection, coding, theme development and any other interesting things that came to my mind especially when I was alone and reflecting on data. The more I engaged with the data, making sense of it became more complicated as new

ideas came up, putting the previous ones in doubt. The final themes were then organised according to the initial research questions. This new analysis stage required another review and reorganisation since my earlier thoughts about the link between themes and subsidiary research questions left a gap with the actual analysis results. According to Kaefer, Roper and Singha (2015) using a multi-level coding with NVivo software could be helpful, which is supported by McCulloch (2009). This was significant because the issues that previously looked important to me were sometimes mentioned only briefly, however issues that I had not thought about turned out to be repeated many times during interviews and focus group. These gaps largely informed my analysis and interpretation because they made me rethink my initial view and reflect on why my initial view of the issue was different.

TABLE 4.1 LIST OF CODES AND IDENTIFIED ISSUES

Parent codes	**Child codes**	**Identified themes**
Home and school cultural setting	Home poverty; home language; difference in lived experiences; indigenous and science knowledges; Culture and beliefs; Community involvement; economic activity; poor infrastructure; Lack of money; no electricity.	Location and economic activities; poverty; learning and physical resources; Indigenous culture; parent participation.
Education Policy	School science syllabus; national and local education policies; Learning and teaching of SS; Learning material resources; Indigenous knowledge linkage with topics ; Exams; school	School science syllabus; language of instruction; national exams.

	science knowledge; Language policy.	
Perceptions of indigenous knowledge and school science knowledge	Teacher and student attitude; home influence; sources of knowledge; shortage of learning material resources; IK devalued; language of instruction; views on IK and SSK; exams; IK used explain science concept; pressure of exams and teaching methods.	Sources of knowledge; ISK and SSK; language of instruction; learning resources; teaching methods.
Teaching and learning methods	Science projects; Student taught by memorizing; Student challenges, dependency on textbooks and policy; Teacher has power over students; Pokot and kikuyu songs and dance; Teachers have less indigenous and science knowledge; Different student ability groups and equality; organisation of teaching science; Support given to teachers and students; Student voice and challenges in learning process; Students culture, practices and virtual things help in	Teacher-centred learning approaches; voice of the voiceless; practical activities; Indigenous teaching methods; language of instructions; exams.

	understanding and interest; Teacher and policy is specific on what and how knowledge is taught; teachers not well trained for actual teaching.	
Challenges of quality instructions in science lessons	Teacher and student attitude; Irrelevant practical activities and irrelevant or lack of or out of date equipment; language students do not understand; practical activities; reference textbooks important; pressure of exams and teaching methods; lack of necessary science teaching resources; lack of teachers; engaging lessons; Improvisation of resources and limit; remote location; teacher training.	Teachers.

4.2.1 Home and school cultural setting

The data collected in this study has identified the home and school cultural setting as having some important issues which impact on learning and teaching in Jebi secondary school. These issues are discussed under the following sub-headings: Location and economic activities; poverty; learning and physical resources, indigenous culture and parent participation.

i) Location and economic activities

This study took place in Jebi secondary school (pseudonym) a public day school in the wider Laikipia county, Kenya. The other neighbouring public school whose headteacher took part was Makenji secondary school (pseudonym) also a day school which is about five miles away. The neighbouring school was included to provide a broader view on policy implementation. The school borders a natural forest which originally was a rich natural environment but has been destroyed by mainly illegal timber traders, people looking for firewood and livestock herders. According to Mr. Njoroh, keeping too many livestock contributed to illegal encroachment and destruction of local forest at night by herders. However, a new "community forest association" has contributed to engaging the community to use available resources in a legal and sustainable way through, "aspect of appreciating the forest". Wild animals which benefitted from the natural environment have suffered from lack of adequate food leading to man/animal conflict where mainly elephants have crossed over to farms and destroyed crops and killed people. The implication is that the challenges experienced in the local setting could be the basis of learning relevant science knowledge.

The school in this study is in an area where agricultural activities and livestock keeping are the main economic activities, within the rural setting. Parents and community members who are more knowledgeable play a significant role in the process of training the youth in indigenous practices. Mr. Njoroh comments, "these students came from small scale farmers. They have survived on…small scale farming of maize, beans, and all that… have livestock …would be taking them to the forest". Mr. Bute believed that indigenous experiences formed a significant part of student's everyday life, "(they) come from localities that have those indigenous experiences and even teachings from the clans". When asked about students' home experiences G (teacher) responded, "children are mostly involved in daily activities with their parents at home." For example, when asked about examples of his home experiences, student AG responded, "these types of germination. Like in beans, these are things that we see at home". In addition, according to student SE, children learn from parents, "… a goat was slaughtered…, salt was applied… when meat was hanged in the

house". Student AG added, "our parents tell us that when the stomach is aching, you take some ash". These activities at home make students and their families endure socio-economic and political marginalisation within a rural setting. The participants' statements above concur with those of Mandikonza (2019:5) that, "individuals first experience the world through social processes where language, knowledge and experiences are culturally shared via other learners, adults, mediating tools and artefacts or a teacher". At home students learn by seeing (empirical knowledge) and doing under the eye of their parents, an important indigenous teaching technique. The environment in the study site is rich with natural resources like rivers and forests.

Family connection is still strong, although the younger generation are migrating to urban areas for formal jobs which are few in the research location. When asked to describe the setting Mr. Njoroh the headteacher replied, "this guy (former student) is already in Nairobi, but he is even sending money so that the parents can be able to farm tomatoes ". He further explained that some former students were employed, "in M-pesa…(and)…Agrovets". The implication is that although school provide skills for employment, IK is still valued and contributes to survival in local study area.

In conclusion the study area is geographically located in an area where students in the study area have indigenous knowledge and practices in terms of things that they know and things that they do with adults. Such indigenous knowledge and practices which are valued by young people have the potential to generate meaning in relation to school science curriculum concepts. There are environmental experiences like rivers and forest which form part of student's everyday life. However, the area presents serious safety challenges related to the difficult and sometimes dangerous rural lifestyle.

ii) Poverty

Income for the Jebi secondary school community mainly comes from subsistence farming and wages from the few local jobs available. The local farming practices fit into the definition of local knowledge (World Bank, 1998; Sutherland, 2015; Mandikonza, 2019). Jebi secondary school community can be considered as being made up of people who are mainly struggling to make ends

meet and would likely find difficulties in adequately financing their children's education.

Rural lifestyles are mainly focused on daily survival, with a high rate of poverty. Several teachers felt that poverty affected learning and teaching in Jebi secondary school. When asked about challenges to learning, Mr. Bute responded, "some of these homes are technically very poor". The headteacher's views about the level of poverty surrounding the schools seem to resonate with findings carried out by the Republic of Kenya (2013) which showed that 43 % of the total population in Laikipia county was considered poor.

Teachers in the study considered most of the students to experience many challenges associated with poverty including social problems, lack of food, insecurity and having to walk long distances to school. When asked about student challenges that impacted on learning, KA (teacher) replied, "The most challenge is that one (school fees)". B (teacher) added, "some have just come to school without food…others maybe they left their parent maybe sick… some have gone home to look for school fees (the government pays for tuition; however, each student needs to pay for meals". Most parents are unable to pay for school meals, putting strains on school finances and occasionally forcing the school to send students home for money. There were unique challenges for this category of school, as K (teacher) explained, "Being a day school …. others walk for long distances… others don't have time to study at home at night for their own preps… so the kid cannot concentrate really". Social and economic problems were identified as Mr. Bute observed, "lot of traumas… they do not seem to feel well attended to by the parents, the parents are divorcing, at time they keep on fighting, others are drunkards, others are separated… homes have not enough lighting, they have no paraffin". It was felt that the income from most homes was not adequate to provide food and pay for new classrooms, lunch money, education tours, science laboratories and lighting for doing homework at home leading to hunger and frequent absenteeism. Thus, school learning was seriously disrupted. Students felt that being in school and passing exams would save them from struggles of everyday village life in the future. Therefore, the migration to the urban area noted above is not unexpected.

When asked about the goal of education there was a chorus answer towards passing exams. Student MW added, "Ndio nisiishi maisha ingine hua naona watu wakiishi (So that I can have a better life, and not the life I see some people lead)… Ya kuchukua jembe kwenda kibarua. Maisha kama hiyo… (using the hoe to work in the farm. Life like that) ". Students related formal education to success in life, while farming was associated with poverty.

In this study, lack of basic needs like food undermines the learner's ability to live healthy, quality lives and adversely impacts on school attendance and successful science lessons. Teachers felt that the prevailing levels of poverty around the school community made it almost impossible to get resources to support the school learning program. When asked about the effort the school was making to improve school facilities, Mr. Bute replied, "we realised that if you call for Harambe (raising money) …our parents… have no funds… the government… say (use) the school funds". The implication is that parents are unable to afford the additional costs of education to supplement limited government funding. Lack of money to improve the school infrastructure and learning resources may have negative educational prospects for Jebi secondary school students.

iii) Learning and physical resources

Teachers and students mentioned barriers that stand against an appropriate implementation of the science curriculum. Students in this remote environment lacked learning materials which the teachers felt could have improved educational outcomes and kept pace with the content in the science syllabus. N (teacher) demonstrated the impact a lack of required science equipment had in his science lesson planning, "Not every time that I can plan my lesson given that some of the lessons require you to use a fume chamber. So, I can't prepare those ones". When asked about learning challenges B (teacher) responded, "some… do not have televisions… we don't have electricity… So, it becomes a challenge". Lack of electricity has clearly contributed to lack of television and therefore the students are denied learning experiences required to keep pace with the requirement of the science syllabus. Mr. Njoroh the headteacher regarded science learning materials as expensive, "You really get to spend a lot

of money". Lack of learning materials and their impact on the process of learning and teaching for students in Jebi secondary school is discussed later in this chapter. Poor physical infrastructure development in Jebi secondary was identified as a barrier to providing a stimulating environment good for the process of learning and teaching. According to Mr. Bute, "facilities are not really adequate… classrooms…are small…no…library…the school administration office was inadequate for staff". However, issues to do with facilities are not limited to concerns about science learning and teaching only as Mr. Bute explained, "field…For those who are not able academically, we can be able to help them in terms of field skills, like athletics, ball games, handball". The school lacked a comfortable environment to support learning and teaching in classrooms and did not support the development of extra curriculum skills enjoyed by some students.

Several teachers were of the view that the single laboratory was inadequate for carrying out effective practical activities in Jebi secondary school. When asked about challenges of learning and teaching in science lessons Mr. Njoroh felt that laboratory rooms were a challenge, "we seriously need the labs". K (teacher) added, "as per the number students having one laboratory and about 250 students, may not be adequate". Lack of laboratories adversely affected the number and quality of practical activities each student experienced so overall the quality of students experience as required by the science syllabus was diminished.

All teachers and students felt that the school did not have adequate science learning and teaching materials and resources for effective instruction. When asked about laboratory facilities Mr. Bute replied, "we are implementing a science curriculum that should be practical and technical and should be making the kid generate very skilful knowledge but at the end of the day you (school) are not providing the facilities…most of them (school leavers) go out there and start learning from zero". Asked a similar question K (teacher) responded, "The laboratory facilities are not really enough… but we have the basic facilities that can be used to conduct the experiments in school". Teachers were forced by limited laboratory supplies to resort to teacher centred teaching approaches. When chemicals were unavailable KA (teacher) resorted to a lecture method

and memorisation of facts which student do not like. Limited supplemental resources and activities adversely affect instruction in science lessons in Jebi secondary school. The experiences of teachers are consistent with Jepkemei's (2020) observation that quality of instruction will be achieved if it is supported by adequate learning materials to deliver a school curriculum.

According to teachers and the students in this study, shortage of science teaching resources was a major obstacle to interesting and enjoyable practical science lessons for learners. Teachers in this study indicated that lack of funds limited educational tours for students. As a student in secondary school, I was really frustrated sitting in a double science lesson (80 minutes) listening to a teacher explaining scientific processes without demonstrating them practically. Chemicals and equipment needed for experiments were often out of stock, unfortunately often leading to teacher talk dominating science lessons. In addition, my teachers could not prepare school tours to the flourishing environmental surroundings to learn about nature citing lack of funds. However, at home my parents always taught me about the surroundings including the benefits and names of both plants and animals, which to me is a useful learning resource. Students in this study indicated that they are rich in ISK, mostly learned from parents, so if the school lacked funds, then ISK from parents could mitigate this and offer learners opportunity to interact with ISK through inviting parents to classrooms. However, teachers in this study seemed under pressure to complete the science syllabus and teacher-led approach potentially helped in this. In addition, it appeared "safe" for teachers to use the teaching skills they were more confident in. As a student I wanted to pass my exam and teachers emphasised completing the syllabus to improve my chances, which I did not doubt. Although this silenced me and I did not enjoy learning science, this was similar to views of students in this study who enjoyed practical science as it allowed them to interact more, in the process taking more ownership of their learning.

Inadequate education materials is a challenge for teachers and students in science classrooms, a situation worsened by a rigidly prescribed science curriculum. The course content is rigidly prescribed by the government through an exit exam, which is the only tool for student assessment. A focus on exam

often determines the way teaching and learning takes place in science classrooms, conditions that often marginalise IK.

iv) Indigenous culture

The community in the study area is ethnically mixed and so diverse languages and cultures are represented. Unsurprisingly, the understanding of indigenous knowledge is also diverse. According to Mr. Bute, "like this community is an integrated community, we have the Pokot, Samburu, Kikuyus". Mr. Njoroh added, "the majority here are the Kikuyus (ethnic group)". The implication is that Kikuyu culture may be dominant over other ethnic groups, an issue discussed in chapter 5. Such an ethnically mixed setting relates to Mandikonza's (2019:4) description that each ethnic community in every setting was socialised differently from the others, "people from different cultures are thought to have different thinking tools (IK and languages) because they have internalised different external stimuli in their particular context". The diversity in the community means that there may be diverse indigenous knowledge, languages and experiences making it challenging to have a common understanding of IK. However, diversity of experiences can also enrich the discussion when working towards understanding a phenomenon under investigation. How language impacts the learning process is discussed later in the chapter.

Several teachers were of the view that students demonstrated skills in traditional songs and dances, in which learning and teaching took place at home. Omolema (2007) argued that learners were already well familiar with their culture, which would be a good starting point of making connection with new knowledge. According to Mr. Bute, "Like the music festivals, they are so much engrained in those traditional songs, so, meaning in cultural music they are able to enhance it because they have started it right from their home background ….So you find the Pokot will come up with a Pokot song and they teach the Kikuyus and they learn and are able to sing the same song. So technically they enjoy that". Indigenous learning and teaching approaches like songs and dances which students enjoy, as part of their culture are important teaching methods which could promote understanding of scientific concepts through contextualisation of science lessons. How this looks in practice is discussed later.

Omolema (2007:600) argued that cultural activities re-ignited student's traditional way of learning helping them, "to conceptualise places and issues not only in the local area but also beyond their immediate experience". Referring to environmental education, Omolema (2007) suggested that students would enjoy learning about the environment through songs and dances. Student-centred learning was also promoted when students actively participated in finding out about some common traditional retold stories about environmental education.

Teachers were of the view that traditional beliefs were common and influenced the student behaviour. Students of Jebi secondary school upheld acquired indigenous knowledge in the form of revealed knowledge and which formed part of their worldview. Beliefs held by students according to several teachers had negative and positive outcomes in learning and teachings. When asked about how traditional beliefs impacted on learning of school science G (teacher) replied, "in most cases you find that the student's behaviour is a reflection of what is done at home". When asked about the effects of such beliefs in biology topics ND (teacher) responded, "in some of the ethnic groups, some of these topics are unteachable. So, bringing the student to be able to interact with you as a teacher on one-on-one basis about a topic (pregnancy) or a subject they regard as a taboo will surely require some effort to break the barrier". Other beliefs for example, sexual abstinence is promoted in traditional beliefs which is what is taught as a protection against sexually transmitted disease in science lessons as ND (teacher) put it, "highly discouraged and condemned in almost all the cultural and religious". ND (teacher) views are shared by Chikunda and Ngcoza (2017:88) that African beliefs and practices can, "be incorporated in the classroom to enhance science teaching and learning". Teachers should be aware of such beliefs and be sensitive to them so that learning and teaching does not exclude or undermine the beliefs of students which they respect.

Student and teacher voices in this study show gaps between SSK and ISK mainly influenced by the science curriculum, although ISK is not wholly dismissed. The local culture into which I was born has had a significant influence on the beliefs and traditions I hold. My parents were followers of routine activities which they

learned from my grandparents, and which were passed over to me. In my primary school days, while discussing time using the clock, the teacher asked how we can tell time. I raised my hand as was the routine and answered, “using the length of our shadow”, the teacher and some students laughed at my answer. I did not understand why it was funny, because I learned from home that the shortest shadow meant mid-day. According to the teacher, the “right” answer was a clock which I had limited understanding of, and which was the “modern” way of telling time. The teacher response was shocking to me, implying that anything I learn from my parents was “primitive” because they did not go to school. At this moment, I lost confidence and self-esteem and was confused. My teacher demonstrated the gap between SSK and ISK, a thinking that implied that I was “liberated” through the use of the clock and without it I would continue to be “primitive”. However, the teacher was correct in that the clock could tell the time at night and in cloudy days, which was a challenge to the cheaper way using the shadow implying that both could tell time and complement each other in context. In reference to this study my experiences align with findings from the data, that school science is not connected to learners' homes and social contexts, which contribute to decontextualised learning.

As suggested by teacher ND some biology topics are unteachable due to taboos, implying that taboos could be done away with because they are an “obstacle” to learning, although teacher ND also has a positive thing to say about taboos related to good morals. Data in this study show that science learning needs to be contextualised. As a child growing up in the village my parents had cows and sheep in the family farm. I was instructed to always carry a wooden stick when taking care of the animals because they would consider me a serious herder. In the choice of herding stick I was discouraged from cutting one particular species, the Mu˜gumo tree (fig), because it was a taboo since “ngai”(Kikuyu God) lived there and would be unhappy and bring bad luck to the individual and community. However, I quietly wondered what I would do if other trees were not accessible.

I noticed two Mu˜gumo trees in the school compound that were massive and ever green even during the dry season. The two fig trees were left standing

when the field was being cleared to build the school, because it was a taboo to cut them. During the dry season, I with other children ate the sweet fallen fruits under the tree; for me the fruits supplemented my diet and held my hunger back before mealtime. Goats and sheep belonging to neighbouring homes would be allowed to join in feeding on the fallen fruits and leaves including enjoying the shade in the hot weather. In addition, the Mu˜gumo trees were home to several species of birds and small animals. It would appear that the taboo on the Mu˜gumo tree limited the destruction of the environment and provided a means of survival for both people and animals. It follows that the views of teacher ND, that taboos should be abandoned, is debatable. Helpful ones could be considered part of local culture and identity and treated as a learning resource to be linked with SSK for meaningful learning, as teacher ND also suggested that some taboos are useful in upholding moral values.

In a student's personal experience, what they are told by their parents and elders and what they do together at home and in their communities play a significant role in everyday survival and understanding of the immediate environment. Such students' experiences are regarded by Mandikonza (2019) as important in making sense of scientific concepts.

Data in this study seems to refer to community involvement through parents. Several teachers felt that parents were welcome in school to participate in other school matters outside classrooms. When asked how the community was involved in the school. Mr. Bute replied, "we even have community leaders here, right from the church from the farming department and all that. Whenever we have an issue, we call them, and they come and talk to them…. Issues like counselling on the behaviour patterns and how to relate your behaviour with the learning…(however)… Some (parents) did not go beyond secondary".

In relation to science learning, contributing to scientific knowledge is not something that teachers in this study perceive parents can do, because this role is mainly reserved for professionals. These teachers view formal educational experience as a determinant for parents to have the ability to contribute. If IK/ ISK topics were a considered focus, then the knowledge and experiences

parents bring would place them in the role of expert. According to Mr. Bute, "When it comes to education, they (parents) may not have gone ahead of class 8 and class 7. Some did not go beyond secondary (school education)"so parents are perceived by teachers as "lesser" professionals. All teachers in this study identified university education as the main source of science knowledge and teaching skills. However, students and teachers were of the view that parents were important "teachers" at home who provide solutions to everyday life challenges, thus giving meaning to the world around. According to student AG it is easier to link the science lesson to the perspectives of parents, "it makes me understand why our parents tell us that when the stomach is aching, you take some ash". G (teacher) was also of the view that experiences at home often made science lessons meaningful, "mwana ucio kuria aumiite okorwo muraria uhoro wa machine, machines ici tii hindi acianjia. Ithee ringi ni makanika…(na)… nginya mucii kwi mashuma… ni agukuria kiuria very advanced. (if you are teaching about machines, the child has already seen them at home with a mechanic dad… the child will ask very advanced questions)". It is encouraging that the ingenuity and skill of parents is being recognised in relation to science by teachers and students in this study. Home and school are both sites of knowledge production and should complement each other.

Some teachers were of the view that community members who are beneficiaries of western knowledge with associated careers are the only ones welcome to share their science knowledge in the school. When asked about community members' involvement in school G (teacher) replied, "the health centre from around can send people to train students on certain issues. Students also learn about the advancement in technology… A student might have a project that concerns electronics and coincidentally we might have a villager who is also good in electronics and who can be able to help the student with this project". It could be suggested that teachers' preference for one type of knowledge system over another impacted on the use of indigenous perspectives in learning and teaching.

When asked about the involvement of a community member to discuss issues related to indigenous perspectives, G (teacher) responded, "We don't have enough time for such things [laughs]". Teachers of Jebi secondary school were

more focused on things that complemented the science curriculum, and which were "lacking" in parents.

Teacher KA found it funny when a student suggested that "we use the charcoal [laughs]" in a chemistry lesson. The assumption by this teacher (KA) that local practices were less likely to have an impact in science lessons mainly because of the dictates of teacher education in Kenya is contentious and contestable. I would argue that teacher KA is influenced by cultural beliefs and traditions, practices and cultural rituals that teacher education often does not explicitly value. The teacher and teacher education relationship could have limited influence on learning and teaching in science classrooms, but the knowledge and practices experienced at home could have a significant influence. It can be argued that life experiences including scientific, spiritual or social from the local environment impacts on learning and teaching in science classrooms.

In conclusion, Jebi secondary school setting is endowed with various natural resources including rivers and forest which form part of the student's physical environment. The students are part of family and wider community from whom they learn to survive on the land. Students observed and joined their parents in farming activities using indigenous knowledge and practices and used indigenous language for meaning making. Students also learned about community culture and beliefs (dos and don'ts) that formed the foundation of understanding the immediate environment. Jebi secondary school teachers believed that parents were welcome to take part in other school activities, although not classroom teaching because they lacked the technical knowledge needed in classrooms. In Jebi secondary school, lack of adequate government financial support led to severe lack of necessary learning material resources including laboratory supplies which became unaffordable within the school budget. Further, most parents are poor and could not afford adequate food for the family nor contribute money towards school programmes including laboratories.

4.2.2 Education policy

In this section I will provide documentary evidence and participants' views about how educational policies inhibit or promote effective learning of school science. What teachers did in Jebi secondary school classrooms as a result of

both national and local policies is summarised under the heading school science syllabus. These themes contribute evidence towards how education policy meets or does not meet the needs and the interest of students.

i) School science syllabus

Learning and teaching in the Kenyan education system is guided by the school syllabus, which defines the objectives and prescribes the content that teachers must adhere to. The school syllabus is written by the government and presents science education from a disciplinary perspective consisting of a specific science content, scientific methods, and characteristics of SSK. As noted in chapter 2, according to the Kenya Institute of Education (KIE) (2002) learning and teaching of secondary school science is guided by the secondary school syllabus, volume two, (Mathematics, Physics, Chemistry, Biology, Agriculture and Home science). This remains the syllabus in place in 2020.

ii) School science knowledge

The government through the syllabus document outlined the importance of respecting the many cultures that existed at local and global levels. The national goal of education (KIE, 2002: vii) should, "promote respect for and development of Kenya's rich and varied cultures". Further, the objective of secondary education (KIE, 2002: vii) was to, "enhance understanding and respect for own and other people's cultures and their place in contemporary society". The above overall goal of education and the objective of secondary school education demonstrate that the government values the inclusion of the range of cultures in education.

The national goal of education requires teachers to take account of the complexity of the social and historical context. According to KIE (2002: vi) "Education should promote social equality and foster a sense of social responsibility within an education system which provides equal educational opportunities for all. It should give all children varied and challenging opportunities for collective activities and corporate social service irrespective of gender, ability or geographical environment". However, according to Mandikonza (2019) most rural students experience difficulties making connections between what teachers teach as curriculum knowledge and the

student's experiential knowledge experiences, values, beliefs and world views from home. The rigidity of the school science syllabus in terms of content, methods and processes of generating knowledge and time allocated has become a challenge to actualising this instruction.

One of the general chemistry objectives (use the knowledge and skills acquired to solve problems in everyday life (KIE, 2002) states that teachers should teach knowledge and skills in a way that students are able to solve everyday problems. The policy intention is that school science knowledge should be meaningful to students' everyday life. When a student learns knowledge of chemistry, he/she is expected to be able to relate this to the immediate environment.

Through chemistry project work, the syllabus attempts to create space, linking science knowledge to the learner's immediate environment. Such an approach is intended to develop creativity, interest and problem-solving skills through the learned scientific knowledge. Teachers and learners are encouraged to design their own projects; however, scientific principles that students have acquired should guide the choice. Such an approach causes tension between indigenous knowledge and school science knowledge when one knowledge system is given more prominence than the other, as indicated by the views of teachers. The syllabus did assume that one type of knowledge system – that is the SSK - is dependable in solving challenges experienced in the study area, tending to exclude indigenous perspectives.

iii) Scientific method

Practical and interactive approaches are advised, to encourage students' interest in the topics. Teachers are also encouraged to be creative in expanding on highlighted projects and teaching methodologies for effective achievement of science lesson objectives including solving contextual challenges. In physics (KIE, 2002:34), "These projects are designed to enrich the experiments carried out in the laboratory and enhance creativity…(and)… finding solutions to problems".

Most of the learning resources required to implement the science curriculum are considered cheap and locally available. According to KIE (2002: 55), in

chemistry, “Most of the apparatus, chemicals and equipment required for carrying out experiments are basic and affordable by most schools. Improvisation and use of local materials are encouraged where necessary to cut down on costs”. The Kenyan government assumes that all schools would easily afford learning materials or teachers would be able to improvise. It is not clear how prepared teachers are to do this. The impact of learning materials on quality of instructions is discussed later in this chapter.

The biology general objectives emphasise the scientific methods in the learning and teaching of school science in Kenyan secondary schools. Social interaction associated with the subject study is provided space in the science classroom. Biology learners should, “apply the knowledge gained to improve and maintain the health of the individual, family and the community” (KIE 2002: 80). In this regard, the syllabus instructs teachers to use local examples in explaining school science materials. It is hoped that through learning of biology, students would acquire scientific knowledge and be able to have certain desired attitudes (develop positive attitudes and interest towards biology and the relevant practical skills). According to policy wording and teachers’ views, students were being prepared to develop a western attitude in solving everyday challenges because SSK (Gitari, 2012: 31) is, “worthy knowledge with universal application”. One of the general and specific objectives in the physics syllabus emphasizes the connection of physics knowledge and the world around student. According to KIE (2002: 36) a student should, “not only acquire knowledge but also discover more about the world around him/her and as such develop interest in the subject”. It is assumed that the teacher should be well prepared in terms of training to be able to help the student make those connections.

iv) Explanations of our world as “facts”

Any prior student observation and understanding of the world have no space in chemistry lessons. The aims for teaching science in secondary schools in Kenya are intended to develop skills and ways of thinking that have a mainly empirical basis. However, students have curious minds about their surroundings as student EM explained how her mother’s high blood pressure experience motivated her to search for more information about it, “So, when the teacher came to teach, I enjoyed more because those things I knew them. I had some

knowledge about it". Student SM added that her curiosity, when she heard about, "bombs and the nuclear" made a "difficult" topic easier to understand. Students have the capacity to sustain a conversation about science and discover more information about their surroundings. According to Kirch and Amoroso (2016: 1) students are known to be interested in their environment as, "curious investigators, astute observers, … relentless knowledge seekers, creative interpreters, and meticulous note keepers".

The general objectives (KIE, 2002:80) strive to enable a school science student to, "acquire a firm foundation of relevant knowledge, skills and attitudes for further education and for training in related scientific fields". The needs of the learner who pursued science knowledge for higher education is emphasised in terms of acquiring a solid foundation of the required knowledge in all science subjects.

Chemistry knowledge acquired by the student is mentioned as important in understanding the world around us. According to KIE (2002: 54), "The knowledge of chemistry is necessary in the understanding of the composition, properties and behaviour changes of matter that form the environment around us". According to G (teacher), "My main interest is to make sure that the student is rich in information by the time he is completing school. He or she will also have answers to many mysteries that occur in the environment". However, such a disciplinary approach to science lessons may lack space for a student's prior knowledge, methods, and beliefs about the world.

In conclusion, the Physics, Chemistry and Biology syllabi considered formal science knowledge as very important for the student to be able to understand their immediate environment. Such knowledge is seen as objective and important for everyday survival. Scientific methods of learning and teaching of science are highlighted as important in science lessons. However, the teacher is required to make connections between SSK and everyday student experiences as a way of making science lessons more interesting.

v) Language of instruction

In Kenya the Ministry of Education in Sessional Paper No. 1 of 2005 directed that mother tongue be used as language of instruction from grades 1 to 3, when learners acquire basic literacy skills in the broader agenda of providing quality education. In all other classes upwards, English is used as language of instruction. The policy position creates an obstacle to the use of indigenous languages in science lessons. English language is regarded "higher" than all other indigenous languages, giving it official status denied to any other language. The government instructs teachers to adhere to the language policy in science lessons. According to Mr. Bute, the government was wrong in the choice of English as language of instruction in all subjects, because "that restriction made the kids feel completely side-lined". Mr. Bute's views resonate with Jepkemei (2020) that Kenyan language policy and practice is often contentious. How language policy impacts on the use of indigenous perspectives in science lessons is discussed in chapter 2.

During the focus group I allowed students to use a language of their choice; however, although English was rather challenging to students in expressing their ideas, it dominated discussions. Kiswahili was often used to make things clearer or when a student had no English words to use in expressing an idea. There was often humour and relaxation when indigenous language was used. According to student NM, "In a topic in form two, about salt. The teacher comes in class, and he start teaching, where he told us about some other people understand salt at home. They just call salt as chumvi where he came and told us this is sodium chloride that we are using. That make me to start being interested in that topic. As the teacher start teaching, the topic was hard to me. But as long as he starts using the Kiswahili words to explain some compounds, actually I start understanding". When asked what language made understanding better student AG responded, "Kiswahili (group of other students answer together in agreement, body language shows agreement)". In a follow-up question about the language that dominate discussion between students, student AG replied, "It depends, if you like using Kiswahili, English….it depends". Indigenous languages which are stores of traditional wisdom are very popular among students and teachers. The popularity of indigenous languages

gives hope to the conservation of Indigenous knowledges and cultural heritage. The language (s) spoken and indigenous knowledge available in the rural community has the potential to influence the student's and teacher's views on IK and interactions in a science lesson through learning science knowledge in a familiar language. According to G (teacher), most students, "use mother tongue" in everyday communication. Implementing English policy in the study site is a challenge. Mr. Njoroh explained that the majority of teaching and non-teaching staff were from one ethnic group, the Kikuyu, which was the main language of communication, a challenge in enforcing the English language policy, "They will find themselves diverting to another language (Kikuyu)". The social and cultural background of the school may explain teachers' decisions on the relevance of indigenous knowledge language and culture in the learning and teaching of school science as a way of harmonising science lessons.

Indigenous languages are considered by teachers and students as important in understanding SSK by students.

When asked about meaningful science lessons student BM responded, "… you will understand when explained in your mother tongue. Lugha yenye unaelewa (language that you understand better)… Kiswahili or kikuyu". However, according to student BM understanding a concept explained in mother tongue is not all helpful, " … ikifika kwa exam, you won't have the right words to write in the exam (if you use mother tongue you struggle to express yourself in the exam). Maybe you will fail in the exam. Even though umeelewa, you don't know maybe to translate in the English language (even though you understand a concept you find it difficult to express yourself in English language)". When asked what language was often used in his science lessons, G (teacher) preferred using English language for exam and scientific terminology reasons, " I will use English… language they will use when answering questions... the student have to be trained to mention a certain concept in their answers".

Several teachers and students felt that ISK was important in explaining scientific concepts to students for deeper understanding. However, sometimes teachers use indigenous languages to support English language to understand a world view of indigenous students and this undermines ISK in the process.

According to G (teacher), "…when giving examples not related to examinations, particularly about everyday experiences I use Kiswahili language because it helps them better understand a concept, I am teaching. Therefore, if am just giving them some general knowledge which I know cannot be tested, I use Kiswahili so that all of them can understand". Teachers often used every day experiences (ISK) in the Kiswahili language to improve understanding of a scientific concept, however when ISK was the subject of discussion often about things outside the syllabus, Kiswahili language was used. So indigenous language is the store of ISK and student's life experiences and is necessary to use to link that knowledge with SSK.

Several teachers and students viewed indigenous languages to be lacking in scientific terminologies and so students required extra support to improve English language skills to pass exams. According to K (teacher) indigenous languages were deficient of scientific words, "are not able to comprehend the terminologies in biology…But you cannot use Kiswahili across because most of the terminologies are scientific and do not have Kiswahili words. So, you have to strictly use English…". ND (teacher) felt that scientific terminologies were new to student's experiences so they, "find it difficult to follow you... (and)… lose interest… (so use a) … different language… (to)… understand better". The use of indigenous words expressed the students cultural view of the natural world and existence, an example of the use of indigenous perspectives in science classrooms.

As a student in upper primary school it was quite evident that the location of my school had a significant impact on school culture through the use of local languages, enjoyment of practical activities in classrooms, interactive physical activities among learners, significant respect for adults during learning and teaching. In addition, although the teacher encouraged learners to use English language in naming objects, local languages were often used to make things clearer for learners understanding. From home I had acquired language, norms, values, religious beliefs, customs and traditions, that shaped the way my thinking developed and the way interacted with others. My teacher could often use local languages in science lessons and explained why fasting, a religious belief, is connected to health and well-being, thus showing the relevance of

culture in teaching school science. However, the existence of diverse cultures in the school complicated the effective use of culture in learning, since there was limited common understanding among learners on some issues although having lived with people of other cultures for a long time, I could understand some other local cultures and practices. Most teachers in my school were locals and could speak their mother tongue and other local languages which likely influenced their attitude towards indigenous knowledge. Although my teachers often used local culture in classrooms, they often cautioned that ISK was "useless" and irrelevant for the future. Although teachers, through the influence of western education, have often devalued the culture and beliefs of indigenous people, it is apparent such thinking is changing and is accommodating them in classroom practices. It can be argued that the extent to which formal education negatively influences the cultural teaching and practices of local students in Kenya is a question for further research.

vi) National exams

The government's expressed intention in the syllabus is to prepare learners to solve every day social and economic challenges experienced in Kenya. However, the science curriculum focuses on science knowledge and pedagogy of teaching that prepare students for exams excluding the contribution of students' everyday lived experiences and IK in classroom science experiences. When I asked students, what was the most important in school, all agreed with student's AG answer," Pass your exams". According to G (teacher), "(the) science curriculum is not good… It focuses on the academic work and performance… not everybody who is good in academic work. So, restricting everyone into academic work and grades only is unfair". According to student MW, exam questions on a topic are limited in scope and, "does not move wider from that topic". Further, Mr. Bute explains that teachers must follow government guidelines and, "prepare lesson plans" to guide them (teachers) in learning and teaching process. The rigidity of the content in the science curriculum leaves the teacher with little room to expand on any topic or use different teaching approaches. There are also specific objectives for each science subject which are meant to signpost the teacher and learner into specific depth of a topic's content. Teachers in this study felt that the learning

and teaching process focuses more on passing exams because of the rigidity of the science curriculum. Each topic is allocated a time for completion which may limits inclusion of student's lived experiences in learning and teaching process; however, it's encouraging that flexibility is allowed but is dependent on the teacher to allow (or not) student's lived experiences in classrooms. The impact of exam performance on learning and teaching in science lessons is discussed in chapter 2.

The exit national examination, Kenya Certificate of Secondary Education (KCSE) played a significant role in determining instruction in the learning and teaching in science lessons. According to ND (teacher), "I teach because I know my students will be examined somewhere and when they are examined, I have prepared them, covered the whole syllabus… (exams) show that I was teaching". Further, Mr. Njoroh the headteacher felt that grades are very important, "In fact, it has and … as we have maybe had many people, even us complain. You realize that the grades will determine even the promotion of teachers. Like now there is this thing they call the HOYA/TOYA (Head Teacher of the Year and Teacher of the Year Award) …and yet they are pegging the same in the grades or in the mean scores of the schools". In this regard, schools invite people skilled in exams to advice students on exam techniques so that they are well equipped according to Mr. Bute, "in answering questions in the national exams".

Teacher-centred methods of teaching using English language as language of instruction was emphasised in science lessons, mainly in response to the need of completing the content of the science syllabus, an exam focus and inadequate learning materials. As a result, student's voices in indigenous language and cultural ways of learning were not prioritised in science lessons, limiting the understanding and contextualisation of scientific concepts.

In conclusion the science curriculum is under significant state control in terms of language of instruction, science knowledge, how knowledge is taught, choice of learning material resources and teaching methods. Further, each science topic is supposed to be completed at specific times in the pupil's school career which often puts pressure on both students and teachers. The specific and

depth of the official knowledge and learning resources, language of instruction and teaching approaches are focused on meeting exam requirements. However, at this preliminary stage a range of challenges including inadequate learning material resources, teaching approaches focused on maximum content coverage and exam focused learning have been identified as impacting on meaningful learning in science lesson.

4.2.3 Perceptions: School science knowledge (SSK) and Indigenous science knowledge (ISK)

In this section participant views were categorised into: Source of science knowledge; learning material resources; about ISK and SSK.

i) Source of science knowledge

When students were asked where they got science knowledge from in school, they all answered, "From the teachers (and) textbooks". Students learn science "facts" through trusting teachers and textbooks, however, when asked if all science knowledge is in textbooks, student SM responded, "I think the information in the textbook is just but to guide a learner in terms of when it comes to exams…there are things you maybe you do outside and you maybe you do it daily… and you think it is science but when it comes to books, it is not there". It appears that home is the main source of science knowledge in students. According to student AG, "…yaani, yenye unasoma shule, inakusaidia sana kuelewa ile knowledge unakua nayo nyumbani (What you learn in school helps you understand knowledge acquired at home). Kwa mfano kama ukiumwa na tumbo, unaskia ati ni acid inakua released (For example stomach upset may be caused by acid released). So ukilamba ash juu ni basic, inaenda ku-neutralise hiyo acid (So if you lick wood ash which is basic, it neutralises the acid). Na sasa shule tunaambiwa acid na base zikireact there is a neutralization reaction (In school we learn that when acid and bases react together, that is neutralisation reaction). … I get to understand that there is a neutralisation reaction that takes place in my stomach". In addition student SE comments, "…parents use to…kama atachinja mbuzi. Kwanza anapaka the salt (when a goat was slaughtered at home salt was applied). So, there at home, we don't know the reason why you put your salt. But when you come on secondary, now inafafanua (in secondary school you understand in more depth what you already

know). So, you had the knowledge. What you wanted to know is the why. … So, you apply what you have seen at home now you come and apply it in school". ISK seems to be the main source of science at home and is not seen to have any benefit for students' future education and careers, while teachers and textbooks seems the main sources in school.

All teachers in this study were university trained and so gained most of their science knowledge from college. Some teachers felt that teacher training did not adequately prepare teachers for the science curriculum they were meant to teach. When asked how prepared he was as a science teacher W (teacher) described his science knowledge as mostly adequate, however, "when you go to chemistry for example…. The concept I learnt in the university is not the one that am teaching… we are not the masters of knowledge…. there are important things you do not know… We are not holistic". A teacher who is not holistically trained is less equipped to adapt science lessons to include student's experiences as a way of contextualising science lessons.

My main source of science knowledge as a science teacher was the university curriculum which was focused more on SSK and exams. I experienced the absence of ISK in what was taught at the university, although many cultures were represented in the classroom. I also wondered how the diverse cultures in my classroom could agree on a common culture, although at home we shared similar ways of selecting healthy maize seeds from a specific part of the maize comb for planting in the following season. However, putting together such cultural knowledge could be a challenge, although starting with the few common areas where cultures agree upon could be helpful. Unfortunately, teachers in this study demonstrated that these tensions still exist today at the university. Teachers in this study made efforts to reduce the tensions by integrating ISK when science content and their teaching skills allowed to make science lessons understood by learners and more so pass exams, which in such context is reasonable practice.

All participants in this study felt that ISK and culture was part of their lives, either through parents, family or community members. When asked about source of her science knowledge, KA (teacher) replied, "Some can be what

you've been learning or what you already learnt some years ago or you are still learning while others can be may be from indigenous knowledge... maybe the real-life situations". When asked about the role of ISK is in her science lessons, B (teacher) explained, "the moment a student gets to a secondary school, he is kind of polishing what he already knows…at home he does this and this, but he doesn't know why. When he comes to school, he is being explained". The comments above are like those of Mandikonza (2019) that teachers and students learned ISK and practices from their communities as part of their lived experiences. The SSK explains why things happen while IK is in the form of practical solution to problems.

Teachers in this study used the same prescribed textbooks; however, they organised their science lessons differently mostly based on the approved textbook knowledge. KA (teacher) explained that textbooks are very important; however, she made decisions on what to teach and how to teach the content in each lesson including the resources. For example, "Do you need the notes … reality? … a chat? … manila to write something and use it in class… emphasise a given definition… by reading… the textbooks ".

In conclusion the main sources of knowledge for teachers are prescribed textbooks, teacher education while ISK is a minor source. For students, ISK is the major source of science knowledge while teachers and prescribed textbooks are minor sources.

ii) About Indigenous science knowledge and school science knowledge

It was interesting that most of the participants felt that the science which they taught and learnt was objective and not socially constructed. Explaining about SSK, W (teacher) cited actual body parts like the eye and the ear to represent the nature of SSK. Student EM felt that knowledge should be practically proved or else, "you don't know whether it is true or it's a lie". Teachers' and students' perspectives were that science lessons should follow clear and logical steps to arrive at objective and verifiable knowledge. It follows that any contrasting knowledge type that lies outside the parameters of objectivity is held with suspicion. Students are exposed to a "factual" type of science that disregards their own prior knowledge, methods, and worldview. Teachers are

reduced to transmitters of knowledge which students memorise. Part of the problem is that teachers are influenced by the content in the syllabus which they taught daily, and which excluded ISK. To teacher K, most students did not understand the content of the selected science textbook, while student SM suggested that selected textbook content is focused on exams, challenging to understand and leaves out "general knowledge". Textbooks are teachers main sources of science knowledge.

Several participants felt that SSK often led to higher education and formal careers which provided status. SSK is preferred by rural students to pass exams, join higher education, get a job and improve their life chances. MW explained that she wanted to pass her exams and join university from where she could get a good job away from the farm. Student MW's view was expressed by majority of students through a chorus answer in response to the question about the importance of passing exams.

Several teachers believed that some topics in the science curriculum offer knowledge that could lead to self-development. When asked about how SSK benefited graduates B (teacher) replied, "we have this topic on electricity, the moment you understand then you can be able to do the wiring at your home. You can even do wiring to a school or a house". Some SSK is relevant in terms of employment skills; however, students of Jebi secondary school community, a remote area without electricity supply, would not benefit much from this topic today as implied by B (teacher). G (teacher) also highlighted the importance of learning English language as being essential in terms of status and communication, leading towards a successful car washing business and development projects associated with Europeans. G's(teacher) views are shared by Ameyaw, Dei and Raheem (2012:1) that, "African education is geared towards a Western expert-led economy". Participants viewed SSK as important in solving current challenges of the students and for preparation for higher education and careers. It looks like current local needs and IK has little role to play in student's future life goals.

Several teachers and students were of the view that SSK allowed them to make sense of their experiences in 'scientific' terms. When asked about the

relationship between ISK and SSK student SE explained that the topic on food preservation was part of his everyday experience when salt and smoking was used to preserve goat meat. W (teacher) added, “there is a lot of chemistry which is being done at home… baking, the soap that is used to wash clothes”.

These views demonstrated an awareness of the existence of a link between SSK and everyday knowledge that students bring to school. However, although all teachers and students identified links between SSK and ISK, SSK in textbooks is perceived as the “truth”. According to student SM, “not all the time that everything we do at home is per what is supposed to be done. But now you know when you get to learn in the books, you will understand that so here I have been going in the bad direction, so it’s supposed to be this way. Maybe you will change and maybe it will work out better than the way it had worked out before”. Students did not automatically reject indigenous perspectives; however, using SSK improved understanding of some home practices. SSK was considered more valid knowledge than ISK.

Several teacher’s views suggest that they had decided what learners should know (or should not). So teachers often made assumptions about what young people have learned at home. G (teacher) felt that some students’ experiences were “outdated” and of little use in science lessons and should be disregarded. He doubted if they were “even true” from a disciplinary perspective. ND (teacher) added that some student’s beliefs were “not real” and students should be advised against them. According to W (teacher) felt that students needed to learn scientific methods and explanation given by scientists about how the world works. However, ND (teacher) added that some traditional beliefs promoted learning of SSK. Some students believed that IK and SSK were complementary. Student NW felt that students are expected to understand scientific explanations of the world around them from an idealised SSK ignoring indigenous perspectives about the world.

Students were of the view that some of the SSK theories in textbooks and taught by teachers in the classroom were disconnected from the way they perceived reality. According to student AG, … “when we are told that this potassium, sodium…they are metals and when we come to the lab, we see they

are sugary, salty…yaani ni kama kiunga ivo (actually like soft paste) but you are told they are metals and you know of a metal is like that one (pointing at a metal water tap)…[all laugh]". Although not specific to SSK, Mandikonza (2019) argued that rural students had a "poor fit between their home experiences and what they learn at school". There is a gap between what they're told and what they see and learn from home.

The relevance of formal education goes beyond the school science curriculum, to formal education in general. B (teacher) explained, "we have some other students may be interested in things like music, games but now in the curriculum that we have right now. It is not allowing that. It is just basically education", that does not accommodate learner interests and needs. So Kenyan education in general is not inclusive of all students interest.

When teachers were asked about the methods of teaching school science, all of them prioritised scientific methods of discovering necessary scientific knowledge in the syllabus. According to W (teacher), "When I give a practical for example, you normally find that the concept comes out clearly… from the results that my students normally get ". Teachers felt that they had achieved lesson objectives if students reproduced knowledge in textbooks as Mr. Bute's opinion, "compare with what is drawn in the books. They can become more enlightened". Further, students had to carry out experiments to prove they had learned the theory, G (teacher) explained, "We don't learn the kind of things that you cannot prove, so after the theory there is still the part of the practical lesson". However, the methods and process of experiencing SSK is something students experience daily as student EM explained about fat changing into liquid in cooking.

Overall, the teachers and students in the current study think that most students in Jebi secondary school do not seem to benefit from the current science curriculum. When asked how or which students might benefit from studying the science curriculum, Mr. Njoroh said, "So now, well very few. But it is not actually helping much. But I know of a few who have gone out there and they have done good things. But it is very minimal". When asked about his views on the science knowledge he taught, K (teacher) explained, " I think there should

be more of a technical curriculum based than the learning, because much of what we are giving the students, after school if they do not succeed to go for higher studies, the rest in the village, there is nothing they can really do with the knowledge they learn in secondary school …. But as for the technical subjects, these are subjects that someone will apply directly whatever they have learnt in secondary school". When SSK was the main source of knowledge students were struggling to apply what they had learned to practical situations at home, thus SSK was not very helpful.

Most teachers lacked adequate overall ISK of the multi-ethnic school setting as ND (teacher) explained, "when am teaching the Maasai, I usually used to ask my colleague who was a Maasai on the various resource material I could use". Such teacher's ISK deficiencies may have been noted by student EM who observed that, "[laughs] it isn't enough". ND's (teacher) views are like those of Mandikonza (2019), who argued that every ethnic community had its own ISK, and so there were challenges of understanding each other. However, like Sillitoe (2006) suggested about some aspects of cultural practices being similar among diverse communities, ND (teacher) observed that some cultural practices were, "highly discouraged and condemned in almost all the cultural and religious gatherings".

So at an early age, all participants were socialised within traditional culture each of which had specific and widespread understanding of the world around among diverse communities. Such everyday life experiences could be used as resources in learning and teaching to enable students conceptualise issues beyond these local experiences.

ISK has been in existence for centuries among indigenous communities where it was the foundation of survival. According to student SM, ISK has been there since her ancestors and will persist for a long time to come, "… my parents walizaliwa wakaipata hapo (were born and found it there), I the same. My kids the same… it doesn't explain where it came from. So itakua ngumu kuelezea mtu (it is complex knowledge to explain) that we do this because of this. Even if umeisoma kwa shule, huwezi jua because sometimes it's hard (even if you learn it in school, you cannot really understand it because it is complex)…it is

the basis of the school science but then things we do maybe are different in some way". Student SM's words supported Odora Hopper's (2005) argument that ways of knowing have existed for centuries and were key to survival in indigenous communities.

Several teachers and students were of the view that ISK promotes self-esteem and pride at both personal and community level. All students in the focus enjoyed using local languages which they understood and could speak better, showing recognition of their identity within their individual communities. When asked about the feeling when ISK was used in science lessons student AG responded, "I felt so good" that ISK helped in understanding, "and even in exams I knew that ash is better. I could remember why my mother tells me to use some ashes when my stomach was aching". When asked about the role of ISK in science lessons Mr. Njoroh, "there would be a lot of interest… they will realize that their tradition had a scientific knowledge. And that whatever they were doing is just like the new modern chemistry". Mr. Njoroh's comments are like those of Shizha (2014: 118) that the use of ISK in science lessons results in students taking ownership of the SSK and, "deconstructs the misconception that valid and authentic knowledge exists outside African society". Such a positive mindset towards ISK impacts on the use of indigenous perspectives in science lessons.

Students felt that the inclusion of ISK in science lessons would make science lessons interesting. When asked about her reaction to home experiences in science lessons, student BM responded, "very lively… (because you want to) … Know more about it (general knowledge and school science taught together)". Student AG added that when ISK and SSK was used together in science lessons, "I get to understand the concept". However, according to student SE, some ISK has been modified over time, "So, they don't have their origin from the indigenous". It is possible that the lack of updated records of ISK for reference might adversely impact on the use of indigenous perspectives in science lessons.

Teachers and students were of the view that ISK was useful in making sense of science lessons, however ISK may cause some misconceptions. When asked how

she used ISK, KA (teacher) replied, “It all depends on the syllabus. What are my lesson objectives and all that? Can I bring ISK? Then will it fit or help them understand...if you use it where it does not fit that means it will be different information”. Indigenous perspectives must align with the science syllabus content, limiting the use of indigenous perspectives especially on areas where the two knowledge systems differ, demonstrating a power imbalance in favour of SSK.

Several teachers felt that ISK was a barrier to learning and teaching in science lessons. ND (teacher) previously explained about the challenges of teaching some topics students considered taboos. G (teacher) doubted the scientific basis of indigenous cultural beliefs about thunderstorms. ND’s (teacher) views are consistent with those of Shizha (2005) that ISK was misinterpreted as unscientific out of ignorance of other people’s worldview. Further, ND (teacher) considered the student’s world views as a challenge to learning and teaching of SSK. Misunderstanding of ISK and ways of knowing impacts on the use of indigenous perspectives in science classrooms.

Several teachers and students were of the view that the presence of multiple ethnic groups, each with their own ISK and culture, created problems of understanding each other. When asked about ISK in the community Mr. Njoroh said, “they lack kind of a common tradition on most of the issues that are maybe scientific”. Mr. Njoroh indicated that the multi-ethnic community around Jebi secondary school had different ISK, indigenous languages and culture, which was a challenge in understanding each other. Mr. Njoroh’s views are shared by Chikunda and Ngcoza (2017:89) that multiethnicity limits the use of, “examples from the students’ own contexts” in science lessons. When asked about the challenges of ISK in science lessons student MN responded, “we have different ancestors… there is a lot of arguing about something. So, you don’t prefer it”. Student MN’s comments are supported by Chikunda & Ngcoza (2017:89) that, “many regional and cultural variations of indigenous knowledge, names and stories… may lead to disagreement among learners “. Referring to language, ND (teacher) felt that by using indigenous language in his science lesson in Jebi secondary school, “I will be discriminating other students”. The views of the participants are consistent with those of Mandikonza (2019) that

indigenous communities have indigenous knowledge and practices which are unique to them. Lack of common indigenous knowledge and practices may impact on the use of indigenous practices in science classroom.

As observed above, teachers and students in this study participated in the teaching and learning of school science using the same science syllabus and material resources. However, during my conversation with them, they demonstrated varying understandings of and perspectives on the school science that they experienced every day in science classrooms. They also had shared and contrasting views about how they mediated between ISK held by students and teachers and the SSK in science lessons to contexualise the learning experiences.

When asked about the connection between SSK and ISK, student AG connected the germination topic and planting of beans at home. Student SE also made a connection between a topic on food preservation and traditional salting and smoking of goat meat at home. When asked about a science topic that incorporated indigenous knowledge, student MW added, “Yes. Just asked how people used ash to neutralize the reaction in the stomach. We came across the topic in chemistry where there is acid and base. You can neutralise and it becomes a neutral substance”. Student AG comment made a link between ISK and SSK. Therefore, students could see the connections and how to understand their world better because of SSK, demonstrating the importance of the use of indigenous perspectives in science lessons.

Some teachers and students believed that using everyday experiences in science lessons would improve creativity and understanding of scientific concepts. According to student AG, “ you can use the knowledge you learn at school to understand what you already know and you can use what you already know to understand what you learn at school… . So, I combine those two knowledges and I get to understand the concept”. ND (teacher) believed that ISK was, “handy when delivering contents in class”. The participants seem to echo Semali & Stambach (1997) cited in Shizha (2014) that contextual ISK describes reality as perceived by the community. When asked about any role for IK in science lessons student SM saw a connection between the two

knowledge systems, however the language and teaching methods were different, " most things we do at home they are simply what we are taught in the school… in a different way… using different language…". The comment by SM is like those of Kirch and Amoroso (2016:8) that home experiences were presented, "as if they are something new and foreign" in science lessons. However, the ways of knowing are different as W (teacher) explains, "this one that is learnt at home is more automatic…no hustles involved, no struggling, there is not thinking; it just comes naturally. But if you take the same knowledge and bring it in the school life, this one for the school requires a lot [laughs] maybe you think, you struggle". The way students acquired contextual ISK was through daily interaction with adults and ways of knowing in each community while formal education knowledge involved learning specific knowledge and culture which may (or not) be important for survival depending on context.

Several teachers were of the view that students in this study faced challenges in connecting home experiences and SSK and that they needed help. Such perspectives are consistent with the views by Aikenhead (1997) that students should be assisted to bridge cultural borders between school science knowledge and indigenous knowledge. Several examples were given by teachers to connect SSK and IK and practices. W (teacher) mentioned baking, and soap. In Physics B (teacher) identified, "topic on radiation of heat, conduction of heat... (to)...maybe in the evening they go to the fireplace… (and)... warm themselves. But they don't know that they are applying that knowledge in physics…things to do with radiation of heat". Teachers were able to cite examples of home experience that they considered helpful in achieving lesson objectives, through bridging the gap between school science and indigenous perspectives so that science lessons are meaningful. There was a connection between SSK and students' informal learning experiences. However, the ways of knowing consistent with indigenous knowledge and practices was limited impacting on the usefulness of indigenous perspectives in learning and teaching. ISK seem dissociated from learning and teaching, only picking one ISK example to help students understand a scientific concept.

Some teachers and most students referred to indigenous knowledge as part of 'general knowledge', which makes sense of the world around. However, although general knowledge was the foundation of the participants' daily survival, they somehow doubted it because it was missing in science textbooks. When asked about the meaning of general knowledge which was commonly used during focus group student SM, replied" These (general knowledge) are things you maybe you do outside and you maybe you do it daily… and you think it is science but when it comes to books, it is not there… they leave it out because it cannot be examined". Student SM's and Chikunda and Ngcoza (2017) share the view that IK is poorly documented. Students often make sense of world around them using the common-sense things they do. 'General knowledge' seems to have been used to differentiate school science and ISK.

The Kenyan school and higher education curriculum, like many others especially in developing countries is often a reflection of a global curriculum and which is presented as beneficial for all learners to study. When I went to university in Kenya, the head of department informed us that the course materials and syllabus were the same as the ones in European universities. I felt good about this at the start; however later in the course I realised that the issues and subject contents had little link to my local experiences and needs. Although local context was mentioned, there were no opportunities in the curriculum for SSK to improve the local knowledge systems and therefore improve problem solving skills at home. My experiences resonate with the views of teachers in this study, who said that in college they were not prepared to teach learners in rural areas who were rich in ISK and indigenous languages, implying little has changed since my time in college.

In conclusion, participants in this study are either directly or indirectly involved in indigenous perspectives at some point in their life. Indigenous perspectives are poorly represented in the science syllabus and pedagogical practices, owing to the limited reference to contextual knowledge and practices that resided in the school setting. Participants did not dismiss ISK as being unimportant in understanding scientific concepts and a source of interest in science lessons. However, teachers appeared to favour SSK referring to it as objective knowledge, while indigenous perspectives were regarded as being of lesser

value, limiting its use in science classrooms. The science lessons, science syllabus and textbooks had an influence on the favourable perception towards SSK by participants. Therefore, the use of indigenous perspectives in science lessons faced challenges associated with unfavourable perceptions towards IK, and with what the goal of science education was perceived to be.

4.2.4 Teaching and learning methods.

Teachers' learning and teaching approaches are discussed under the following headings: Teacher-centred learning approaches; practical activities; organisation of learning and teaching.

i) Teacher-centred approach

Most teachers had a similar pedagogical approach in science lessons that involved the extraction of information from the approved textbook, which is presented to students and copied by them into jotters. As a teaching method, G (teacher) provided his students with assignments and solved examples to guide them learn a concept, "because I will be very strict…So that they can understand the concepts well…(so that)… when I come to class the next day, they will be ready to learn another concept". For KA (teacher), "they have to just memorise what you told them". According to student SM, if the teacher confirmed that a student had achieved a lesson objective, then, "you know that you are perfect…now …you can believe in yourself". The classroom power balance which is in favour of the teacher persists. Focus on performance is an important issue raised in determining pedagogy in science classrooms and this is discussed later.

Learning and teaching focused more on prescribed knowledge that would enable students to answer some standard questions, fulfilling the requirements of policy and demands of exams. This may lead to students learning and memorising random "facts" about the world with little contextual understanding.

Several teachers and students felt lecture methods were inappropriate teaching methods. Mr. Njoroh considered it as, "not fair in science". ND (teacher) added that students were passive learners, "laid back… don't ask questions," and

teachers could not identify learning challenges which formed, “a barrier to a concrete understanding”.

Teachers’ and students’ interactions provided an empowering space for students in science lessons. Students demonstrated knowledge of some contextualised SSK which teachers may not have had. Teachers also felt that students potentially had something new to contribute. For example, when discussing about acids and bases under the topic of neutralisation in chemistry, KA’s (teacher) students suggested, “we use the charcoal [laughs]. Okay they get the charcoal and dissolve it in water, and then you taste the solution… I don’t know. That is what they told me”. KA (teacher) added, “doing calculations… maybe they know of an alternative … they can tell you of an alternative way of doing the calculations”. ND (teacher) added, “You will hear them (students) suggesting different kinds of test. Like on Saturday I was having a tuition class and they were telling me instead of doing the smear test to test for lipids we should use the emulsion test”. When students suggested doing things differently, it made the teacher appreciate the capability of students in taking more ownership of their education.

Students and teachers felt that student to student interaction allowed independent learning for better understanding of SSK. According to G (teacher), “The teacher should give students time to think and speak out their mind and give direction”, so ISK could be the foundation of learning science. Student AG added, “maybe you ask a question from your friend. The person might be knowing more about it. Then from what he/she shall tell you, you understand more…you can use any language...like vernacular”. Student AG support’s views by Mandikonza (2019) that student interactions using indigenous perspectives in classrooms improved intellectual growth. According to student SM when a student is allowed to make classroom presentations, “you see they are attentive… believe in yourself”. On the other hand, according to student NW, some students may undermine each other that, “you do not know much… (or is) …lying to them”. So, students need effective interactive skills for effective learning in groups.

Several teachers encouraged students' voice in the school science classroom and reduced the gap between school science knowledge and students' experiences as a way of making science lessons more interesting. According to ND (teacher), "…Let's say for example if it is not part of the concept that am supposed to teach but this student is curious about something that they do at home ….So, I will… tell the students on how to make it better…I have not poured cold water on the student, but I have shown interest in whatever the students were telling me and I have even suggested on how they can make the process a better one. Then I will use a link back to draw the attention of the student back into the content I was supposed to deliver in class". G (teacher) added, "go down to their level, because if the gap widens (student/teacher) it becomes a problem freely interacting…know their language… give them the freedom to speak their mind…do not condemn them... That calls for some patience… you can tell where they are going wrong and correct them". When teachers positively engage with student's' curiosity and link it into the learning and teaching process, they are promoting indigenous perspectives that lead to meaningful science lessons.

Most teachers and students felt that the science curriculum often left out things that students were more interested in. When asked to comment on school science topics, student MW replied, "topics are narrow leaving out things I consider important". According to G (teacher), "the student may not ask about exam questions but about their everyday experiences on electricity. They ask questions like why birds stand on electric wires which carry a current of about 10,000 volts but they are not electrocuted [laughs]". Student SM felt that practically connecting wires in radio was more important in a physics lesson because it was part of their home experiences, however, "they (teachers) leave it out because it cannot be examined". Students appeared to know about what they wanted to know, which was understanding their environment better, contradicting the curriculum focus on exams (examinations are discussed later. One teacher expressed fears of free teacher student interactions because they did not want a discussion to go in a direction they did not know about. According to G (teacher), "a teacher feels pinned down when a student takes discussion in a direction that the teacher may not like or do not know".

Teachers may have felt threatened by discussing things they considered outside the syllabus impacting on use of indigenous perspectives including the potential formulation of new ideas in science lessons.

ii) Practical activities

Learners in this study expressed enjoyment in the natural learning environment where they could discuss their experiences with each other in languages they were familiar with, including English language. For example, student AG mentioned enjoyment in a topic on types of germination which she experienced at home, while student BM enjoyed discussions that allowed the use of indigenous languages and English, although there was a risk of not doing well in English written exams. I recall in my primary one class, my teacher taught about plants and animals pointing with a wooden stick at photos on the classroom wall. I could recognise most of the plants and animals. However, it was only when I visited Nakuru National Park on a school trip that I came face to face with most of the animals in my science lesson and learned about their importance to humans. I also learned about the food chain that existed in nature, when I experienced lions and jackals hunting for food, a real-world learning that is still fresh in my mind. This experience encouraged me to converse with other learners, teachers and parents who accompanied us into social interaction and engagement in this natural learning environment. Since learning was outside the school, I and others on the trip were allowed by teachers to use their mother tongue, I felt at ease expressing my emotions, asking questions and airing my views in confidence.

All teachers and students in my study believed that practical activities increased student engagement and interest in a science lesson. Student AG explained that learning about a leaf through doing and seeing, “would be so interesting”. Student SE added that practical work improved understanding and retention of information. So students enjoyed hands-on approach in science classrooms. K (teacher) felt that more practical lessons were necessary for engagement with work and, “a wide exposure using apparatus (and) reagents”. However, according to Mr. Njoroh the headteacher, the financial cost of science equipment was inhibiting, so the school has limited science facilities.

The scientific method of science formed the foundation of scientific investigation to arrive at predetermined "facts". According to ND (teacher), "I prepare the experiments and guide the students on how to do them". For W (teacher) "There is a working sheet I must ensure that they follow - there is that guideline… we have the observations and the conclusions" so scientific methods are used to prove a science theory. Student MW commented, "some practicals do not make sense", so some experiments do not link to student's life experiences. These views are consistent with those of Kirsh & Amogoro (2016: 1) that students were interested in doing experiments most of which they could not relate with, "and over time science is seen as a place where students go to learn and memorize random facts about the world discovered by an anonymous person".

The views of teachers and students in this study seem to agree with my experience in school and my realisation that the aim of development of hands-on practical sessions have an element of control through rote memorisation of procedures to be applied that leads to a confirmation of a certain theory.

4.2.5 Challenges to quality of instruction in science lessons

Education resources which are important in learning and teaching methods are closely connected to exams. The challenges were discussed under the heading: teachers.

i) Teachers

Science teacher shortages have been identified in this study as a challenge to the learning and teaching. According to the school headteacher Mr. Njoroh shortage of science teachers and high turnover is a challenge, so, "we are also trying very much to retain most of our teachers". The consequence of teacher shortage, W (teacher) explained is that "individual (pupil) attention is not there". Classes seem too large for effectively teaching for all learners.

Most teachers in this study felt that they got into teaching by accident after failing to qualify for their chosen careers. However, after finding that teaching was the only job for them, they accepted it and were enjoying the experience. B (teacher) wanted to be a nurse; however, she did not get the needed grades. According to Mr. Njoroh the headteacher, teaching was originally never an

option, “I never thought I would be a teacher… I didn’t like it” … (later) I really realized I am in the right place… I enjoy being in teaching”. Teachers with weak academic achievement in a career for which they never psychologically prepared themselves, may find themselves overwhelmed by the complexity of formal education which may include students with many needs.

All teachers in this study are graduates of education from Kenyan universities, except the headteacher who holds a diploma in education. Most teachers are trained in school science knowledge at university level and have received limited further professional developments and experiences. University degrees take four years to complete, and diploma course take two years. The science knowledge acquired from university by teachers in this study had little focus on the students to be taught. According to W (teacher), “Many are the times even after maybe the university, there are important things you do not know. I was once new in this profession, and I did not know things like the preparation of solutions. Not many teachers know how to prepare solutions. So, you see it is not holistic. It has not prepared that person. Or like in our case here, I have teachers whom I have trained on how maybe to prepare solution. So, you see there was a link that was not wholly catered for…that time allocated (for training) is not sufficient. Therefore, we learn while in that job”. W’s (teacher) views are supported by Chikunda and Ngcoza (2017: 89) that teachers should have adequate disciplinary knowledge to be able to incorporate ISK in science lessons.

Teachers’ training had left gaps in knowledge that teachers continue to fill guided by the syllabus, putting doubt on indigenous perspectives whose guidelines did not exist. When asked about the relevance of university training to actual teaching W (teacher) said, “what I teach, I had the prior knowledge from the university... (in) chemistry for example…there is a topic Organic chemistry. The concept I learnt in the university is not the one that am teaching. It is so broad. Maybe it is preparing me for further advancement... the concept is enough, and we can teach what is required but no, some of the content taught is not what is in the high school syllabus. It is at an advanced level”. When asked about teacher training in context W (teacher) replied, “it does not cater for these mushrooming schools. Especially right now when we

have the compulsory secondary education… you had 100 marks …it is compulsory that you go to high school. So maybe the curriculum, it should cater for such level of students". Teacher W was referring to the majority of rural students who achieved low grades at primary school exit exams, mainly because of a disadvantage contributed by an exclusive education curriculum and remote environment. In addition, teacher W doubts if teacher training provided adequate pedagogical skills to effectively teach inclusive classrooms.

Teachers felt that continuous professional training was limited; however, the school made some effort to encourage it. When asked what training support he offered teachers Mr. Njoroh the headteacher paid for workshops, "for example in mathematics we have been sending them, though I have not seen any from science". When asked if the government offered any professional support ND (teacher) answered, "No". Teachers have no professional development support to update school science knowledge adversely impacting on the quality of instruction in science lessons. Such teachers with less science knowledge may not have the skills needed to make connection between student's home experiences and science knowledge.

In this chapter I have identified some key points which I am going to discuss in more depth in Chapter 5 in relation to answering the research question. The adoption and influence of western culture and values on the science curriculum was highlighted by teachers and students in this study who experienced disconnect between science knowledge, English the language of instructions and pedagogy and ISK, indigenous language and local culture. Teachers seem to have limited voice in policy making, curriculum planning including learning and teaching/pedagogical strategies. Students are often silenced in classroom through the use of English language, teaching methods and exclusion of ISK. ISK which children experience everyday through their communities and families tends to be excluded from the classroom. Teacher preparation had a significant influence on science knowledge, methods and attitudes that were held by science teachers. There seemed to be limited connection of science lessons to all student's immediate physical environment, the spiritual and cultural values of learners and their communities. These issues will be the focus of discussion in chapter 5.

Chapter 5: Analysis and discussion

Introduction

This study is investigating the extent in which indigenous science knowledge (ISK), indigenous languages, culture and pedagogical approaches is used in a rural secondary school science curriculum in Laikipia County, and how this information could be used to support and inform future curriculum reforms.

The main issues identified from the data centre around 5 areas:

1. Drivers impacting on the place of ISK in the curriculum.
    - Policy

    Curriculum content, resources and funding
    - Language of instruction
2. The place of voice.
    - Teacher voice
    - Pupil voice
3. Teacher education and learning and teaching.
    - Teacher Education
    - Learning and teaching
4. IK and Science in the Community.
- Tensions between what community knows and what is taught and valued in schools

5. Concerns for sustainability, climate issues and challenges

It is important to discuss these issues in more depth in order to assess their potential impact on future curriculum reform.

5.1 Drivers impacting on the place of indigenous science knowledge in the curriculum

Within this section there are three areas that were identified as impacting on the place of indigenous science knowledge through the data. These include

1. Policy
2. Curriculum content, resources and funding
3. Language of instruction

5.1.1 Policy

Education policies shape and influence the direction of development in schools. They align with society's goals and aspirations and are seen to be a way of introducing change to a system (UNESCO, 2023). The Kenyan government are clear that they want to develop and transform education and recent policy developments are aligned with the overall Vision 2030 document that was launched in 2008. One strand of this vision centres on science, technology, engineering and mathematics (STEM) programmes and is clear that education has a key role to play. An aim of this policy is "to promote experiential learning, innovation creativity and attraction to STEM related disciplines through well-coordinated programmes in education, R&D and Training in all aspects of ST&I at all levels starting from Early Childhood to Primary and Secondary Education levels up to University" (Kenya Vision 2030). However, despite this, gaps remain between what policy says and what happens in schools (Angrist & Dercon, 2024).

Education in Kenya is conceptualised as a "powerful weapon against poverty" (Ministry of Education, 2008: 4) and as a means of bringing about national unity where English language was viewed as a tool for unity and a bridge to global knowledge and trade. However, Ogunniyi (2015) argues that most African people in educational leadership were western educated and so the curriculum and exam bodies they are in charge of assume colonial universal science content, culture and language, to the exclusion of the student's background and the socio-cultural contexts. In addition to this, a lack of African models of development have encouraged the domination of western culture in education and development policies (Republic of Kenya, 2005; Mwenda, 2003) thus impacting on the use ISK in classrooms. It is noticeable that many of the sources of opinion on the drivers of curriculum and pedagogy are from European or North American sources (Kaviti, 2018). Literature focusing on the Kenyan, or even the African context is more often a response to European or North American models of education rather than the development of a distinctive African educational model (Kaviti, 2018). It could be argued that this

dominance contributes to the ongoing minimisation of ISK in the science curriculum.

African countries and in particular Kenya make decisions relating to education mostly based on outside influences. For example, according to the International Commission on Financing Global Education Opportunity (2016) poverty is reduced through economic development and growth. In Kenya, the Sessional Paper No.14 of 2012 focuses on economic growth, social development fuelled by the development of skilled employees and particularly in Science, Technology and Innovation (ST&I) and who should be educated and trained in the education system. However, Jepkemei (2020) argues that poverty alleviation has a cultural dimension, where identity through language is the foundation of intellectual innovation and development, ideas which support the inclusion of ISK in science lessons for meaningful learning to reduce poverty.

The 2012 Policy Framework for Science, Technology and Innovation identified a knowledge-based economy as the foundation of industrialisation in Kenya. Within this framework the "concept of technical and vocational education starts from primary education as Environmental Activities and Science and Technology learning areas" (Osumbah & Wekesa, 2023: 183). The inclusion of technical and vocational education and training would seem like a positive step forward, however Mattu & Rothwell (2023: 11) argue for the "integration of indigenous philosophies into the TVET framework" suggesting that this aspect has been overlooked. They suggest the inclusion of this would herald "a paradigmatic shift towards a more localized, inclusive, and equitable education system in Kenya". The Kenyan 2030 vision document is clear about the importance of indigenous learning. Article 11(2) (b) and (c) states "the Constitution recognizes the role of science and indigenous technologies in the development of the national and the promotion of the intellectual property rights of the people of Kenya" (Ministry of Education, 2012).

The policies and vision seem to acknowledge and offer opportunities to include IK and ISK, but these opportunities are not always taken. As discussed later in this chapter ISK has a role to play in contributing to sustainable development (United Nations Department of Economic and Social Affairs, 2019). Anor (2024)

concludes their study with a series of recommendations, one of which is "The recognition of indigenous knowledge's role in providing education for sustainability should be reflected in educational policies". The policy landscape in Kenya would seem to already include this. When the rhetoric in policy is placed alongside the lived experiences of the participants of this study the gap between policy and practice becomes evident.

5.1.2 Curriculum content, resources, and funding

Internationally, the content of the school curriculum is usually a key public issue that often results in long debates around politics in constructing the official school curriculum, which is often viewed as a set of government statements of what students are expected to know and be able to do (Levin, 2007). Such statements often unintentionally (or not) exclude students' experiences at home. Shizha (2014) argues that the content of the school curriculum in Africa reflects western values, practices and beliefs. Dei (2014) argues that the curriculum represents the social values of those in power who often resist an education change that does not serve their interest. It is important to offer all stakeholder equal contribution at every stage of policy development to improve inclusivity. The Kenya Institute of Education (KIE) (which is today Kenya Institute of Curriculum Development KICD) plays the role of curriculum development including deciding on subject-specific syllabi in basic education. KICD decides on the prescribed knowledge and material resources to support the syllabi (Kenya Institute of Education, 2009). It is clear KICD controls the knowledge and the way it is learned in schools impacting on alternative knowledge and learning methods in explaining nature. In Kenya, the curriculum focuses on memorisation of "facts" and exam performance rather that relating learning to the socio-economic needs and self-reliance of learners. Within curriculum as a body of knowledge model, Kelly (2009) argued that subject content is presented based on clear objectives to be tested at the end, in the process excluding alternative ISK to explain nature.

The influence of globalisation makes the reference to curriculum as a product (as discussed in chapter 2). This is relevant, particularly in independent African countries where the focus of poverty reduction is a key goal. In Kenya (Jepkemei, 2017; Amukowa et al 2013) education reforms are mainly in

response to social and economic needs, globalisation and constitution requirements. The Kenyan science curriculum fits into what Kelly (2009) called a curriculum model that was concerned with a specific body of knowledge per discipline where teachers only associate it with documented instructions sent to schools by authorities for the teachers to translate into meaningful knowledge (Curriculum as a body of knowledge). According to some authors (Kelly, 2009; Schiro, 2008) content to be taught and pedagogy is clearly grouped together along very specific performance criteria to facilitate easier assessment. The Kenyan science curriculum recognises IK and practices without providing implementation guidelines, leaving teachers to decide for themselves whether to include it in class or not. Dei (2014:179) argues that SSK is guided by capitalist ideals within a globalised world which, "run contrary to issues of the Indigenous and Indigeneity" so although there is recognition of IK within the content of the school curriculum in Kenya it also reflects western values, practices and beliefs. Ogunniyi (2015) suggests that the science curriculum links the content, teaching and assessment in a potentially organised version, often leaving little room for students' home experiences which could allow them to question for deeper understanding of the topic. Teachers are expected to transmit prescribed knowledge to students using an appropriate teaching method (Blenkin et al 1992), and also teachers are often not involved in the process of making policy, restricting them to the role of transmitter of knowledge (Kelly, 2009).

The teachers in this study said that they spent considerable time in science lessons reviewing what was learned in the last lesson to confirm that scientific concepts were well understood and that there were no misconceptions. They were concerned that learned science knowledge and skills would become automatic, although occasionally when a student asked about ISK teachers attempted to make a link between it and SSK which encouraged students to engage more with the lesson. However, teachers reported that teacher preparation did not provide teachers with skills to allow student's life experiences and practices to be routinely incorporated into lessons. Focusing on set learning objectives often silences students by limiting their worldview and culture to become part of the lesson. Potentially teachers are also prevented

from being innovative in their teaching approach. Local cultural knowledge or community contexts seem to lack space in classrooms and teachers are often denied opportunities of responding to differences among students or in their learning contexts.

Data from participants in this study indicated that science lessons were mostly focused on achieving set objectives in the science syllabus and these were organised in topics in science textbooks. This concern was highlighted to the task force appointed to oversee the re-alignment of the education sector in 2012 "the curriculum is objective oriented and geared towards passing examinations. This approach hampers learning as learners are often drilled to pass examinations" (MoE, 2012:51). Teachers and students in the current study prioritised learning of the prescribed science knowledge in a way that focused on attaining good grades, particularly for the exit exam. Ogunniyi (2022) argues that when science lessons limit the non-western contribution to science, indigenous students can feel alienated and lack interest in "foreign" science knowledge, studying it only to pass exams. Students in this study reported that the science textbooks did not include aspects of IK calling into question the use of ISK in classrooms, although teachers in this study indicated that in some science lessons, they did try to include IK, student's life experiences, language and culture which promoted student understanding and interest. One student described how food is preserved at home to keep it fresh for a long time, while some teachers suggested that lack of food among students at home in this study was a major problem impacting on learning and teaching. The study area being a rural dry area with little rain for farming meant that lack of food is a significant challenge, however science instruction failed to introduce these into projects focused on increased food production and preservation. Linking student home knowledge to scientific concepts could have a practical impact on the students' lives, although teachers had limited awareness of student's cultures and background and limited pedagogical skills to successfully incorporate student's diverse cultures in science lessons. The data from students showed that IK and language which students have interest in and have connection with at home was missing in science textbooks which were dominated by SSK and written in English, the language of instruction, implying

that a science lesson that draws on the cultural knowledge and lived experiences was needed. According to some authors (Avery and Simmons, 2001) official textbooks contain official school knowledge, identities and national values which the government pass to students through classroom instructions.

The selection of the textbooks that are used in all subjects in Kenya is the role of the Kenya Institute of Curriculum Development (KICD), which is also responsible for authoring, publishing, and assessment of official subject textbooks, teacher guides, and supplementary materials. However, Ogunniyi (2022) states that learning and teaching of science and the organisation of science knowledge into topics in science textbooks often discriminate against non-European student's knowledge contribution and interests. Lack of students' lived experiences in science textbooks leads students to feel that science is a "foreign" thing outside their everyday life, and they only study it to pass exams. Although students and teachers in this study did not dismiss IK, SSK in science textbooks was viewed as legitimate knowledge, in particular a student suggested that SSK needed to confirm if IK is "right". Teachers and students often interpreted their world from idealised world of SSK in form of beliefs about science knowledge and what need to be known, impacting on the use of ISK.

As far back as 2013 Mulongo noted that schools which are located in remote areas of Kenya faced a dire shortage of infrastructure and learning equipment and facilities. Teachers in this study reported that inadequate science laboratories and equipment presented a serious challenge and impacted on the learning and teaching of science lessons. Teachers reported that teacher-led methods of teaching were often a result of the lack of science equipment. While there was indeed a lack of science equipment, teachers gave no consideration to the rich resources in the environment. The resources in local environment could have been utilised to provide opportunities for engaging science lessons. But since teachers perceived that the lack of laboratory equipment was the barrier to certain forms of science, local resources did not become part of the solution to the lack of expected science resources. Students and teachers in this study therefore reported that a lack of adequate science

equipment to achieve the stated lesson objective was a barrier to more interesting science lessons.

The school in this study could not afford the high cost of laboratory equipment. The study school had few classrooms, inadequate laboratories and equipment, no library, lack of supplementary resources and was located in a remote area. Inyiega et al (2021) argue that politicians fail to see the place of teachers and students and learning resources in the educational reform process. As a consequence, science classrooms in Africa face serious challenges of inadequate learning materials especially laboratory supplies which impacts the quality of instruction (Ogunniyi, 2015). According to Nashon (2013:216) the local setting has a "richness in scientific phenomena that can be readily mediated through curriculum"; however, the Kenyan science teachers in this study rarely exploited the potential to mediate student learning. Takayama et al (2014) have argued that there is improved motivation, enjoyment, and engagement when learning takes place in natural setting. Research by Alon and Tal (2015) found that both teachers and students agreed that nature activities whether teacher directed or student-centred improved engagement and motivation. The school setting in this study is rich in both farming and livestock activities since it borders a natural forest and other natural resources, a favourable location for learning and teaching of natural science.

The study school has limited science laboratories and equipment and financial resources. However, the surrounding school setting could be viewed as a natural science laboratory where students are surrounded by the natural world. In this study, students identified crop farming and livestock keeping as some key activities at home. These and others like bird watching, bees, flowers and stars add to the curiosity of students, where through practical science activities they could develop observational skills, literacy skills and scientific enquiry. Kuo et al (2018) state that nature makes a significant contribution to student creativity, more social and improved cognitive development. Science concepts are explored and understood through more practical ways. A teacher in this study reported that he used potato starch available locally when commercial starch was unavailable and achieved the learning intentions in the process contextualise a lesson. Achieving science learning intentions and successfully

solving a problem with local readily available resources is an energising experience for both the teacher and the students.

The Kenya government disburses capitation grants to all public schools to buy learning materials and cover other running costs including teacher professional development. According to Republic of Kenya (2012) funding is allocated up-front to ministries and districts rather than defining functions and then determining resource needs, impacting on required funding especially for resource poor rural schools. Capitation disbursement often disadvantages rural schools without adequate classrooms, library, science laboratories, science equipment and teacher numbers. There is evidence in literature (Rollnick, 2014; Woolman, 2001) to suggest that globally and especially in Africa, rural schools often receive relatively less government financial support in terms of the need when compared to urban schools. In Kenya due to weak economic circumstances available funds are the minimum required (MoEST, 2015) for the increased number of students enrolled, with implication for effective learning and teaching. Parents were expected to contribute money to children's education to fill the shortfall, a cost which is relatively higher in rural areas, despite the fact that most rural poor have limited income (World Bank and UNESCO, 2009). Naidoo and Lewin (1998) reported that inadequate funding of rural schools in South Africa led to inadequate facilities for science such as laboratories and basic equipment needed for improving quality of science education. In this study lack of money meant limited laboratory equipment, few teachers professional development opportunities or educational tours, few practical lessons, creating a barrier for teachers in linking prior experiences of students with prescribed science content.

To provide complete free day secondary education in 2018, the Kenyan government developed an initiative to avail all educational resources needed to cover compulsory secondary school education (Kaviti, 2018). However, the government plan to provide funds and resources to construct school facilities (science laboratories and classrooms) was very ambitious since there is a regular delay is sending capitation funds to schools thus impacting on education programmes. With the regular cash crisis some public schools almost halted learning and teaching, casting doubt as to whether the Kenyan government

could afford to provide Free Secondary School Education and a new and expensive curriculum (Kaviti (2018). There are also hidden education costs to parents above the resources allocated to public schools. Students in this study reported often missing classes due to lack of money for school meals and school uniform. The Head Teacher in this study reported that the funding he received was inadequate for the school. The disbursement of funds to the school were not always paid on time. This impacted on the teachers' ability to allow the pupils to engage in practical experiments due to a lack of equipment. Teachers felt forced into doing practical demonstrations thus denying the young people a hands-on experience.

5.1.3 Language of Instruction

Jones (2012) argues that due to the past colonial histories of sub-Saharan African lifting the profile and status of indigenous languages is particularly important. Citing Adegbija (1994) she claims that a failure to speak English can result in a person's aspirations being curtailed. Drawing on the work of Hovens (2002) she argues that interest in maintaining indigenous languages provides "the opportunity for learners to benefit from the pedagogic, cultural and social benefits of using them for instructional purposes" (Jones, 2012:237). In this study, the headteacher reported that he allowed students to use indigenous language in the school and by extension encouraged the use of IK in classrooms. Students in this study seemed to enjoy discussing science with peers using indigenous language which improved their understanding of scientific concepts. They believed that IK worked, and they could identify some links between IK and SSK, demonstrating complementary principles of the two knowledge systems. Students considered IK and SSK to be equally important in explaining natural phenomena, and the use of IK in science lessons could make learners value it more and develop confidence in IK, which is the foundation of survival in context, however using a second or third language as language of instruction and exams was problematic as they reported that they struggled to competently express their ideas. Although students in this study supported the perceived usefulness of IK in making sense of SSK, they were concerned about diversity of IK and indigenous languages among themselves which are a problem in understanding each other, so they seemed to support the use of both English and indigenous languages.

Mavuru and Ramnarain (2020) found that although indigenous languages encouraged critical thinking in students, science teachers had little pedagogical skills in using local languages in science lessons. However, using mother tongue and foreign language provides a broader alternative perspective of understanding the world around, although challenges of the choice of language to use emerge where learners come from multilingual families (Mavuru and Ramnarain, 2020). Both English and indigenous languages should have equal status in science lessons to allow students to move from silence to speech for meaningful learning. Barret (2017) argues that mother tongue should be allowed in science classrooms so that students are facilitated to engage with and build on dynamic local practices experienced every day at home, promoting the use of ISK. While the school allows for the use of indigenous languages, assessments take place in English. This puts pressure on teachers to limit the use of indigenous languages given the pressure to pass exams. In addition, the exams assess only SK and so the incentive to include ISK diminishes.

A teacher in this study, suggested that science should be translated into indigenous languages so that students could be more interested in it. According to authors (Aikenhead, 1997, 2001) knowledge of local languages allows one into the store of IK and local cultural practices. Aikenhead (2001) argued that translating an indigenous word into another language may not provide an accurate meaning and deeper understanding in classrooms. When indigenous languages are used in science lessons, students and teachers may have an opportunity to have a broader perspective of an issue from different language structures and worldviews (Metallic & Seiler, 2009). The implication is that understanding of indigenous languages by teachers offers students an opportunity to link IK with SSK for meaningful learning.

Another teacher reported that he was confident using his mother tongue to identify plants when teaching students from his ethnic community, however he struggled in a classroom with different ethnic group and sought help from a colleague from that ethnic group. This collaborative way of working resonated with an investigation into Māori medium science classrooms by Wood and Lewthwaite (2008) who found that teachers with more understanding of Māori knowledge and practices supported those teachers with less of that knowledge.

5.2 The voice of the voiceless

The concept of 'voice of the voiceless' was used by Shizha (2007) in a study in Zimbabwe to investigate the inclusion of IK and languages in rural primary school science lessons. Shizha found that IK and language representing the students' voice reflected their social and cultural perspectives which made science lessons more meaningful to them; however, education systems - particularly the exam system – sometimes prevented teachers from using a variety of pedagogical strategies.

In my study the issue of power was particularly important, as it is argued by some authors (Dei, 2014; Giroux, 2002) that formal education is a place where power plays a significant part in the process of knowledge production. Issues around power relationships often determine how teachers' and students' voices are heard, valued and acted upon (or not) in school. For example, in the focus group students were often able to express themselves within the space provided by research protocol. Eloquence and confidence were observed as students expressed themselves on issues about SSK/ISK and also expressed strong opinions on how to mitigate the tension between the two knowledge systems for more meaningful learning of science. As a researcher and a "teacher", power relations still existed, however in the school space provide in this study, young people freely expressed themselves. This contrasted with classrooms where young people were sometimes restrained expressing themselves.

5.2.1 Teacher voice

Dunn (1995) describes the policy making process as political, where powerful policy makers in government make all policy decisions from setting the policy agenda, formulation, adoption, implementation and evaluation. Globally, teachers including the Kenyan teachers in this study have little input in education policy formulation. According to Gikungu et al (2014) education policy formulation and curriculum development in Kenya is controlled by policy makers with the intention of reducing individual poverty and improve economic development of the country. However, teachers' autonomy, which allows teachers to make professional decisions and act on them in practice is limited

not by the policy per se, but by circumstances in schools such as exam performance and a lack of resources and funding.

Teachers in this study knew that ISK contributed to more interesting lessons and more effective learning and teaching for their learners. In addition, teachers in this study allowed students to use indigenous language to help them express themselves better, although English was the language of instruction. The data from the teachers in this study demonstrated that teachers knew more about the realities in their classrooms and about how they could support young people in their classrooms, they have something important to contribute to the curriculum planning process, if they are afforded opportunities to contribute. This resonates with Munazza (2004) who argued that when teachers are involved in the curriculum planning process, they potentially develop skills that provide the right context for effective learning and teaching. As far back as 1992 Oliva argued that when teachers are involved in curriculum planning process, they become more innovative in their teaching and provide students with more effective learning experiences. Mulenga (2015) states that teachers play a key role in encouraging learners to learn prescribed knowledge, practices, values and attitudes. With specific reference to Kenya, Wanyama and Chang'ach (2013) argue that the government control over pedagogy has made many teachers uncomfortable with teaching strategies that do not reflect realities in classrooms. As data from this study shows, teachers are rich in knowledge and classroom experiences which is an asset to curriculum planning process, however teachers' classroom experiences can only be useful if they are part of a curriculum planning process that determines what teachers are to implement (Baene and Apple, 2007). Teachers in this study suggested that they have important role to play in the curriculum planning process for more effective learning and teaching experiences for students. Teachers suggested that the curriculum planning process needs to take account of the challenges students face, and what should be integrated or removed from the curriculum. In addition, teachers had specific ideas about a curriculum that includes the needs of all students and includes a wide range of curricular areas such as music and games which all students were interested in.

Findings in this study show that headteachers were rarely invited to join workshops discussing the curriculum planning process, indeed the headteacher reported on only being invited once to a workshop where they were told what the curriculum would be. According to some authors (Kaviti, 2018; Handler, 2010) school headteachers around the world including Kenya were seldom involved in the process of curriculum development. This denied them sufficient knowledge and understanding of the curriculum they were expected to implement. However, in Kenya and internationally, headteachers are representatives of the government in schools, a position that Webb and MacDonald (2007) suggest provides power and authority to make curriculum decisions in schools, implying they can facilitate incorporation (or not) of ISK in classrooms. In this study the headteacher was supportive of the use of ISK, but in spite of Webb and MacDonald's claim, this was limited by the factors mentioned above. Priestley et al (2015) argue that if the culture of the school encouraged different pedagogical approaches in achieving curriculum goals for teachers, then teacher agency is likely to develop. They suggest that a trusting formal and informal relationship between teachers, the headteacher and students, where information flowed easily will lead to a sense of confidence within the school and cultivate an environment where teachers would use different pedagogy to solve the problems they experience. Black (2011) argues that headteachers can allocate time and opportunity within the school timetable and curriculum to allow teacher voice. In my study although headteachers could empower teachers through the school system and policies so that they are part of the decision making within classrooms in terms of science curriculum development, pedagogy and choice of learning material resources, both teachers and headteachers felt constrained by the circumstances in which they found themselves. Both groups seemed to feel disempowered. A lack of professional recognition and identity for teachers and headteachers appeared to have an impact on learning and teaching because they often lacked the freedom to use their professional judgement in, for example, science lessons. Teachers and headteachers had limited input into the policies and curriculum that shaped learning and teaching.

5.2.2 Student voice

Within the classroom there were limited opportunities for "student voice" to emerge. Sometimes this was due to cultural respect for elders. Other times it related to the language of instruction and also how learning and teaching was organised within the classroom. However, as my study demonstrates, the young people had ideas and opinions that they were willing to share if offered the opportunity.

Data from this study demonstrates that teaching techniques and ways of knowing used in science lessons hindered or supported "student voice". My conversations with teachers and students indicated that most of the time teachers used teacher-led pedagogy to be able to complete the broad science curriculum content set for each level and year. Banihashem and Macfadyen (2021) suggest that the behaviourism model (discussed in chapter 2) focuses more on measuring learning outcomes and keeping track of learning progress through learning activities, implying that pedagogical approaches are tailored to achieve specific learning outcomes, and they offered little opportunity for student voice.

In my study, the prescribed science knowledge and guided learning activities were intended to assist a student to master the science content so that they could achieve the learning outcomes and pass exams. Understanding core scientific concepts was more important rather than critically understanding the underlying sense of science knowledge. Rollnick (2014) argues that teachers fail to actualise active learner participation in their classroom and persistently use the lecture method of delivery, mainly because of a lack of science equipment, teacher beliefs and practice. However, in the view of students in this study, when a teacher used indigenous language in the lecture method of teaching, they reported that their interest, engagement and understanding of scientific concepts improved. With this came reports of increased confidence in learning and engagement.

Students also reported that practical activities improved student engagement, understanding and retention of science knowledge and offered an opportunity for their voice to be heard. Teachers occasionally allowed classroom presentations, practical work and peer to peer interactions which learners

expressed enjoyment in and reported that they developed confidence in the process. However, staff reported that the financial cost of providing this was prohibitive and underfunded by Government. This lack of resources therefore impacts on consistent opportunities for student voice to be heard in the classroom.

According to Laux (2018), groupwork encourages learners to work as a team, interact, be creative, express themselves and become self-reliant. Students in this study reported that they enjoyed working in a team of friends where they could use any language they liked, including their mother tongue and English language to better understand SSK. However, Kenya's examination-driven education system reinforced regular reliance on rote learning. Students also indicated that they had to translate their understanding into a second language to pass exams. Students were often constrained in discussing and communicating their ideas by their lack of competence in English, the language of instruction in science lessons. Teachers in this study reported that most students especially those of "lower ability" who had least understanding of the language of instruction often remained silent in science lessons. Students reported using indigenous language to discuss science with their peers. Students in this study believed that IK worked and identified some links between IK and SSK, demonstrating complementary principles of the two knowledge systems. Students considered IK and SSK to be equally important in explaining natural phenomena, however using a second or third language as language of instruction and exams was problematic in competently expressing their ideas. This situation was seen within the focus group. For example, I told participating students that they could use any language of their choice, in an attempt to make them feel at ease and perhaps allow them to make their points clearer. Although English was a third language for most students in this study, they persevered with the use of English until they struggled to make their point. At this juncture, the started using their indigenous language. When students used their mother tongue in the focus group there was humour and a more detailed expression of ideas, encouraging other students to contribute as active participants. For example, during a discussion about the pros and cons of IK in science lessons, students were able to challenge each other's points of view

and critically evaluated the depth and breadth of their thinking. Within the context of Freire's (1970) concept of critical pedagogy, the dominant use of English language in the focus group shows that English language as the language of instruction contributes to "oppression" through the power given to it by the school structure. The students' language which they use to express their ideas and experiences in constructing their reality in a social setting is alienated, disempowering students. In the focus group English language was "oppressive" and made discussions difficult because it did not link to everyday life experiences which are socially learned and understood in their mother tongue. According to Jepkemei (2020) most Kenyan teachers and parents did not support the use of mother tongue in classrooms because unlike the importance of English language in exams, mother tongue had little exam benefit. On the other hand, students in this study valued the use of indigenous language and English language in their discussion as they could make things clearer, and it eased the communication of ideas.

Although as noted above the HT was supportive of the use of indigenous language in the classroom and outside, this was not previously the case. In the past there would have been potential penalties for "offenders" (users of indigenous language) if they did not speak in English either in class or at play. During my own upper primary school time, the use of indigenous language was banned and those caught out punished. On several occasions I held on to a humiliating piece of wood (commonly called a "montor") that was passed onto "offenders" throughout the day, and the last pupil to have it at the end of the school day was punished. On reflection, being exposed to English language did not make me good at answering questions or speaking my mind in lessons in English language, although I did not explicitly doubt the importance of the language in school and outside the country. I always struggled answering questions in English language. Lo (2015) argued that being exposed to a certain language does not always follow good understanding. My focus was doing well in school, although I was silent and did not engage much in the lesson. These contextual factors made me think that English language is the language of school, leading me to accept silence as part of the education system, which

often made me dislike school. As I talked with the young people, their experiences resonated with my own despite considerable time having passed.

Students were also excited to tell of their personal experiences in the focus group. In addition, what their family or community members had experienced also appeared to resonate well with students as their own. During the focus group they frequently referred to what their parents or ancestors had told them. Generally, in the traditional African setting where age determines life experiences, children are lower in social hierarchy (Smith, 2014), so perhaps that explained why they attributed their knowledge mainly to parents at home or teachers in the school setting for it to be trusted. When a knowledge claim was attributed to an older adult member of the society it was a particularly effective way of communicating issues around experiential knowledge. In addition, students reported personal experiences they have seen with their own eyes and done with their hands. This knowledge which the students have seen was significant and "privileged" for them. However, there were few if any opportunities to share this kind of knowledge in the classroom.

Overall, it could be seen that students had few opportunities to have their voice heard in the classrooms. In a few cases where opportunities were available, they could communicate their ideas better and seemed to have more confidence. This has implications for how classrooms could be organised to allow more student voice.

5.3 Teacher education and learning and teaching

5.3.1 Teacher education

Teacher education in Kenya was neglected by the government contributing to lowering the social status of the profession which few school leavers wanted to join (Mwang'ombe, 2021).Teachers in this study reported that most entered teacher education after failing to meet higher grades needed for what would have been their preferred careers, indicating that their subject knowledge could be relatively lower, with implications for the depth of science knowledge they bring to the classroom. According to the 2013/4 EFA Global Monitoring Report (EFA Global Monitoring Report team, 2014), high student teacher entry grades is not an obvious answer to effective learning and teaching skills. Baiton, Barret and Tikly (2016) argue that teacher preparation institutions enrol

candidates with lower academic grades. These candidates would not qualify for professions of their choice, professions perceived to be of "higher" status in terms of good salaries and employment in cities. This gives the perception that the teaching profession is less lucrative and less skilled. It is arguable how emotionally and academically prepared such demotivated teachers are for high student achievement.

Notwithstanding the issue of the status of teaching, research suggests that teacher preparation seems to play an important role in influencing teaching methods and attitude found in science lessons (Shizha, 2007). Teachers in this study said they derived most of their science knowledge from university training, the science syllabus, approved textbooks (also notes) and laboratory supplies. However, all teachers in this study are Kenyans and belong to a particular culture, so they may also have some knowledge of IK, indigenous languages and practices, although such knowledge was viewed by them as less important in science classrooms. According to some authors (Ogunniyi and Rollnick, 2015; Shizha, 2007) western culture and power determine the initial teacher education curriculum content, pedagogy and attitude. These apparently contradictory sources of science knowledge can leave teachers feeling conflicted in how to respond and often they resort to the western based knowledge as required the examination syllabus. Although education policy allows for the incorporation of IK, teacher education appeared to offer limited opportunity for the incorporation of IK, and so it was challenging for teachers to practice it in classrooms. However, from a theoretical perspective, teachers in this study were positive about the importance of IK in the science classroom and reported using it in a limited way. Teachers seemed to attribute their reluctance to use IK to an examination-oriented science curriculum and lack of knowledge and pedagogical skills to meet the educational needs of rural students.

For the teachers who enrol in university, the science curriculum and pedagogy appear not to be linked to the needs of the schools and broader society. One teacher reported that with compulsory education, all students either with low grades or slow learners at primary school must attend secondary school. This means that teachers will have a wide range of ages and abilities in one

classroom. It also appeared that the university does not update the curriculum to link with the dynamic needs of the society and the type of graduates' society expects from schools (Ogunniyi, 2015).

A teacher education curriculum that does not acknowledge the social and cultural realities of the different cultures that exist in society may produce teachers with limited teaching skills to teach all students (Anor, 2024). When a teacher education curriculum does not acknowledge that students have their own way of perceiving the world around and understand practices that solve problems at home, such a curriculum may confuse students. Although not writing about science education in particular, some authors (Gathumbi, Mungai and Hintze, 2013; Hardman et al 2011) have challenged ITE in Kenya which is inclined towards imparting knowledge and skills that do not align with reality as perceived by students in the schools where teachers teach. Schotgues (2022) argues that there is a general assumption that as long as a teacher has content knowledge, they are qualified to teach their discipline well. However, in SSA most teachers have difficulties with content knowledge and lack skills needed to translate content knowledge into effective classroom practices (Schotgues, 2022), impacting on the use of ISK. According to Darling-Hammond, (1998, 2017) it is important that teacher education programmes emphasise understanding of the subject content knowledge, student learning styles and how to link the content to what learners already know. A study by Ogunniyi (2007) in South Africa demonstrated that teacher education courses need to include ISK and teaching skills to encourage more inclusive science classrooms. It is clear from teachers' comments in this study that ISK was not part of the teacher preparation curriculum courses or pedagogical practices when they were studying. It is not surprising that although teachers do not overall reject ISK, they often do little to value learning science through ISK, language and pedagogy.

In this study, teachers viewed IK as contributing to increased interest in science lessons by students especially the low ability ones who benefited more, however they did not think IK is scientifically proven science knowledge. Research from Canada by Snively (2009 cited in Kim, 2017) investigated student teachers in the classroom. These student teachers were encouraged to allow

pupils to explore science concepts through interrogating differences and similarities between their own indigenous beliefs and perspectives and science. Findings showed that this approach in aborigine science classrooms turns silence to speech, adds interest and produces new, more meaningful science knowledge.

Shulman (1987) viewed pedagogical knowledge as skills that teachers use in teaching and suggested pedagogical content knowledge is specific to a discipline. Pedagogical content knowledge (PCK) which is key to good teaching practices including how to teach a concept and correct student misconceptions is possible on sound subject content knowledge. PCK could be achieved through learned theoretical knowledge in ITE, teaching practices in classrooms and subject content knowledge in the full duration of initial teacher preparation. Findings in this study show that the teachers had gaps in science content knowledge and skills needed to translate science knowledge into effective instructions and activities for students in their classrooms.

Research suggests (Westbrook et al 2013), that in addition to being competent in the use of groupwork, familiar local languages and students' social and cultural experiences, teachers need to be competent in the use of IK in the classroom. The use of IK within science teaching is a very specific pedagogical strategy and it cannot be assumed that student teachers will learn this strategy without specific discussion of this during their ITE programme. IK and local culture could be integrated into SSK and also form part of PCK curriculum as a key part of their learning about how to teach scientific concepts across their teacher education programme. One way to address this issue is for teachers to continually update their professional knowledge through a range of continuing professional development (CPD) activities (Schotgues, 2022). In Kenya and Tanzania, the focus of CPD was in upgrading qualifications, familiarising teachers with curriculum developments and mostly on improving subject content and pedagogical knowledge, trivialising classroom experiences of teachers (Hardman et al 2017). In this study, the few CPD opportunities available were mainly focused on how to help students to pass exams. The assumption that what CPD works in Europe will equally work in other contexts has proved to be a significant challenge for developing countries (Nyarigoti,

2013; Hardman et al 2011). In Western based CPD opportunities the focus is on attending a specific course of study with a clear learning agenda that helps to achieve a specific learning outcome. The key issues for teacher development in developing countries centres on teachers being supported to develop capacity to effectively teach pupils with diverse learning experiences and conceptions and connect them with what pupils know and how they can effectively learn.

In Kenya, the Teachers Service Commission Act of 2012, part II, section 11, requires the commission to design policies that ensure that the set standards of teachings are upheld by all teachers through facilitating teacher professional development and career progression (TSC, 2020). In addition, the Constitution of Kenya (2010) requires the government to update teacher knowledge as a way of preparing the human capital development needed for Kenya vision 2030. All Kenyan teachers are required to train and enhance their content knowledge and pedagogical skills on a regular basis to keep up with the changing education systems focusing on skills for employment. If exams continue to be emphasised as the defining measurement of success in science lessons, then teacher-led teaching methods for exams could pose a significant challenge to more inclusive science lessons. Hardman et al (2012) found that teacher trainers could not secure funding to travel to schools especially in rural areas which are difficult to access. With reference to pre-primary refresher courses in rural Kenya, Andiema (2017) found that most teachers have never attended a single course since graduation. Abuya et al (2015) found that primary school teachers in Kenya had no CPD opportunities and workshops. These findings resonate with the findings in this study conducted in a rural location in a Kenyan secondary school, where CPD was rarely available. The headteacher in this study tried to pay for CPD for teachers with the little money available, but there were few available CPD opportunities and most involved significant travel.

In conclusion we need to “re-orient, re-connect and re-imagine” (Wals and Corcoran, 2012) in terms of change to the development of new competency approaches in teacher preparation, by accommodating the new “reality” of local culture, innovation, inclusivity and culturally relevant science lessons within the teacher education curriculum. I now attempt to link my data with relevant literature.

5.3.2 Learning and teaching

It was clear from my data that, despite teachers' awareness of constructivist approaches, learning and teaching most of the time followed behaviourist patterns. It appears that teacher-centred instruction was dominant in science classrooms where teachers went page by page covering of science content in approved textbook. For example, Mr. G identified that his teaching methods involved combining teacher's notes, textbooks and assignments as his guide in science lessons. In addition, teachers felt that they had achieved the lesson objectives if students reproduced knowledge in textbooks. When I asked the students where students got science knowledge from, they all gave a chorus answer, "From the teachers, textbooks". It appears that science lessons in this study had limited learner engagement or interaction. In addition, science lessons mainly involved lecturing, class notes, rote learning, memorisation, and assessments, all of which align with behaviourist practices. So, the main source of SSK for students is teachers and textbooks. This aligns with the study by Ibrahim et al (2013) which found that the main sources of knowledge for those entering a gateway science course. Another focus for both teachers and students in this study was covering the syllabi on time to improve the chances of doing well in exams. Other similar studies (Li & Wang, 2024; Weinberg et al 2012) show that for decades little have changed. The impact is that students feel that they have "all" the science knowledge they need and have no need to generate science knowledge by themselves. This contributes to passive learning, thus limiting critical thinking and the development of reasoning skills important in science. With substantial amounts of information to take in and remember for exams, students often remained silent, and their behaviour often reflected behaviourist approach. With reference to behaviourism theory, Lerman (2014) suggested that student behaviour in classroom depended on the reinforcement of certain practices using reward and punishment. Pupils in this study felt rewarded when a teacher and textbook information confirmed that an answer was "right", this again contributing to passive learning. Getting the "right answer" seemed to be more important than the processes of learning and understanding. It appears that, in general, learning and teaching in this study reflects a behaviourism approach (discussed in chapter 2) where teachers are the sole authority in classrooms. Teachers chose from the syllabus the

knowledge to be learned and how it was to be taught and mainly to suit the exam.

On the other hand, there was some evidence of more constructivist approaches. For example, practical activities potentially allowed learners to verify some aspects of science through their own enquiry. Such opportunities allowed students to engage with learning materials, peers and also with the teacher; however, it appears from teachers' comments there were rules and procedures to be followed in experiments. Thus, learning and teaching was to a large extent superficial and required learners to show that through standard practices that some theories had been proved and they had mastered curriculum content. Therefore, although teachers in this study may have had a constructivist approach in mind, the use of conventional guidelines in experiments to arrive at expected conclusions appears to identify with the views of behaviourists. It is also assumed that learners within the context of constructivism have "sufficient prior knowledge and skills … to engage effectively and productively" (Rowe, 2006:101) when learning together. However, data in this study show that although students had an opportunity to manipulate learning materials during experiments and potentially come up with new ideas, there were rules to be followed that aligned with prescribed knowledge.

Similarly, in this study it appears that the instructor-pupil interactions were to solicit for "factual" information rather than to encourage meaningful learning conversations. The science experiments done in science lessons allowed students to learn by doing and reflection as they engaged with learning materials, other peers and making observations as they acquired knowledge and skills, but this was limited to attaining the required outcomes. Science lessons as explained by the teachers seems to align with Dewey's (discussed in chapter 2) idea of education about the importance of student's ideas and interests as the guide towards an active learning and teaching process in classrooms. However, actual teacher practices seem to be guided by a prescribed content and pedagogy, a behaviourism approach. So, although students are allowed to get involved in independent science inquiry, manipulating equipment and arriving at their own ideas, these ideas are expected to conform with a

prescribed “right” science knowledge. The use of teacher guides seems to confirm what Dewey (1938:18) termed, “imposition from above and from outside”, making education appear stationary ignoring ways in which knowledge is created and what changes may occur decades to come. Student AG’s view that, “If we … did it (activity on a leaf) practically… it would be so interesting”, reflects Dewey’s ideas that through experiential learning, teaching effectively engages children to make sense of their own worlds and are more likely to develop new understanding.

5.4 Indigenous knowledge and science in the community

In this section I discuss that indigenous communities have a set of principles that encourage indigenous students to develop interest in science education. Such principles may be an asset to the development and examination of science lessons to promote learning for all.

All societies in the world hope to pass their own culture and worldview to their children through knowledge, learning and education (Little Bear, 2009). It is through teaching that children get an identity, knowledge, language, history, beliefs and traditions (Kirkness, 1992; Barman, 1987). An understanding and respect of culture is key to an education. According to Kim (2017) science lessons in Canadian schools have minimal connection to aboriginal student’s immediate physical environment, the spiritual and cultural values of learners and their communities, leading to inaccessible and culturally irrelevant science knowledge.

Students in my study valued their culture and enjoyed learning and teaching that involved interactive learning that allows indigenous language and practical activities. In addition, students in this study lived at home with family or adult members of the community which has an effect on learning culture and language which helped them construct their own understanding of the world they live in. Teacher and student voice in this study reported a gap between SSK taught in school and IK held by local elders, parents and community members.

The Kenyan school curriculum and in particular the science curriculum which is the focus of this study is much embedded in western ideology as prescribed in

the education systems to mainly acquire new behaviour. Data in this study show that the school is generally encouraging the involvement of parents who have careers in science such as medical doctors in classrooms. They provide role models for pupils showing what can be achieved if they pass exams. However, there was no evidence of parents who were holders of ISK being invited into classrooms in the same way. This could be seen as a hierarchy of professions and knowledge with some being viewed of more value than others. In this way ISK is once again marginalised within the school system. The setting of this study was a remote area where rich natural resources existed besides human economic activities. According to Aikenhead (2001) an effective science curriculum links well with local community, impacting on the use of ISK. Brayboy & Castagno (2008) suggest that teachers need to allow local elders and other community members to be involved in lessons. If local resources and community activities were at the centre of learning and teaching, elders then become an important science resource. Barnhardt (2005) suggested that pedagogy that was place-based encouraged the inclusion of local culture and the world around indigenous students and would facilitate a link with wider understanding of the topic, in this case science and ISK. McRae & Huber (2018) argues that learning and teaching will be more effective when local culture of a particular community including IK, language and culture is included in the choice of courses and resources. In such a classroom, indigenous students had an opportunity to contribute their knowledge of local culture and surroundings (Dublin et al 2014).

Little Bear (2009:7) suggested IK knowledge needs to be viewed through the local context so that it can be better understood in practice. Teachers' views on indigenous knowledge are also likely to be influenced by the rural setting of the school. The social and cultural background of the school in my study may explain the teachers' decisions on the relevance (or not) of Indigenous knowledge and culture in the learning and teaching of school science. The culture of the community (beliefs, values) plays a role in students' conceptualisation of school science. Community practices and cultural beliefs may also explain the teaching methods choices and the attitude held by teachers and students towards indigenous knowledge and practices. Such

Indigenous perspectives are likely to be important in bridging school science and indigenous knowledge leading to deeper understanding of school science.

Within community settings, it can be argued that individual members share common knowledge and acknowledge each other as holders of knowledge which can be a driver to solving local problems. However, within a school setting two forms of knowledge – ISK and SK – seem to compete rather than work together to solve local problems. The knowledge that students have acquired from their parents and wider community could be a valuable resource in the science classroom. Snively & Corsiglia (2001) argue that indigenous students engaged more with school science when teachers acknowledged students' cultural perceptions of science concepts. Aikenhead (2001) found that when teachers in Canada invited local elders in science classrooms to contribute their knowledge about the environment, students developed more interest in science. In such classrooms both teachers and students contributed to making decisions, while local elders contributed their knowledge in achieving science learning intentions. Such a model if implemented in the research school would seem to hold potential for both forms of knowledge to be valued and utilised in the solving of local problems.

Although there were ethnic differences among teachers and students, all are Kenyans and some local to the research area, so a strong community influence is likely to be felt in the school in terms of indigenous knowledge, culture and language in the learning and teaching approaches. People may lack a common tradition, but a new ISK could be produced as the different ideas and practices come together in community. Some teachers in this study felt that local cultures had been almost extinguished by westernisation, and they said this made it difficult to know how to use them in the classroom. However local languages were heard in the classroom and cultural practices related to food for example, did exist suggesting that different cultures were present and could be integrated into the curriculum. This links to Mandikonza's (2019:4) argument that each ethnic community in a setting was "socialised differently from the others" and this could be used as a resource to broaden understanding of science concepts. Teachers and students in this study were able to cite some examples of indigenous knowledges and resource materials that were used to

demonstrate similarities of knowledge despite cultural diversity. Such perspectives are consistent with the views by Aikenhead (1997) that students should be assisted to bridge cultural borders between school science knowledge and indigenous knowledge. For example, in this study, student cultural practices such as agricultural knowledge, use of manure, knowledge of human ailments and traditional medicine and traditional food preservation could be integrated into science lessons for better understanding of scientific concepts and meaningful learning. However, where challenges of incompatibility of certain taboos and culture emerges, this could be a chance to reflect and question.

In the focus group, students were vocal in defending the cultural practices which they learned from parents, and which are essential for basic survival. Such a positive view of ISK from participants was not what I expected, and it supported the argument for the use of ISK in science lessons (Ogunniyi, 2021). Before attending school, students have already acquired survival IK and practices from home (Adeyemi & Adeyinka, 2002). Students in my study were ethnically mixed with diverse languages and cultures meaning a diverse understanding of IK. Such diversity of experiences could broaden the understanding of IK. According to Akwasi Asabere-Ameyaw et al (2012:7) cultural differences should be celebrated as, "sites of strength" in promoting science education for All. Dewey believed that a student's experiences, culture, and interest are very important factors in producing meaningful knowledge which solved immediate challenges. Eromose and Danny (2017) note that IK provides advice to farmers in Africa on what crop to plant in particular season, indicating that students are culturally well-educated impacting on the use of ISK. In this study the social practices of students are essential in making connection between SSK and the creation, development, and acquisition of knowledge. Mr Bute viewed traditional songs and dances those students learned from home, and enjoyed performing in schools, as a potential teaching resource. Various cultural practices including dances and songs in this study which students enjoyed (according to one participant Mr Bute) are stores of indigenous knowledge and values which provided skills for sustainable living, survival and expressed feelings and attitude towards to issues in life. Mr Bute

described how students enjoyed cultural songs and dances during music festivals, and how although they were multicultural, they taught each other a particular cultural songs and dances and effectively performed well. In addition, although challenges of understanding each other within a multicultural setting exist, data in this study show that learners easily teach each other songs and dance moves from other cultures and enjoy the experience.

5.5 Concerns for sustainability, climate issues and challenges

The traditional African science curriculum took place in the environment rather than in laboratories as is done today (Omolewa, 2007). It can be argued that the close relationship between the traditional education curriculum and nature provided an opportunity for sustainable living. A curriculum which recognises the relevance of the environment in everyday life could offer opportunities for addressing the issues that arise from climate change challenges, especially in Africa (Anor, 2024). In African languages, development and sustainability are conceptualised together (Nursey-Bray et al 2022). This conceptualisation impacted on the understanding and ownership of the land. Similarly, the changes to the climate are impacting on the traditional indigenous knowledge.

Indigenous knowledge effectively links human beings, norms, beliefs, culture and ecological needs together in a symbiotic relationship where each depend on the other, guides local practices (Singh, 2016). According to United Nations Department of Economic and Social Affairs (2019), indigenous knowledge systems is now being globally recognised as a partner in tackling global challenges and achieving Sustainable Development Goals (SDG). Sustainable development was derailed by colonial languages and their legacies and so Nursey-Bray et al (2022) argue that we have ended up with deforestation and destruction of land digging for gold. The indigenous value of respect offers opportunities for environmental conservation activities; consulting with elders in the local environment; encouraging elders to contribute expert environmental knowledge. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (2019), a United Nation body offering guidance on scientific knowledge related to the natural environment and sustainable living, reported that indigenous knowledge and perspectives

are key to addressing challenges of the global ecosystem. Acknowledging indigenous voices in respect of climate change challenges at global level is encouraging (Reisinger et al., 2014); however, it is challenging to translate indigenous voice into action at a local level based on thinking from a global perspective (Nursey-Bray, et al 2022). Nursey-Bray, et al (2022) found that it was challenging for teachers to actualise student voice and agency in science lessons, although the science curriculum allows the use of ISK in classrooms.

Developing countries are more vulnerable to climate risks due to limited economic, social and institutional resources contributing to low adaptive capacities (Nursey-Bray, et al (2022). To improve chances of sustainable development what happens at local community, regional and global levels in relation to education, values, attitudes, beliefs, structures, is key to finding solutions.

Anor (2024) conducted a study in Ghana to find out about how pre-service science teachers perceived IK in terms of encouraging sustainable science education. Anor's (2024:384) findings showed that IK promoted "sustainability and interconnectedness" resonating with other findings (Harvey & Russell-Mundine, 2019; Kaushal, 2023) which encouraged the conservation of IK as a source of culture and identity. Anor's findings further showed that integrating IK in science classrooms often promoted sustainable education, since IK contained values, norms, customs and beliefs (Antonelli, 2023) that represented cultural identities of indigenous people that sustained life, amidst serious local life challenges (Anor, 2024). So indigenous people have for centuries been guided by a broad range of beliefs, norms, customs and practices in their attempt to preserve their ecological and social systems. However, challenges of skills to integrate IK in classrooms among some teachers was identified as the main reason for doubts about IK promoting sustainable education in Anor's study.

Among African communities in particular, cultural values and social practices can be argued to be the foundation of sustainable agriculture. According to Son et al (2021) sustainable agricultural practices including preservation of soil fertility, intercropping and adapting well to climate challenges is much

associated with indigenous people. For example McNeil (2012) reported that among the Maya people in Central America, various traditional methods of farming take place. In Ghana, traditional food preservation methods and intercropping are popular practices (Anor, 2024). Such traditional farming practices represent sustainable farming practices. Among indigenous communities, a link existed between fire, soil and life, particularly in land management. For example among the Aborigines in Australia, cultural burning was deeply rooted in Indigenous knowledge and traditions and a crucial practice in caring for landscapes and nurture biodiversity (Egloff, 2017). Cultural burning was only done to benefit the health of the soil and make ecosystems more resilient. Cultural land management practices takes the perspective that people and the environment are interconnected to each other and through IK and practices are linked to people, spiritual and ecological needs where non can exist without the other. Such practices is evidence that Indigenous communities have a deep cultural and spiritual connections with the land.

I have presented findings from interviews with teachers, focus group for students as well as data gathered from documents. The findings are organised in the form of narratives from participants and extracts from documents. I now focus on conclusions and recommendations derived from the study findings. My conclusions are specific to the school context and should not be assumed to work in other contexts.

Chapter 6: Conclusions and recommendations

6.1 Introduction

This study set out to explore the extent to which indigenous science knowledge (ISK), indigenous languages, culture and pedagogical approaches were used in the existing secondary school science curriculum in Laikipia County, and whether this information be used to support the implementation of the new education curriculum reforms. The empirical research that was based in one secondary school focused on gaining understandings of the views and experiences of six science teachers, the headteacher and eight students. Further insight was gained through classroom observation. School policy documents were useful in the exploration of how national policy intentions influenced practice in the school and so the science curriculum documents (science syllabus), official science textbooks, schemes of work by teachers and the school policy document provided a context for the study and with which to analyse the findings.

Across this study it has been shown that there is a desire both within national policy and in the understanding of teachers and students to incorporate IK and ISK in the classroom. However, a range of factors contributed to the barriers that meant that despite this desire, practical implementation of IK and ISK in the classroom did not always happen. This final chapter considers the implications of this research for various educational practitioners and stakeholders. Section 6.2 looks at the findings through the lens of sustainability. It includes a discussion of the significance of the findings from the current study in terms of ongoing work around sustainability and science education and practice in Kenya. It also includes some limitations of the study. Section 6.3 discusses the contribution this study makes to the field, offers recommendations for future practice and makes suggestions for future research directions. The chapter concludes by arguing that ISK, indigenous language and culture could be integrated into the Kenyan science lessons through the science curriculum and pedagogy.

6.2 Education for sustainable development (ESD)

Globally, Education for sustainable development (ESD) is being emphasised as a key element in education systems if sustainable development is to be achieved (Nyatuka, 2020). In 2013, Opanda argued that a focus on education for sustainable development in Kenya brought to attention the need to

- improve access to quality of learning and teaching,
- reorganise the education system,
- raise public awareness and
- improve the teacher education curriculum.

Although these ideas about sustainability development issues were raised about a decade ago and were not specifically about science education, they are still relevant today and relevant to science education. Science education seem to be removed from the social and cultural realities of particularly the rural student, contributing to marginalisation of ISK from the curriculum and classroom interactive activities where knowledge is constructed. For example student SM reported that, “There are things you maybe do outside and you maybe you do it daily… and you think it is science but when it comes to books, it is not there”. The implication is that when life experiences are left out of a science lesson, learners are denied to acquire Education for sustainable development (ESD).

Nyatuka (2020) argues that teachers are particularly important drivers of transforming education for sustainable development. Ganira and Odundo (2018) argue that appropriate teaching and learning methods that create interest and empower young people to be knowledge producers could encourage appropriate actions for sustainable development. In my study student participants viewed a science lesson that incorporated ISK, indigenous languages and practical activities as more interesting, more meaningful and empowering, a step towards science education for sustainable development. In addition teacher pedagogy that allowed active participation of learners in knowledge construction encourage the development of problem-solving skills an aspect of Education for sustainable development (ESD).

Teaching and learning approaches for sustainable development encourage acquiring knowledge, practices, perspectives and values that sustain communities. Findings in my study suggest that the teacher education science curriculum and pedagogy seemed disconnected from the needs of the schools and society that teachers would be teaching, with implication for Education for sustainable development (ESD). It is important that teachers are effectively engaging with education policies and providing the necessary conditions for improved teaching and learning for sustainability. According to Nyatuka (2020) teaching and learning approaches for education for sustainable development require teachers to focus more on learners to take more ownership of their education and allow them to develop their ideas and values. Findings in my study show that when life experiences were part of a science lesson, students engaged more and suggested alternative ways of doing things, a way of developing creative thinking among learners, encouraging them to form and develop their own ideas and values, all key factors in education for sustainable development. Teachers should create a classroom environment that encourages active student participation in learning of a topic. Findings in my study suggest that teachers should use pedagogical approaches that allow the voice of their students for meaningful learning. So teachers could be trained in aspects of sustainable development in the teacher education curriculum which include relevant content and pedagogy (Nyatuka, 2020).

It can be argued that the existing local and national policies can support the work, but it is the work itself that is the most important. In my study participants had a positive view in the vital place of ISK, culture and indigenous languages for meaningful in science lesson, implying a willingness to support education for sustainable development. In addition students in the study appeared to be rich in ISK an important learning resource for education for sustainable development. However, within the educational documents, specific guidance as to how to move from words to actions and how to support and resource these activities was missing as evidenced throughout this study.

6.3 Limitations, contribution to the field, recommendations and future research

6.3.1 Limitations

Like all methodologies there are strengths and limitations in the way this research was approached. For teachers in this study, being interviewed by me, a Kenyan who spent most of his early life in Kenya, may have had impacted both positively and negatively on how they interacted with me. On the one hand, knowing of my early life in Kenya could have encouraged them to talk about their experiences more freely in a more detailed and honest way, providing deeper insight into their experiences. On the other hand, although I informed participants about the confidentiality of all information provided, teachers may have resisted talking about some aspects of school practices they perceived to be a challenge, possibly concerned about the headteacher's response to such disclosure, since they were aware that I had known the headteacher. Knowing the headteacher potentially unsettled the power balance between me and the participants, while on the other hand they trusted me having been known to the headteacher. Participants may have potentially felt inclined to take part to please the headteacher and me. In addition, in some interviews teachers may have assumed that as a Kenyan I knew their experiences, so teachers were trying hard to give "right" answers to my questions indicating a perceived power imbalance in the researcher's favour. To mitigate any negative influence from knowing the headteacher, I asked teachers' advice about time and place of the interview. I made effort not to disrupt any teachers' or school programmes and fitted my research into the school timetable.

Another potential limitation was that the study gathered data from only one school in one rural area of Kenya, although a neighbouring secondary school head teacher was asked to participate. This would have potentially given a broader view of how school policy and practices work in practice but since the schools were located in a remote area with serious socio-economic challenges, accessing a larger group of participants in two schools in such circumstances was not possible. However, it can be argued that deeper understanding and insight of one school context creatively and interpretively analysed offers rich qualitative insights.

Student recruitment was mainly done by the teachers, so it is possible that students perceived to be more eloquent, willing, often follow school rules and high academic achievers were purposively selected. Other potentially resourceful participants who did not meet the teachers "conformity criteria" may have been deselected, limiting broader and deeper insights from all "real" resourceful students for this study. Nonetheless, the data shows that the group of students offered valuable insights into their educational experiences.

The choice of focus group was intended to provide a democratic space where students were free to communicate their ideas with familiar peers rather than a face-to-face encounter with an authoritative researcher. Some outspoken students seemed to dominate the focus group discussion, with their information apparently suppressing information from the quieter students. However, I made attempts to mediate domination by equally distributing questions around all students regardless of whether their hands were raised or not. Data that came out of the focus group was regarded as student voice or viewpoint, which does not originate from one participant (Smithson and Diaz,1996).

6.3.2 Contribution to the field

Young people in this study were clear that groupwork, a practical and hands-on approach to learning while allowing familiar indigenous local languages and experiences often transformed silence into speech in science classrooms. Teachers too acknowledged the contribution that ISK could make if introduced in the classroom. These may be the central contribution to knowledge of this thesis. Students in this study could speak about ISK, lived experiences, culture and indigenous language and this has implications for learning and teaching. Science curricular initiatives in Kenya acknowledge the necessity and desirability of understanding of students lived experiences and worldviews when considering how to approach learning and teaching in the science classrooms. However, the focus on SSK content in the science curriculum (science syllabus) seemed to reduce the opportunities of incorporating IK. This research can help fill the gaps around the challenges of integrating IK and ISK into the classroom.

My interaction with young people in this study shows that when afforded opportunities, they have a voice and can articulate well what they require in science classrooms. When teachers clearly understand the ideas and customs in traditional communities as a means of survival then they are likely to value them and allow them in classrooms. This research contributes to the call to create a learning environment where student voices and ideas are accommodated and respected.

My qualitative study concerning the use of ISK in the science curriculum and classroom uncovers potential differences between national policy - which is clear that ISK is an important component – and the tensions that result from assessment priorities, poor resources and a lack of funding. In this way this study may be seen to open the pathway for future research with students, teachers and other stakeholders in Kenya that may deepen our understanding of how they interact with, perceive, and shape the inclusion of ISK in the science curriculum.

6.3.3 Recommendations

This research suggests that from the perspectives of teachers and students ISK has a role to play in learning and teaching, but teachers faced challenges in its implementation. As countries across the globe seek to work in ways that are more sustainable the response must include the alternative perspectives that can be brought by valuing and respecting the contribution of ISK to the science curriculum. Achieving this will necessitate interested parties working together to achieve the sustainable development goals (UN, 2015). The suggested recommendations below are addressed to policymakers, school leaders, teacher educators and teachers; however, as additional stakeholders, students, and parents should be a part of any future process.

Policy makers

- This study has shown that both teachers and students have a positive view of ISK. The government envisages an inclusive science-indigenous science curriculum through education policy. To achieve this, it should involve teacher and student voices in the development of policy. It should also set up the

necessary pathways to support implementation by providing adequate funding, appropriate learning materials and training for staff.

- The Kenyan national education policy specified the use of the mother tongue (i.e., the local language spoken in a student's home) as the language of instruction in Grades 1 through 3, transitioning to English in Grade 4 and thereafter (Kibui, 2014; Ministry of Education, 2006). In this study indigenous languages were often used in the focus group and in science classrooms to make things clearer. Language policy should be reviewed to recognise indigenous languages as language of instruction in secondary schools.

- This study recognises the significant role IK plays in providing education for sustainability, so contributes to the body of knowledge suggesting that education policy should reflect IK within education for sustainability.

School Leaders

- Should carry out a review of school language policies to ensure that student voice through local languages is heard and actualised so that all students could have an opportunity to actively participate in their education.

Teacher educators

- Initial science teacher training curriculum should include an emphasis on innovative teaching pedagogy that integrates students' lived experiences into science lessons to achieve science objectives.

- All teachers including those already in service should learn through professional development on how to allow students' voice and actualisation of that voice in learning and teaching.

- Teacher education should review their curriculum to focus on teacher pedagogy that incorporates IK and practices in science lessons, so that student learning might change from silence to speech, especially in rural areas.

- The teacher education curriculum should prioritise indigenous perspectives so that science experiences in the classroom become culturally rich and cultural experiences and knowledge are passed on to future generations.

- There is a need for comprehensive education on indigenous knowledge, including its holistic, adapt able and practical aspects. This education should emphasise the significance of indigenous knowledge in promoting sustainable practices and its foundational role in education and science.

- The pre-service teachers' training curriculum should incorporate indigenous perspectives to provide a more inclusive and culturally rich educational experience, which transcends to the younger generation.

Teachers

- What teachers experience in their own science classrooms should be the foundation of professional development courses so that teachers could be helped to improve their classroom practices based on their own experiences. However, there are challenges of potential perpetuation of wrong information especially when teachers on their own are involved in continuing professional development. So, teachers, researchers and policy makers should come together and provide CPD.

- Teachers should be educated about their key responsibility within the parameters of the curriculum and they should be more trusted as professionals who can meet the learning needs of their students. They should feel free and confident professionals and not compliant technicians. They must consider a new curriculum to be desirable, relevant, and practicable in the present educational context.

- Through teacher education and professional development, teachers could be empowered through relevant teaching pedagogy to embed the students' culture in science classrooms.

- Teachers could be provided with learning materials that offer current information about traditional cultural knowledge, since evidence in this study shows that participants were concerned that IK had changed over time and that there was often little information available about it.

- Teachers should integrate indigenous languages with the language of instruction through code-switching to encourage debating of issues.

• Whatever students do and learn from home represents all social and cultural influences and experiences and so teaching practices should prioritise student's lived experiences, IK, culture and practices as the foundation of teaching scientific concepts so that students learn science content both for their career and for application at home.

Students

- Students have their own ways of knowing and doing that encourage debate between peer/peer and peer/teachers for deeper understanding and more meaningful learning among students, so learning and teaching should be a more interactive process.
- Students' views, opinions and experiment results whether they agree or not with teacher's expectations is the student voice and should be encouraged while still respecting teacher authority in guiding learning and teaching.
- Participants in the focus group effectively communicated diverse views about their experiences of science to an adult in a language (s) of their choice. Students have multiple voices and agencies that should be listened to, heard and valued as the foundation of learning science in context.
- Teaching practices should encourage the use of both English and local languages so that, like student participants in this study, they have an opportunity to express their ideas better and enjoy debating science content in confidence.

6.3.4 Future research

As noted elsewhere in the thesis, some of the issues faced in the 21-century classroom in rural Kenya were similar to those I experienced growing up. While much research has taken place in the intervening years, this study clearly shows that there is still much to be done. The following aspects would benefit from further research:

• During the current research study it became clear that parents are an important element in the learning process. Future research should speak with parents to investigate parental knowledge of ISK as the students highlighted

that this was where their understanding about ISK originated. Opening up these discussions with parents would allow a conversation to take place around the tensions that exist between what research says about the importance of indigenous languages in the science curriculum and what parents believe about the importance of English language instruction and examination results.

- Investigate whether the science curriculum could benefit from the integration of cultural practices such as music and dance in order to increase engagement and motivation for learning.

- Curriculum development is currently being implemented in Kenya and this offers an opportunity to examine how teachers are being prepared and supported to take on board the requirements of this new curriculum.

6.4 Final comments

In this study I have recorded my confusions, ideas, feelings, insights and struggles in an attempt to make sense of data. When I began this study, I was aware of the importance of my own experiences of learning, both at home and at school, and recognised that these were one of the drivers behind the project. The literature and research on which I reflected often resonated with my own experiences and highlighted some areas where changes may have been occurring over the years since my own schooling, as well as identifying many ongoing challenges. In line with existing research, I found that the school which I studied had inadequately equipped science laboratories owing to funding for learning and teaching facilities failing to match the increased student population due to the change to compulsory free secondary education in Kenya. The simultaneous failure to recruit an adequate number of well-prepared science teachers to meet increased demand often led to large class sizes. The consequences of inadequate learning and teaching resources contributed to teacher-led pedagogical approaches which sometimes do not allow students to effectively participate in their own education. Overall, very little would seem to have changed since my own time in school.

At the start of this study, I explained how I observed my parents solve everyday problems, although they had not attended formal education. The everyday experiences of my parents constituted knowledge which made sense in the

context where it is constructed and used. My findings show that similarly to my experience students possessed prior knowledge and were familiar with practices which were learned from parents and the community where knowledge was constructed and solved problems at home. Again, this points to persistence of indigenous knowledge playing a big part in the students' understanding.

Findings in this study show that students and teachers have a positive view of ISK which is something I did not expect. The insight offered by the young people in this study about learning and teaching of science was surprising to me and goes beyond what I had expected and is in advance of the knowledge I possessed when I was their age. I learned that young people know more than adults think and what young people need from adults is for them to listen and act on student voice. It is important to involve student everyday experiences, ISK and culture at home in learning and teaching of science, so that the knowledge produced can have a reciprocal effect and become useful to students at home. Findings in this study show that when learning and teaching allow ISK and SSK as complementary knowledge systems, students actively participated in science lessons, talking more and making their ideas known contributing to critical thinking. Allowing ISK and worldviews which are the foundation of survival among indigenous communities promotes such knowledge systems that are the foundation for self-reliance and higher education. Reality as perceived by students finds space when ISK and culture are allowed in science classrooms.

Studying the use of ISK in science classrooms has been meaningful to me. I began this study with a belief that ISK would make science lessons more meaningful for learners in the classroom. I now have evidence for this belief; however, whether other teachers would share this belief depends on their own attitudes, beliefs and experiences. I am convinced that qualitative inquiry has been effective in helping me improve as a teacher. Although classroom contexts are different and teachers bring different views and experiences to those classrooms, nonetheless, this method of enquiry offers opportunities for teachers to reflect on their practice as they progress towards being more effective teachers.

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APPENDIX A- Ethical approval

10/09/2018

Dear Francis Gatongi
College of Social Sciences Research Ethics Committee

Project Title: Science education, curriculum and pedagogy in 21st Century Kenya: An investigation in Laikipia County, Kenya.

Application No: 400170236

The College Research Ethics Committee has reviewed your application and has agreed that there is no objection on ethical grounds to the proposed study. It is happy therefore to approve the project, subject to the following conditions:

- Start date of ethical approval: _ 01/09/2018 _____
- Project end date: __ 20/09/2020 _____
- Any outstanding permissions needed from third parties in order to recruit research participants or to access facilities or venues for research purposes must be obtained in writing and submitted to the CoSS Research Ethics Administrator before research commences. Permissions you must provide are shown in the *College Ethics Review Feedback* document that has been sent to you.
- The data should be held securely for a period of ten years after the completion of the research project, or for longer if specified by the research funder or sponsor, in accordance with the University's Code of Good Practice in Research: (https://www.gla.ac.uk/media/media_490311_en.pdf) (Unless there is an agreed exemption to this, noted here).
- The research should be carried out only on the sites, and/or with the groups and using the methods defined in the application.
- Any proposed changes in the protocol should be submitted for reassessment as an amendment to the original application. The *Request for Amendments to an Approved Application* form should be used: https://www.gla.ac.uk/colleges/socialsciences/students/ethics/forms/staffandpostgraduateresearchstudents/

Yours sincerely,

Dr Muir Houston

APPENDIX B- Letter from the County Director of education Kenya

Letter removed due to confidentiality issues

APPENDIX C- Plain language statement-student participant

University of Glasgow

College of Social Sciences

Title of Study: Science education, curriculum and pedagogy in 21st Century Kenya: an investigation in Laikipia County.

Researcher: Francis Gatongi.

Supervisors: Dr Margaret McCulloch and Dr Margaret Sutherland.

Course: Doctor of Philosophy in Education

Dear Student,

I am inviting you to take part in a research study to describe your learning and teaching experiences in a secondary school science classroom as your teacher's put effort into making school science more applicable to your everyday life. The study would like to explore and describe the experiences of secondary school science teachers and students as they attempt to make learning and teaching of school sciences related to student's home understanding, through mixing of local science knowledge, use of local language and beliefs and changing teaching and learning styles in the classroom. The study would also provide you with an opportunity to share your views which are hoped to reduce problems to learning and teaching of school science, leading to better teaching ways and improved learning. This study is a part of my research studies at the University of Glasgow. Two science students from each year from year one to year four will be asked to take part.

A research study is a way to learn more about something. You are being asked to take part because your experiences of the secondary school science syllabus, local methods of teaching and learning, native languages and beliefs and local science knowledge are important for this study.

Before you decide if you want to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the information on this page carefully and discuss it with others in the school community and your parents/carers if you wish. Ask me if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

What is this study about?

The aim of this study is to find out how you and your teachers attempt to make school science applicable to your everyday lived experiences through making use of home knowledge, home language and beliefs and home learning and teaching methods led by parents/carers. Your views will be important to determine how

school science can be made more interesting to Laikipia County secondary school students and increase the number of students taking science subjects.

As well as talking with you, I will be speaking with some of your teachers and your head teacher about how they think science teaching can be done best.

Do I have to take part?

You do not have to take part in this study, and if you decide not to, or your parent/carer does not wish you to take part, you will not be penalised in any way. Neither will you be penalised if, after you have started to take part, you change your mind. Participation is voluntary and you are under no pressure to participate or to answer questions you are not comfortable with. If at any time you cannot carry on or wish to withdraw you may do so without giving notice or reason. Any information you had already provided would be deleted and not be used in the findings.

What will happen if you decide to take part?

I will try not to make this research a problem to you and will carry it out when it is most convenient to you. I am inviting you because I believe you have suitable understandings of the secondary school science curriculum information and things you do which are important for this study. If you decide to take part, I will ask you to participate in a group discussion lasting approximately one hour with the other seven participating students. You will be discussing the kind of learning and teaching students prefer for better learning of science in classrooms. Particularly I will want to know about things that you and your teachers do in a science lesson that connect things you know and do at home, home language and beliefs and how you learn at home from adults and other young people.

With your permission, I will sound record the proceedings and take notes to ensure I do not miss important points you say.

About the information, you provide.

All the information you provide in my paper notes will be securely stored under lock and key in a private cabinet in the school premises. Only I will have the cabinet key. If this is not available, I will use a secure private briefcase. Research information stored in my computer will be secured using a password, only known to me. The information will be destroyed at the end of the research. I will not include your name or school when I write about my findings. I will use a fake name so that no one can identify you, you can choose a name for me. No one else will ever know what you said except the other 7 students in the group.

However, please note that confidentiality will be maintained as far as it is possible, unless during our conversation I hear anything that makes me worried that someone might be in danger of harm, I might have to inform relevant agencies of this.

How will I know about the findings?

Once I have collected all the information from everyone who is taking part, I will then go back to my university and write a thesis which is a long essay or like a book which is needed by my teachers to mark, before I get my degree. A written summary of results to all will be provided on request. I may also present findings at education conferences and use the information to write journal articles.

Review of the study

This study has been reviewed and agreed by the College of Social Sciences Ethics Forum, University of Glasgow

Contact for further Information.

If you have any questions about this study, you can ask me, Mr Francis Gatongi (f.gatongi.1research@glasgow.ac.uk) or my supervisors, Dr Margaret McCulloch (email Margaret.mcculloch@glasgow.ac.uk) and Dr Margaret Sutherland (email Margaret.sutherland@glasgow.ac.uk) or the College of Social Sciences Ethics Officer, University of Glasgow Dr Muir Houston email: Muir.Houston@glasgow.ac.uk

Thank you for reading this.

Yours faithfully,

Francis Gatongi

APPENDIX D- Coding examples for teacher KA

FG: Okay, thank you for taking part in this interview. Ebu niambie umesomesha miaka ngapi? (how many years have you been a teacher?)

KA: Okay I have taught for like four years.

FG: 4 years… eeh… Where did you go for your university?

KA: Laikipia university. [***Source of school knowledge]***

FG: What subjects did you study?

KA: Chemistry and mathematics.

FG: So, what level was that?

KA: Degree.

FG: What is the name of the degree?

KA: Bachelor of education science (B Ed sc).

FG: You are just like me; I also had taken biology and chemistry and had the same B Ed Science. Now, can you tell me about…eeh… when you go for a lesson, what documents normally guides you on how to present your lesson and achieve your curriculum goal?

KA: introducing any lesson…?

FG: Yeah, any lesson… you teach chemistry and math. Let's talk about chemistry. You go to the chemistry class, what documents do you normally use that guides you into achieving your curriculum goals?

KA: Okay like the textbooks? [***Source of knowledge Resource]***

FG: The textbooks… anything else?

KA: In chemistry we use like the KLB book (course textbook). [***Source of knowledge Resource]***

FG: Which is this KLB book? Is it a course book?

KA: mmh.

FG: Any other source of knowledge or probably document that also helps you?

KA: Sometimes I do have notes I make. [***Source of knowledge Resource]***

FG: Is it your own class notes?[***source of knowledge***]

KA: My own notes which we made last year from a copy that was sent to us through WhatsApp[***Source of knowledge Resource]***. Instead of every time getting to the phone, we had to write and compare the notes in the textbook and what was in the phone and maybe from another revision book.

FG: Okay, so you had quite a number of sources which include WhatsApp… is it that you had a group of teachers?

KA: Yeah, we have a group of chemistry teachers, a group for science teachers That is where they send… if you want a chemistry guidebook or revision materials, they send it to the WhatsApp.[*Source of knowledge/teamwork Discuss materials]*

FG: And you normally share some information?

Kari: Yes, we do share concerning some areas tested or maybe if you have a question. You just post it there and they kind of have a discussion.

FG: Okay, any other source of knowledge that helps you get your curriculum goals?

KA: Okay. Maybe it depends on the topic also…. because some topics you use the information you have and maybe the real-life situations.*[Real life experiences as source of knowledge]*

FG: You talked about information you have, isn't it… what kind of information is that? Where does that information come from?

KA: Some can be what you've been learning or what you already learnt some years ago or you are still learning while others can be from indigenous knowledge.[*Source of knowledge Indigenous knowledge]*

FG: Is it knowledge that you already have when you came to school?

KA: Okay I learnt it from… if it is like home, you have been seeing something being done so you learn from the same. So, by now that means you already have that knowledge which you learnt from someone else. So, it's not that am going to consult now. That means I will still have the knowledge.

FG: Yeah, things that you knew. Where do you get this?

KA: We learnt from maybe the parents…

FG: Okay. Can I ask you what other documents that guides you and tells you that this is what you are supposed to do?

KA: Okay unless I talk of the revision books, maybe. [*Followed in classroom discussion]*

FG: Do you have any other government document besides the textbooks? How do you use the textbook in the classroom?

KA: In most cases as a reference. Because if I have my notes, [*Personal notes copied from textbook*] I will just use mine to guide me. But if it's a diagram I want them to look at, we now have the textbooks. So, you tell them to turn their textbooks to a given page.

FG: Do you normally ask the students to read the textbooks in a certain topic? Or how do you organize them to use the textbooks?

KA: The textbooks normally helps, [***Textbook main guide in class T/L***] you know it has different topics so is it that you move from one topic to the other? One topic to another… you know you can't teach all these in one lesson. It all depends on which lesson you want to teach. What content have you prepared for that specific lesson? Do you need the notes alone, do you need the reality? Do you need a chat? Do you need a manila to write something and use it in class? It depends on…

FG: Let's say the students have got the textbooks. Do you normally ask them to read the textbooks in a certain topic, I mean, like that? How do you normally organize them to use the textbooks?

KA: Sometimes when you give them like an assignment, maybe to write very short notes in a given part, they can do it as an assignment or maybe in class you want to emphasize a given definition. You know by reading; they are able to see the definition as a whole. And they are also in a position to give their free definition. Not from what they are hearing from me but from what they can see from the textbooks.[***Textbook notes and teachers are main source used in T/L]***

FG: Okay. Do they face any problems in understanding the language used in the textbooks? Or maybe the technical language used during discussion?

KA: Yes, they do face sometimes.

FG: Difficulties like?

KA: Like for example a given concept is being explained in a book and maybe the book is not elaborating for them. So, as a teacher you use a better language to make them understand. [***Students find understanding textbook a challenge, so teacher help make it meaningful]***

FG: What do you mean by a better language?

KA: Like for example there is a topic in form four on the effects of adding an acid to a reaction at equilibrium. So, there are some letters they use and you feel the students may not understand. So instead you rewrite the equation then show them, am removing this hydrogen from this equation, so what will happen? Because they use a given equation there just that I do not have the book here, which the students can't understand.

FG: Okay, which is the official language you use when teaching?

FG: Why do you normally sometimes switch from the official language to Kiswahili?

KA: In most cases it is just to bring them to understand what you mean.

FG: Okay. So, you want to mean they understand Kiswahili better?

KA: Yeah, they understand Kiswahili better.[***Students understand Kiswahili better]***

FG: And you say that helps them understand whatever topic better?

KA: Yes. Like when you are giving them examples of maybe like animals or plants that will produce acids. So, we have the stinging nettle maybe he/she has never had of the stinging nettle, if you say it in Kiswahili or kikuyu….[***Knowledge in a language they understand help them connect with the lesson]***

FG: How do you say it?

KA: Thabai. So, they will understand what you mean.

FG: Alright. So, when you use Kiswahili, they understand it better. That's what you have said. The other thing is… can you tell me of a lesson that you always remember that was very successful and the students were happy and very very interested? Or maybe from your school time? Or a lesson you taught that made them so interested?

KA: Okay you only enjoy teaching when whatever you are teaching can be related to reality or can have a teaching aid where they can see what you mean[***Use of student experience or use of teaching aid make a lesson interesting to students because they connect with lesson].*** For example, if you want to demonstrate how sodium reacts with water, that means you must have the metal which is sodium and the water which are available in our school, and they would be very keen to see how the sodium is behaving on top of water because maybe from the textbooks they read it darts on water. So, they are keen to see if It darts on water. And if they see whatever is happening, they feel like this is magic. Because it will dart and there is a way you can control it using a filter paper and if you limit its movement it will end up burning with a flame. So that's when they feel they have learnt something, and it is whatever they have seen.

FG: Is it a chemical reaction that you did with them?

KA: It was a demonstration of how group 1 elements react with water, and we picked specifically sodium. Since we did not have potassium or lithium.

FG: Were they interested or what happened? What did you see on their faces? What was the mood of the classroom? How did they behave and the like?

KA: Obviously the students will be nervous or anxious to see what is going to happen and the moment they see it, they are happy, and they enjoy more. They ask mwalimu (teacher) do it again? Does it again? Only that you can't do it. Meaning they are happy with what you have done. [***Student s enjoy practical's because they learn more from seeing. They are curious and ask questions]***

FG: Were they asking question?

KA: Of course, they were asking.

FG: You can say that practical will make them more engaged or something like that?

KA: They make them more engaged, and they tend to like chemistry more.

FG: Oh okay, together with that. Can I ask you… Do you have all the laboratory resources that you need to be able to do that more often?

KA: ……For now, I feel that we have more of those apparatus, more of those reagents. This school is much better. Comparing the level of the school and what is available in the lab. It is better [*There is some apparatus but not enough]. (body language showed some filtering of reality-employed by school may try to sound good for the school*)

FG: Would you say that you have everything you need to be able to have such interesting lesson all the time?

KA: Okay, we are not yet… we do not have all that we require but as for now I feel, what has been done is great [***Feels with the school circumstances it is ok, but more is needed]***. Though we still need more.

FG: So, you think with more you can be able to make it a bit more interesting?

KA: Yes.

FG: Now, the other thing is about…. eeh… when you were teaching you talked about indigenous knowledge. Can you give me an example of when you used indigenous knowledge and what the reaction of the students was?

KA: In a topic in form one syllabus, where we have acids, bases and indicators. Giving like examples of… bases and also… reactions like... A reaction between an acid and a base. Like… ok they would tell you why is it that at home when you have a stomach ache… not really a stomach ace…when you have a problem with the acid in the stomach that is the burning, why do our grandmothers and mothers tell us… may be… to take some wood ash solution and have a taste, just a small amount and then the stomach pain comes to an end.[***A good example of using indigenous technology from students own experiences in achieving school science curriculum goals]***

FG: What was the reaction of the students when you said that?

KA: Okey we are the ones who sometimes…okay, when you ask them are there are such things that they do at home which involve wood ash. They will tell you that they use it in such cases where someone has a problem with the acidity in the stomach. Then I would explain to them why they use the wood ash solution. This is because it is basic and whatever is burning them in the stomach is the acid… so it's kind of neutralize the acid in the stomach. That wood ash solution it used in place of like the actal which the anti-acids are given in the hospitals and other medicines given to solve the same problem.[***Teacher using school science to explain the "how" of indigenous technology and how it is connected with each other]***

FG: So, when you did that what was the reaction of the students in terms of the lesson? How was the mode? Were they able to engage you or were they able to ask question? Or maybe suggest other things? [laughs]

KA: Some were saying we use the charcoal [laughs]. Okay they get the charcoal and dissolve it in water, and then you taste the solution… I don't know. That us what they told me.[***When indigenous technology is used students are more engaged, interested and suggest alternative/innovative]***

FG: So, what about their interest? Did they create more interest in the lesson?

KA: Yes, it creates.

FG: What about the level of understanding? When you use that indigenous knowledge, how can you gauge that level of understanding?

KA: Okay, using what they already know of what they already see in their communities, that Makes them understand more. Because you are introducing something which is new to them. What is an acid? What is a base? Give me an example of a base… by so doing they already know that wood ash is an example of a base. But here in school there are other examples of bases ama(or) in hospitals we have medicines which serves the same purpose as that wood ash which are made of… okay, they are basic. Why are they basic…, you can now teach them later.[***School science introduces new words which can easily be understood by using what students are familiar with in their daily real-life situations]***

FG: Okay, I think I will go around again just about the same question. [laughs] Can you tell me about a lesson that was so boring. Maybe the students never got anything… maybe from your own experience or probably from your school days a lesson was so boring… [laughs] it happens, isn't it? Could you give me such a situation and what was the problem? Or what led to that?

KA: The topic I find boring while teaching is metals. Because there is nothing you can do practically for them to see; how this metal is obtained. It's something they are doing theoretically.[***Topics which are teacher-led (giving "facts") with no connection to student experiences or practical are boring]***

FG: Alright, do you mean there is nothing you can be able to connect with what they already know from home or their own experience?

KA: Just the theory

FG: So, could you tell me an example of such a lesson and what was the reaction of the students during that lesson where they could not be able to connect with all the time?

Kari: Come again…

FG: Am asking, in this boring lesson… you said one of the topics is metals and you said they are not able to connect with things that are at home. So, what am trying to ask is that… anything else that made them not be able to connect

with this lesson besides the content? Is there anything else that made it difficult for you?

KA: Okay, you know it's not one metal. They are different metals. So, this student do they really understand how to extract sodium or how to get aluminum, how to get the other metals let's say zinc? And all this, they have to understand. So, unless we use like maybe group discussions, teaching them will kind of wonder what is this you are saying and surely how does it actually happen.[***Instead of teacher-led teaching method, group discussion are better]***

FG: Right. Can you tell me something more about group discussions? When do you normally have them?

KA: Yes, we do normally have them. Like in the evening we do have them, we give them questions from topics that you have chosen, specific questions. And then go around checking if they are able to get the correct answers.[***In school pupils are given some questions and they discuss in groups in search for answers]***

FG: Okay. What language do they normally use when they are discussing?

KA: They use English and maybe Kiswahili.[***Kiswahili and English languages are used during discussion for easier understanding]***

FG: Is there any problem of using Kiswahili?

KA: In terms of what?

FG: You said that when they use Kiswahili, it is meant for them to understand. Now in terms of the policy… is there a problem that you see would say that is created by using Kiswahili? Do you normally encourage them a 100% to use Kiswahili?

KA: No, we don't encourage.

FG: Why don't you encourage them to use Kiswahili?

KA: Because it is the policy of the school that they have to use English.***[School policy is students use English]***

FG: Why should they use English?

KA: So that they can get used to it. So that when it comes to even an exam, they are able to read, write and give the correct answers in English.[***Although Kiswahili help students understand concepts easily it is not encouraged because exam is written in English. Good English help in passing exams]***

FG: So, the exam is the drive that makes English so important?

KA: Yes, because if they don't understand what is being asked in the exam. They will not be able to give the correct answer.[***Good English facilitates passing of exam]***

FG: Yes, okay. Another question is that, would you say that the science students learn in school, does it really benefit them when they go out of school? Is it able to create employment for them?

KA: Employment… because of the science subject that they do?

FG: Yeah, you know the curriculum….

KA: It depends on the student. If they hate chemistry or biology, it means they will not go for a career that is related to the subject.

FG: Okay, so….

KA: But if it is a student who loves biology and chemistry, that student will go for a career related to the same subject.

FG: Okay, So, would you say it help them fit into their environment- where they come from? That is, they can create jobs or be very creative? So that they can be able to get a livelihood out of the science they learnt in school?

KA: That depends on the student, because most will even ask now Mwalimu (teacher), where are we going to apply this chemistry. If the student feels that the best grade, they can have been a D-, so he doesn't see the need of that chemistry or mathematics. But if it is a good student who scores a B or a C or even an A, he or she will be in a position to maybe get into a career that is based on that subject.[***School science knowledge is of little value to a student who does not progress to higher education***]

FG: Okay, we know the reality is that not all students will be able to take that route. Some of them will not be able to kind of get the grades that you are talking about. Does that science help them maybe go back home, go to their community and be productive?

KA: Not much. Maybe unless you say something to do with agriculture, because that is what they can do practically but in chemistry… you know some of these things involve what you do in a laboratory and at home there is no laboratory. Unless you talk of what they do in the kitchen, but they rarely apply what they have learnt. Unless we talk of biology because that is related to the human life itself or the body. [***School science curriculum knowledge is of little value out of school. The knowledge is school based and not easily applied outside school. Agriculture curriculum is more practical and is applied out of school***]

FG: What I got is that you mean what they learn is not applicable out there? Is that what you meant?

KA: Yeah, they might not be able to apply. Especially when it comes to like chemistry. But biology, they can apply. In most cases like what is related to his body. [**Chemistry curriculum is of limited use in everyday use. Biology can be of use especially it deals with our body]**

FG: So, anything they can be able to relate they can be able to apply there and anything they cannot be able to relate with can't be applied. Is that what you mean?

KA: Yes.

FG: What do you think could be done to make it applicable out there?

KA: Unless they get more engaged in science fair.[***Teacher thinks a science fair where students are active in solving society problems is good to make school science more applicable]***

FG: What is science fair?

KA: Okay a long time we used to call it science congress.

FG: What is there in the science congress?

KA: It is where students come up with project out of their own creation and they explain how whatever they have as a project can help maybe control some kind of pollution in the environment or it can maybe improve what we have in our environment or how it can be of great assistance.[***More science project learning method. student led learning student could better identify a problem in their areas and come up with solution- being more creative. If students are exposed to such kind of learning, then school science could be of better use***]

[interrupted]

FG: I think you mentioned something interesting about the science congress, you said that students are able to make their own projects.

KA: Okay the student can have his/her own project, or the teacher maybe could be having a project and then get a good student to present it. But the good thing is when they come up with their own because that means that it is his own knowledge and they only require the teacher to guide him/her. [***Science project could be a creation and engagement between teacher/student or student/***student]

FG: Okay, so the students are able to come up with their own project. Is it students sitting together and coming up with their own things or the teacher come in and they work together as a team?

KA: They can also work as a team. Or the student could be having his/her own project in mind. Or as a team the teacher and the students will come up with a project. After identifying a certain problem in the society, how can we come up with a solution? Or what kind of a project can we come up with to curb such a problem [***More Interaction between teacher/student to identify a problem in society and solve it]***

FG: And then they come up with some solutions?

KA: Yes.

FG: Okay. When they are doing that, what kind of mood is there when they are discussing? You have been there?

KA: I have not been that active.

FG: Have you ever been in one of the groups or anything like that?

KA: I have but I have never been that active.

FG: But you say that is what mainly happen? The teachers and students come together. And they are able to come up with solutions?

KA: Yes.

FG: And therefore, they are able to seek a community problem. Now I would ask you, probably in the same set up. Have you ever had a situation where the student and the teacher sit down and maybe discuss a topic? is it possible? And if other teachers have tried and what is the kind of mood in that particular session?

KA: To come up with a project?

FG: Not actually a project. Just in the same way you say that the students were quite creative, there was a good discussion, there was some kind of interaction between teachers and students. Now have you ever tried something like that in the classroom. Or maybe other teachers tried and how were the students behaving? What were the problems you could face in case you did that?

KA: Okay, I told you I have never been that active. So am not good in that…***[Teacher believes a science fair is good but has not been involved in it]***

FG: Okay I will just phrase it again; do you normally have classroom discussions with the students?

KA: Yes, discussions we have.

FG: You have, whereby the students are able to do the same, try new things, suggest other things, try different way of doing things… have you ever had this kind of discussion with the students…?

KA: Yes. They are normally there…

FG: Do you have an example and tell us how the students engaged in the lesson. In terms of the level of understanding… how was the lesson?

KA: Okay… that has happened when it comes to like you are doing calculations. And maybe they know of an alternative or maybe you have taught for the first time. The second time when you are maybe reviewing that's when they can tell you of an alternative way of doing the calculations. [***Class discussion as a teaching method promote creativity and innovations]***

FG: And do they feel interested? Or what happens?

KA: Yes. Because now they feel they have their own way of doing it. [*When students are in control of their own learning process/ownership the level of interest is high]*

FG: And they feel like they own the whole process? Is that so?

KA: Yes.

FG: Have you ever been involved in the curriculum development?

KA: No, I have never had. [***Teacher never been involved in curriculum development-feel no ownership]***

FG: So, if you had the opportunity, what would you suggest to that panel? Maybe from your own opinion? What would you tell them?

KA: [silence] okay...What I would insist is that we have more of practical lessons than the time we have for theory. (body language showed surprise) [*Silence feels like she has never imaged anyone cared about her opinion. School science curriculum should have more practical's]*

FG: Why would you say about practical lesson?

KA: So that the students can get engaged and can also have a wide exposure using apparatus, reagents and all that. [*Practical engage students more with learning materials]*

FG: In terms of the level of understanding, what would you say practical lessons would introduce in the lesson? In terms of understanding and students getting engaged.

KA: When it comes to practical, it means students will be more engaged and do it by themselves.

FG: And what about the level of their interest?

KA: Because when they are doing it by themselves, they even enjoy doing it. They would even wish to do it more and more than when you are doing it as teacher. [*Pupils enjoy practical more when they do it themselves and not teacher demonstrations]*

FG: So, any other suggestion would you put across to that panel?

KA: On how to improve the science only…?

FG: yeah…

KA: [silence] For now, I don't have any other. I feel that they should only engage in practical.

FG: Okay, the last thing I would probably ask you is about the language that you normally use. On the indigenous knowledge you talked about and the practical, do you think there is a certain level of students that will benefit more from that?

KA: Okay, do you mean that when student learn from indigenous knowledge or practical, they understand better?

FG: Can I rephrase; in you class are all students of equal ability?

KA: No.

FG: Okay, so what levels do you have?

KA: Okay, you will find students who are very good in a given subject, others are average, and others are below average. [***Classrooms have children of different learning abilities]***

FG: Yes, in case we use indigenous knowledge, things that they know or do at home which group is going to benefit more?

KA: The group that is below average because you have brought them to their level now. Okay, those who are above already know themselves and they know they are better. So, this below average feel they are weak and not-really good when it comes to understanding and when you use such things, you bring all of them to the same level. [***Using Indigenous science knowledge help low ability student to understand more. High ability student easily understand concepts so may not need indigenous science connection for understanding]***

FG: Is there anything that makes it hard for you to use indigenous knowledge?

KA: No. I don't think there is anything.[***Teacher feels no obstacles to use indigenous knowledge in teaching]***

FG: What is your attitude towards indigenous knowledge? Do you think they are going to be important in learning of science and solving some problems?

KA: It is of importance and can really help the students in understanding. If it is in line with what you want to teach, then there is no problem. But if you use it where it does not fit that means it will be different information…[***Thinks indigenous science knowledge is important and help student understanding, only if it fits with a topic. If used wrongly could be confusing. Or mean pupils have two views on an issue]***

FG: Now what guides the knowledge you are supposed to teach?

KA: It all depends on the syllabus. What are my lesson objectives and all that? Can I bring indigenous knowledge? Then will it fit or help them understand? Do I require practical? Do I require a teaching aid? And all that.[***The syllabus is the guide in everything a teacher does- content, teaching method, teaching resources , if indigenous knowledge can be used]***

FG: So, you would use indigenous knowledge as long as it does not go against what you are supposed to be teaching?

KA: Yes.

FG: Does it sometimes cause a conflict?

KA: Okay sometimes you will find that there are those who know this is what normally happens and what doesn't happen.[***Not all students know all indigenous knowledge, so may be confusing to some]***

FG: Okay, the other thing is that… what other resources do you get from the government? Do you get some training? Or do you think training would help?

KA: Unless we talk of early last term. We were having workshops for chemistry teachers, English and mathematics and it was of great help towards.[***There are limited training opportunities in science curriculum. The few one have been helpful]***

FG: What help did you get?

KA: We gained knowledge on how to tackle different subjects. There were those who were more experienced than we are, and if you consult them, they will tell you this is how we do it, this is how it is done, and that was one of the ways in which we benefitted. Then we were also identifying areas we feel that are tough for the students. And how to cope with such kind of topics.***[Training helped teachers meet and share good practices. Teacher identified areas of common challenges and way forward]***

FG: Okay, any other challenges you face in the classroom that make you not be able to achieve your lesson objectives?

KA: Maybe if you want to teach a certain topic and something is not available. So, you have to teach without it [***Lack of resources make teaching a challenge]***

FG: Can you give an example of something that is not available?

KA: Okay like you want to teach about maybe solubility… all the salts are available except one that you want to use so that they can clearly see. So maybe it is not available by that time, and you have to do without it. [***Sometimes some important required teaching resource/chemical lacks and the lesson feels incomplete. Lesson objective not achieved]***

FG: So, how do you do it?

KA: You just teach it and make a request that next time it be available.

FG: So, the student kind of have to memorize?... is that the best word?

KA: They will understand from the explanation.

FG: What about those who have never seen it?

KA: Okay, for them they just know it's there, but in our school it's not available.

FG: Yes, would that contribute to let's say memorization if I may use that word?

KA: Yes, they have to memorize because…. Okay, whatever they can see cannot be easily forgotten. But in this case, they have not seen, so they have to just memorize what you told them. [*Lack of essential teaching resources lead to teacher-centered teaching method (rote memory) which led to low retention of knowledge]*

FG: Right, what can you say about memorization? Does it help them understand? Or what is the mood of the students when you teach things that they cannot see and it's not your fault?

KA: At times they can also question you. Why can we get this for us to see what you are telling us.

FG: Yes. What is their reaction or the look on their faces? [laughs]

KA: Okay, it's like you are forcing them to understand something they cannot see. [***Teacher-centred teaching method is like forcing student to understand something that do not exist]***

FG: ahaa. What about the level of interest?

KA: They are not much interested. [*Teacher-centred teaching method led to little interest by students]*

FG: What about the engagement? Do they ask questions?

KA: Okay, of course they will ask because they will be curious, and they will be wondering what this is you are telling us. What is it? How does it look like…?

FG: Okay. If this is not available in this school, do you think there is another way to get around that?

KA: The ones that can be improvised you can try to but the ones you can't, it means you can't. *[Sometimes teacher try to improvise where they can].*

FG: So sometimes you try to improvise?

KA: Yes.

FG: Where do you get those improvisations?

KA: Okay…the students…like if you are teaching mathematics and it is a topic on what?... maybe solids and you don't have them in the school, you mold them with the students. Or maybe you tell them to bring them. Like the one for milk having four corners… so they to come with it, if the school does not have one. [*Teacher ask students to bring some teaching resources from home as improvisation eg four-sided milk packet]*

FG: Is there another problem that you face in class that makes you not achieve your objectives?

KA: Being a day school is a challenge. Because sometimes the students are not in school. Maybe they have gone home for school fees or other issues, so that student will come later after you have taught something may be in the exam.

That means that student will not be like the rest. So, what you taught, you only taught a few of them. What about the rest? those who are absent. [***Students lack school feels, are sent home and miss important information which may help them in exams]***

FG: Why are they absent from school sometimes?

KA: Like school fees challenges.

FG: So, school fees? Okay, any other challenge that you might find?

KA: The most challenge is that one. Now that most of them come from a humble background.

FG: Okay, what do you mean by humble?

KA: Okay, what we feel is affordable to most, it's not affordable to them. [***School fees is not affordable to most students]***

FG: Could you just give me an example?

KA: The amount of money that they pay for school fees you would feel like it is affordable, but it is not.

FG: It is high for them.

KA: Yes.

FG: Anything else that they don't afford which is needed in the school?

Kari: Mostly the school fees.

FG: okay. So, thank you very much for your time and thank you again.

APPENDIX E- Codes and themes

Name	Description
Abstract school science knowledge	Teacher centred ways lead to rote learning without understanding. Teacher and government not giving students a safe place where student learn knowledge and skill, they need to survive through science discussions and engagement but not just submitting to narrow thinking led by authoritarian state policy through teachers. Without a safe learning environment, SS learning will be a challenge for a long time to come.
Adequate science resources	
Calculations are a challenge in science	
Challenges of prior knowledge and misconception	
Challenging student background issues and needs	Public school students are disadvantaged because of poor English language background compared to urban or privately schooled students. Access to education goes beyond being in school- social factors like poverty are important. [bute]Secondly, we also got the jielimishe donors who have normally kept on inducting us on issues to do, how to manage maybe community interests. So that they can enhance education right from the home back grounds all the way to the schools [foreign advice is "superior" over local which is not even mentioned. Local input maybe argued to be lacking in L/T of school science]. So that way they are able to become more confident in what they are undertaking in school [bute]and we also advice the parents to give them a bit of more time to be able to learn [looks like either

Name	Description
	parents do not regard school as important or parents need their children hand in survival]. [BUTE] Because you see the donor will only take a few of the girls they are sponsoring. So, all the others are left hanging [Donor help appear not able solution to learning challenges]
Circumstances force teachers do other things.	[Njoroh] So, as a school we have really tried as much as possible to acquire some of this equipment and chemicals. But now the way we are doing it; is like we are putting off some of these students. From form one so that now, the fewer number can be able to be involved in sciences. So, that is one idea whereby we make the students drop one science especially in form three and four. But now the challenge comes in because, how do you tell this one goes to physics. it will be so random and the idea before was that during the first two years, they will have understood what physics entails, what chemistry entails [Teacher frustrated in deciding what to do when students forced to make decision when less informed]. And it's a bit unfair because sometimes when somebody does the three sciences, it can even build their future career. [Lack of resources forcing teachers to contradict policy of increasing uptake of sciences by limiting intake based on available resources, which teachers know is unfair but have no choice]
Community and school values and knowledge are both important	[Njoror] "But we were able to join the community…they call it, community forest association. We paid some money and then I used the parents and our students to go and harvest the rocks there, bring them and build but it was legal. So, nobody would chase them away, the young people are no longer like the former ones" Implies that community and school can work together to solve community challenges. "And they just went to the parents, and they agreed. And this guy is already in Nairobi, but he is even sending money so that the parents can be able to farm tomatoes and the rest. So, he gave the capital and is also looking for the market." [strong family ties mean communal spirit still exist around here].

Name	Description
Culture and beliefs good and bad	[Njoroh] “And this guy is already in Nairobi, but he is even sending money so that the parents can be able to farm tomatoes and the rest. So, he gave the capital and is also looking for the market. And this people now, they are doing well. [Implies family ties] Stories, beliefs, and practices associated with ISK a lacking in technical sophistication and is unusable.
Day school, other students’ skills and challanges of choice	
Different student ability groups and equality	What teaching and learning ways benefits low and high ability students [Njoro] and even commenting on this kid (as a team), so that we understand them more [acknowledge students may be different]. [Bute] for us here it would be a very major challenge because one, when you tell them to read English [laughs]. It becomes a thorn in the flesh, they have that problem, even those who are very bright, you find they have a problem in communication [English is a problem to all children].
English is science language of explaining everyday things	
Exams are important but not all	Teachers and students fail to know that academic excellence exists within them and not behind exam grade or in colonial school building.
Home knowledge and belief understood through school science	
Home knowledge, language, practices that	Things from home that connect with school science

Name	Description
help understand science	
Knowledge of student environment and grades are important	
Teacher connects home experiences and science knowledge	
Creativity	
Important science teaching guides	Controlling guides leads to specific methods of teaching and do not allow creativity.
Indigenous knowledge is valuable brings equality and already available	[Bute] Like the music festivals, they are so much engrained in those traditional songs, so, meaning in cultural music they are able to enhance it because they have started it right from their home background. But give them anything modern or technical, you will find they don't know. Because especially the language like in English will be a problem. So, you find the Pokot will come up with a pokot song and they teach the kikuyus, and they learn and are able to sing the same song. So technically they enjoy that [laughs] [evidence that pupils are more likely to be interested and succeed in anything that connects with everyday ISK. Interesting that one ethnic group can easily teach the other who live next to each other their own ISK and communicate easily-there is a common ground].
indigenous science knowledge and challenges in classrooms	SM: I think the information in the textbook is just but to guide a learner on terms of when it comes to exams. But when it comes to general knowledge, maybe they(textbooks) assume that you will go out and search on your own. But as for them they will just give you what you will be examined on. [implies that textbooks do not include ISK and assume to be

Name	Description
	instinctively in students and will not be examined- what students do not know is another body of knowledge that is separate called SS and which students will be examined on]
Lack of a specific needed resource to properly teach a concept	
Lack of humour in teaching	
Lack of money to support L&T	
Lack of necessary science teaching resources and infrastructure	[bute]Now in our school, the facilities are not adequate. Like now this donor came and told us they would like to start ICT support so they could give us laptops and that. But they have only managed to give us about four laptops for the teachers and we would have wished… maybe if we had enough laptops. Or maybe even we put computers in a certain laboratory area so that these kids can learn the technology [adequate T/L resources are a major challenge to overcome for this school, I think something else is a must if quality education is to be provided].
Improvisation of resources and limit	
Lack of resources and teaching methods	
Lack of teacher ownership of science curriculum and education policy	
Lack of teachers and effect on subject interest	

Name	Description
Meaning of science not understood	[bute] Like here for instance, you know we are normally able to upload some of these technical and scientific images. Like here for instance, you know we are normally able to upload some of these technical and scientific images. And once they are able to see them over the screen and how they are operating, and then they compare with what is drawn in the books. They are able to become more enlightened, and they can be able to see how they are operated. If it is maybe a practical preparation, they can be able to operate through the computers and then go get the apparatus and they are able to conduct an experiment [teacher assumes what is in books is all you need to be enlightened. Doing an experiment is assumed to lead to a successful science student]. SM: These (the general knowledge) are things you maybe you do outside and you maybe you do it daily… and you think it is science but when it comes to books(text), it is not there [shows the confusion students find themselves in, bridging between SS and ISK]. Bayo: Science is everything we do at home and even in school.
Mother tongue, Kiswahili, sheng and Englis in science	[Njoroh]It (other languages) does (help) to an extent, because if they don't do that, those kids will not be in that class. Even in as far as the forty lessons are concerned, they will just be there seeing somebody, opening their mouth but they cannot comprehend [Feels English use, strongly disadvantages understanding students in all subjects] [Njoroh]but when you talk in Kiswahili, sometimes though maybe the words may not necessarily be very scientific…inaweza kuwapatia an idea (using Kiswahili helps in understanding) [Other languages "inferior"] [Njoro] Yeah, if you find that the students are having difficulties…it is good that you divert to Kiswahili, because it is even a compulsory language subject. You know English and Kiswahili; these are the options. So maybe I shall not tell you to use French or

Name	Description
	German, but Kiswahili will assist you a bit [Teachers have a choice of what language to use] [bute]. So, they are telling them that in literature, you are not only going to be learning in English. Let me put some of those terminology and then translate them. So that as you are reading, you are able to conceptualize the things that are there [Implies that MT is used to help explain a concept in English, it is viewed as "inferior" as opposed when it is used to express a personal, social or cultural experience in the language. So, we are still viewing western knowledge as "superior", so we are getting ways to understand it better and ignore indigenous knowledge in our culture].
Not all topics use home knowledge	This identifies areas where home knowledge can or cannot be used in a science topic
Peer influence in learning	
Perception about school science knowledge and English language	According to Njoro "We have been changing that notion [small scale farming] They also used to have livestock that was not the current kind of modern livestock" implies that school knowledge is there to replace ISK does not work alongside it. Njoro "They are not like the former students or let's say the former young men who were always known to immediately after they leave school, they go for the matatu(taxi) touting, girls go for house maids" [there is predetermined outcome, work in shops, agrovet and M-pesa agents]
Perception about the science curriculum	This is about positive and negative what things and views. The Jebi secondary school HT gives a good example about how a community challenge can be solved by involving the community members "But we were able to join the community…they call it, community forest association. We paid some money and then I used the parents and our students to go and harvest the rocks there, bring them and build but

Name	Description
	it was legal" so a relevant curriculum should involve the community challenges. [Njoroh] If they were to be made compulsory, I tend to think they intermarry [implies that science is not narrowly defined as subjects but overlapping with each other. Interestingly he says science should be defined in their narrow form in lower school level to be built upon into higher levels, but should all be studied together if it is going to be helpful to students] [Bute] but give them anything modern or technical, you will find they don't know. [SS is considered by teachers as separate and elite not part of local daily experiences] [bute]Technically, it would help but it is not adequate as of now… the reason being one, we are implementing a science curriculum that should be practical and technical and should be making the kid generate very skillful knowledge but at the end of the day you are not providing the facilities[The language used implies that the teacher is strongly for this monocultured knowledge source that is so important for survival. But complains about lack of teaching resources and does not seem to have an alternative knowledge system-maybe his similar schooling put a curtain on his face. The teacher is really frustrated with the government inaction]. The broad home science knowledge is easily forgotten because of the narrow SS curriculum that defines science and promoted by exams.
Perception on indigenous knowledge and beliefs	[bute] Now when it comes to the general guidance and counselling, we also call those motivational speakers. They come and talk to them. Like the other day we had a whole doctor, we call him Dr. Stanley Kamau. He had to come and talk to them, to mentor them. Actually, show them the way forward in terms of focusing on their goals [The words use here gives the impression that Bute considers western science knowledge to be "superior" over local science

Name	Description
	knowledge, raising doubt about space for alternative knowledge] [bute]Yeah, right now we even have community leaders here, right from the church from the farming department and all that. Whenever we have an issue, we call them and they come and talk to them [looks like there is limited community interaction, apparently not very important part]. [Bute]No (opportunity for community knowledge), as of now we may not say we have been involving them(community) so much here, because most of the parents here, when it comes to education, they may not have gone ahead of class 8 and class 7. Some did not go beyond secondary, so we have those technicalities [a negative attitude to community knowledge, school knowledge considered "superior"] [Bute] Let me say…technically if it (indigenous knowledge) was applied the right way, I believe because these people have come from localities that have those indigenous experiences and even teachings from the clans [ISK is not outrightly dismissed but thinks could be useful in certain instances]. [Bute] in some higher level of understanding, it (if the same culture was introduced in the education system) can help. Now the problem will be how to go about interpreting from the culture the mother tongue to the academic language which is normally English. If we were in Tanzania, it could be Kiswahili. For us here it would be a very major challenge because one, when you tell them to read English [laughs]. It becomes a thorn in the flesh. They have that problem. Even those who are very bright, you find they have a problem in communication. [ISK can be part of SS; however, teacher feels that issue of translation would be a challenge. Thinks that English is language of academic while other languages are not. It is doubtful if such an attitude is one to promote ISK into SS]. Most teachers are products of the same system that most likely stripped them of

Name	Description
	their dignity, so it is not likely they can be trusted to believe of alternative ways of thinking. [bute] So technically I would feel that if we were to amalgamate all those languages or customs and skills so that a teacher can be able to translate them into those languages (English and Kiswahili) across board, then it can be very okay. The learner would benefit. But of late we can say in secondary school, it (indigenous experiences) is almost being ignored. Normally you don't want them brought in, but I was of the opinion they start bringing them in. Even if it involves further translation, because if you look at our day to day lives, kids have intermarried, so that kind of intersection could also be able to help the kids interrelate the language and the culture and the skills they are learning [implies how hard it is to indigenize the curriculum because of diversity of knowledge. It is good when teacher thinks that local customs, knowledge and languages should be translated into English language and not the other way, which means there is respect of the ideas in their originality, however there is possible loss of meaning during translation. Negative attitude to customs and language is seen when teacher says that they should be combined into one so that they could be easily translated into English the "superior" language-so why not learn in those languages? The teacher is also positive that it is possible to merge African languages because of success of intermarriages] [Gathuri] Therefore, a student would hold on to such beliefs because they do not have adequate information [implies that teacher has a negative attitude to traditional beliefs and associate them to be due to lack of "official" knowledge that teacher associates as "true"]. It is therefore frustrating to expect such a teacher to value student/indigenous perspectives in T/L [Kari] (indigenous knowledge used in science lesson) Some were saying we use the charcoal [laughs] [laughing when a student using IK implies the negative attitude teacher has on IK]

Name	Description
Problems of absenteeism.	
Rapport is important	
School policy on teaching and learning science curriculum	[Njoroh]So, as a school we have really tried as much as possible to acquire some of this equipment and chemicals. But now the way we are doing it, is like we are putting off some of these students, such that, when the students get to form three, they make choices between the subjects. [lack of laboratories forcing school to change how student select science subjects-limited student choices] [Njoroh] the other thing we have done is that…we have created studies during Saturdays, and we have said let these students do practicals on Saturdays. Especially when…you know during that time (saturday)they are a bit relaxed, it's like they are not in school. So, they do them on Saturday. [implies that students are tense (overloaded curriculum) during school day and cannot handle delicate practicals]. Students more relaxed home. Doubtful how L/T in a tense environment could lead to desired outcome. Feedback about T/L through HOD "you know as much as maybe I am not in sciences, I am already aware of what is expected" [feels unsure of some details] but usually possible after exams results [sounds should be a continuous thing]. Teachers monitored through documentations and HOD little face to face contact. One thing we have done…we have insisted on the use of English and Kiswahili [suggests some languages are "superior" over others] "Initially we had a policy where English would be used up to Thursday, and then Friday would entirely be Kiswahili. But we realized there was that abuse of that policy. So, we now insist on English because as much as we may talk of indigenous language, all those subjects and especially science you need a lot of understanding of English to get anywhere". [Student resisting the use of "superior" languages which are being forced onto them through policy as

Name	Description
	the only way to learn science. Teachers appear to be aware of importance of indigenous languages to students but there is little choice left] "So, it becomes a challenge, but the policy is English, we even punish some students when they are caught messing up" [A replication of colonial policy of domination of one culture over another, where force was used for compliance, so do teachers] "But I wish we could even get more Kiswahili people to translate the science [both laugh]" [implies the teacher does not believe on the importance of language policy being implemented] [Njoroh]and we agreed that they must try as much as possible not to use Kiswahili. Then they realized there would be no communication, these kids will remain in the dark [Implies teachers believe in policy, but changes because does not work]. [Njoro]So, it also makes the marking easier, because if am marking question one na yule ako question two, atai-master ile marking scheme easy (marking one question makes it easier to memorize the marking scheme) [alternative views given little space]. [bute] Because normal lessons start at 8.00 A.M. so, with us we tell them to be here by 7.00 A.M. So that between 7.00 am and 8.00am, we are able to mentor them. So, we give that extra hour which we normally commit ourselves beyond the expected lesson programme. So, we are now able to push them up and see if they can catch up. [pressure put on students and teachers to complete syllabus requirement beyond government requirement]. Children are victims of the exceedingly high expectations thrown at them by their schools and teachers. [bute]but technically we have also noted those of them when you push them so much and they realize you are harassing them, they tend to drop out. Because their mind is not focused on learning [pupils are not motivated and disconnected from the learning materials]

Name	Description
Student and school culture conflict	[Njoro]Especially when…you know during that time (saturday)they are a bit relaxed, it's like they are not in school [home and school culture show tension] in fact, I remember one time when I came around, there is a boy when they went for practical decided not to touch anything, because they were told if you break, you replace, and he could not even hold it, every time he is holding it, he is shaking. So, we had to encourage him and tell him not to worry. We don't have to charge you. And he started doing the whole thing [Tensions exist in school /home culture and when reduced learning occurs]
Student attitude to science in context	
Perception of a good or bad teacher	[Njoroh]…you know students disliking a certain teacher. And you know like mathematics and sciences, many a time the students will hate the subject, and they will connect it with the teacher [implies that teachers feel like a victim of implementing an irrelevant science curriculum to student's experiences]. [Njoroh]They see as if the teacher is very strict but when you know that in physics teacher so and so can come…then we are also having the same marking[The word strict implies that if a teacher is following all details of school policy and which students do not relate well with(and teacher), little space for their views. To avoid students picking on some teachers, school tries to have some uniformity in policy action]. [Njoroh]and even commenting on this kid (as a team), so that we understand them more. Sio tu kusema wacha huyo ni mjinga kwa chemistry (not only saying a student is underperforming in chemistry). Mwalimu wa physics ni mbaya (physics teacher in bad). So, we are trying to remove that. [acknowledges negative labels given to teachers and students and which affect L/T of sciences and working to reduce that]

Name	Description
	Anybody can come in and you may find that we may have lower scores, but they have really done a lot for their students [HT unhappy with emphasis on exams in identifying best teacher ignoring other student experiences in school]
problems and good about practicals	[Njoroh] Like say if its physics and there is that idea of batteries, anaconnect hii wire ni negative akiweka pale anaona bulb inawaka (the students connect this negative wire and sees the bulb lights up). You know akiendelea kuifanya namna hiyo, ataanza even ku question themselves (if students do more practical, they may begin questioning themselves). They become more inquisitive. Rather than when it is just practical [practical must be related to student culture to be meaningful and provoke creativity, not just a practical].
Student behaviour	
Student challenges, dependency on textbooks and policy	SM I think it could be fine (having general, knowledge in textbooks). Because not all the time that everything we do at home is per what is supposed to be done. But now you know when you get to learn in the books, you will understand that so here I have been going in the bad direction, so it's supposed to be this way. Maybe you will change and maybe it will work out better than the way it had worked out before [implies that whatever is in the textbooks is "true" and any other knowledge need to be true to be in textbooks-so students are looking for objective knowledge. Students made to believe that SS is not socially and culturally constructed].
Student must do as told to succeed	Use a "superior" language of science or be physically punished or fail exams. Defined knowledge in curriculum.
Student prior knowledge, differ, good for	How prior knowledge impact on learning

Name	Description
understanding and interest	
student response to unspiring lessons	[bute] So we give that extra hour which we normally commit ourselves beyond the expected lesson programme. So, we are now able to push them up and see if they can catch up. But technically we have also noted those of them when you push them so much and they realize you are harassing them; they tend to drop out. Because their mind is not focused on learning. [implies syllabus is too long and extra learning time is needed to drill the students. Too much drill leads to dropouts because they are less interested in what and how they are learning it]
Student taught by memorizing	No new understanding
Student voice and challenges in learning process	[Njoro] Let me say especially with the form three and four, I think they have now really started appreciating what is going on. There is a bit of challenge tuko nayo (we have) in form two and form one. But you know this is because probably they are still new in the system but now that we have started it, we'll see that the challenge will go down. So, when they see now there is that change, probably hawajaishika vizuri (they are not used to it), because we have also now given them the option of making their choices(subject) at form two. Not necessarily at form three, but with the form threes they are now even appreciating such changes, because they know, and the form four the kind of problems we have been having. [Students appear not to be involved in L/T matters related to them-looks like surprise changes to student's L/T process- power dynamics in favour of teachers]
Students culture, practices and virtual things help in understanding and interest.	This node takes on knowledge that is remembered and how it was taught. [Bute] They own it (cultural activities) up properly. In fact, they like it. When you tell them to dress up in that attire, they do it so well, so they get the

Name	Description
	costumes and you see they enjoy so much [When student feel they own an activity which has home connection, they put more effort into it and are motivated]
Lower classes ignored	
Students more engaged on daily experiences than exam issues.	
Students experience integrated into school science	
Support given to teachers and students	[bute]Secondly, we also got the jielimishe donors who have normally kept on inducting us on issues to do, how to manage maybe community interests. So that they can enhance education right from the home back grounds all the way to the schools [outside advice is “superior” than local one-attitude]. [bute] There are normally areas in terms of induction. So maybe a teacher who is an expert in exams... we call them and show the students how they should apply their skills in answering questions in the national exams [implies that there is more emphasis on the exam aspect of quality of instruction while other skills like application of knowledge is ignored. Taking on other “expert” shows undermining his teachers to the students in terms of competence and other learning instructions]
Teacher and physical challenges	
Teacher and policy are specific on what and how knowledge is taught	Narrow knowledge narrative does not lead to new understanding and creativity and job creation. [Njoroh]Yeah, this (team teaching) is what we normally do and encourage. On the timetable because it is a requirement, we will say you are in one class let’s say form four East and I will take form four West, and you are taking chemistry. So instead

Name	Description
	of you just being the one who will take topic one to topic twelve and maybe we are four of us, so we share. That class we say you will take topic three…it is your class yes; you will take topic three in the other class because we are using the same scheme of work [Teacher's capacity to be creative and working together, but within a government policy "timetable" and "scheme of work"].
Teacher and student source of science knowledge	
Teacher attitude and motivation in teaching	[bute]Well, let me tell you these kids are really backward in terms of technology. So, they are also able to learn that because you are in a certain facility you don't just go looking like you are so green. [teacher focused on only one area and expresses a frustration on student lack of knowledge on modern views. This attitude is unlikely to accommodate student home experiences in SS]. [bute] So technically I would feel that if we were to actually amalgamate all those languages or customs and skills so that a teacher can be able to translate them into those languages (English and Kiswahili) across board, then it can be very okay. The learner would benefit [implies a negative attitude to African knowledge and culture which must be changed in one way or the other to fit into the "superior" English language. Such a teacher holds a colonial view of African aspirations and success] [kagunyi] Initially they thought like in the village, they have of somebody having a meal, so they assume it's like a posho mill, the way it grinds food. So now when you take them through, the enzymatic digestion, they come to realize different from what they have perceived [Teacher implies SS is disconnected from village thoughts (undermines home knowledge). Teacher appears to have knowledge of student home knowledge (which he is

Name	Description
	also part of) but his attitude to that knowledge seems to betray him by his bias] [Kagunyi] Misconception, that all the food eaten is digested in the stomach. Then one persists. And takes time to know that one [Teacher implies that home knowledge is "a misconception" which takes pupils some time to understand the "truth" found in SS].
Teacher authority in subject knowledge is important	[Njoroh]but any concept that comes up, ata sasa like even in form one and two when Mr. nyaga feels there is a topic ambayo inampatia challenge (if Mr Nyaga feels there is a challenging topic). You know we are also encouraging the teachers to just agree you cannot be good in all areas. Probably there is a concept that you never got well, and your colleague is very comfortable with it. Sasa utamwambia you go there na mimi niende ile (you agree on topic you are comfortable with) [an acknowledgement that teachers do have knowledge gaps, which may affect L/T process of students in science].
Teacher challenges of indigenous knowledge	
Teacher has power over students	[Gathuri]I also guide them on how they are going to read the textbook together with my notes as reference. So, when I give them assignments, they should be able to handle, because I will be very strict. The students must have notes, and they must complete my assignments. So that they can understand the concepts well [implies the teacher knows what is right and has to be followed, alternatives ways are restricted-it's difficult for such a teacher to incorporated alternative views from students]
Teacher is important	
Teacher knowledge of pupil home culture	

Name	Description
Teacher language and grade challenges in career	[Njoro]and if a teacher has a weakness, probably this person will not be available every day, or they have a problem in language and the student might not really get what the teacher is really talking of. So, they will find that this topic was covered by a different teacher, and we got the concept and probably here hatukupata vizuri (we did not understand). They can be able to approach the teacher and say can you repeat here ambayo hatukuielewa (we did not understand). So, it gives that variety. And as they say variety is the spices of life [both laugh]. [Teachers have challenges of absences, language and communicating, so teacher initiatives of working together makes it easy for students to seek help from alternative teachers, if necessary] [njoro] Am sure they will be able to…like let's say some things like pendulum, if you want to use it unapata unatumia pengine moja na wanafunzi kama watano (presently a pendulum is used by about five students) [mixture of English and Kiswahili languages shows teacher English language challenges]
Teacher not first choice career	
Teacher perception of quality L&T instructions	[Njoroh]in fact, it (indigenous knowledge help student to be self-reliant) would. So, if it can be…like say this, Just the other day I saw an article where a young man, I think from somewhere in Nyeri town in central Kenya) … is it Nyeri or Kirinyaga, is really making a lot of money out of making soap-bar soaps and all that. The other day we used to buy detergents here, but nowadays using our deputy, our students are the one who make them, they go for those chemicals and they make the detergent here [Appears HT appreciates the use of knowledge and skills by students to solve problems in the school] To me it appears he does not appear to understand that ability to problem solve and passing an exam could be attributed to the quality of instructions.
Teacher quality	[Njoroh]Because we realize that some teachers ata akipewa (even if they are allocated a) class, one class would lag behind, depending on probably the

Name	Description
	teacher has been sick [Implies the H/T is more concerned about completing the syllabus rather than any other L/T including creativity, problem solving skills etc that students may acquire.] There are 2 mentions of teacher being sick by HT which make me think that teacher health would be a factor in L/T in the school. But supposing they were to say, this is the marking scheme, how far have you been able to be innovative in your teaching of science, or in whatever subject you are teaching by using IT? Anybody can come in and you may find that we may have lower scores, but they have really done a lot for their students [HT frustrated by the criteria used to identify good teachers-emphasising exam scores and ignoring other achievements].
Teacher support from colleagues, students and parents	[Njoroh]and as I said the teachers have been requested to revisit certain topic done by their colleagues. And that is why we are having those we are calling remedial classes. Ours is a bit different from what people would say tuition. We are having remedial classes whereby a certain teacher taught a certain concept and probably they did not get it very well. Then another teacher will come, and they will be told it is the same thing, but this is a remedy. So, wherever you found weaknesses, can you now change [Implies that either the teacher or methods of delivering learning materials is deficient].
Teacher talk has some challenges	This node stores information about things learned in school and forgoten
Teacher training challenges for teaching	This nodes stores information about highest qualifation achieved. [Njoro], you know we are also encouraging the teachers to just agree you cannot be good in all areas [implies that teachers have a knowledge gap, which they do not readily accepts, probably because of the power they have over students].

Name	Description
Teacher turnover high	
Teachers Influenced by others or issues to be teachers	This node stores information about influence of others into the teaching prefession
Effects of government documents on teaching	
Teaching as a calling	This node stores all perceptions (positive and negative) about teaching.
Teachers have less indigenous and science knowlege	This node stores all information about teaching career having people who have not got higher grades needed in other careers.
Technical language only in English language	[Njoroh]but when you talk in Kiswahili, sometimes though maybe the words may not necessarily be very scientific…inaweza kuwapatia an idea (using Kiswahili helps in understanding) [Implies only English words are scientific (superior), other languages are "inferior"]. The broad home science knowledge is easily forgotten because of the narrow technical SS curriculum that defines science and promoted by exams.
The science learning approach pupils enjoy and dislike	Pupils enjoy openness to others, dialogue, cooperation, negotiation and collective reconstruction of knowledge and skills needed for survival. However, there is little opportunity for this, a normal classroom dominated by teacher talk. [Njoro] Then there are those things we call science fair and technology. When kids are going there, some of them do perform very well. Then again and I think this will go to the language part of it. But when they come to present, those students are completely hindered by the language. They (organizers) should even make it possible to use Kiswahili so

Name	Description
	they(students) can explain whatever concept that they have, because most of them(students) present what the teachers have…so nikama wimbo tu ameambiwa (memorise what teachers told them). So, if questioned, they get confused [Implies that although students enjoy and relate with science fair they are alienated by language, lack expressive skills in English so just copy what teacher told them.] [FG] As the teacher start teaching, the topic was hard to me. But as long as he starts using the Kiswahili words to explain some compounds, actually I start understanding [Looks like Kiswahili is used to help explain some SS concepts and not as a source of explaining ISK that students have- its "superior" vs "inferior" language]
Using Kiswahili and English languages help more understanding	This node is about the good and bad of using these languages for students. [Njoroh]Yeah (teachers use other languages teaching), from both sides. The teachers themselves…to bring themselves nearer to the students, they have to use Kiswahili [Implies use of other languages reduce teacher/student power balance].
Student backgroud and learning	This code looks at pupil backgroud and how it affects their learning.
Teacher has freedom on planning a lesson	[Njoro]Yeah, if you find that the students are having difficulties…it is good that you divert to Kiswahili, because it is even a compulsory language subject. You know English and Kiswahili; these are the options. So maybe I shall not tell you to use French or German, but Kiswahili will assist you a bit [teacher has freedom of language to use]. [Njoro] Yeah, this (team teaching) is what we normally do and encourage. On the timetable because it is a requirement, we will say you are in one class let's say form four East and I will take form four West, and you are taking chemistry. So instead of you just being the one who will take topic one to topic twelve and maybe we are four of us, so we

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	share. That class we say you will take topic three…it is your class yes; you will take topic three in the other class because we are using the same scheme of work. [Shows some initiatives teachers take to work as a team to achieve curriculum goals, within government policy] [Njoro]…. Even that idea of having tension between teachers [teacher can work together to reduce conflict among themselves to benefit students]
Views about indigenous knowledge and barriers to use	There is limited mention of ISK and its relevance in everyday use in student communities during interview which tells me that T/L takes place with less benefit of the rich surrounding environment knowledge and practices. Teachers did not find enough space for ISK in the SS; however, ISK is not out lightly dismissed.