Understanding trainee teachers' engagement with prior everyday knowledge and experiences in teaching physical science concepts: A case study

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BY

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DECLARATION

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and has not previously in its entirety or in part been submitted at any university for a degree.

Signature: .... Date:...

ABSTRACT

The constructivist world view is advocated in the Namibian National Curriculum for Basic Education (NNCBE, 2010) since it encourages teachers to use different knowledge sources. This perspective embraces a multicultural approach to science teaching and learning. Indigenous knowledge (IK) and western science (WS) are some of the knowledge sources that are advocated. Yet, it has been noted that some science textbooks used in school science curricula do not consider IK. It is often diminished and considered of lesser value. The sole use of WS in teaching and learning is often distant from IK sources which can be used as prior knowledge. In this study, I therefore endeavoured to minimize this gap in the science curriculum.

Essentially, the study focused on investigating trainee teachers' engagement with prior everyday knowledge and experiences of natural phenomena in teaching physical science concepts. The rationale behind the study emerged while I was supervising twelve trainee teachers on school based studies (SBS) in the Caprivi Region. Observations revealed that learners frequently asked trainee teachers to relate their IK to WS to contextualize what they were learning. However, most trainee teachers seemed to experience challenges. This pedagogical gap and challenge was investigated using the instruments below.

An analysis was done on the Namibian National Curriculum for Basic Education (NNCBE, 2010), extracts of research papers and a chapters on pressure in physical science textbooks. A worksheet was used to orientate trainee teachers with suggestions on how IK could be fused with WS to contextualize teaching and learning. Thereafter, this was followed by the simultaneous use of brainstorming and audio-visual techniques. Base line instruments paved the way for the main data generating techniques; namely, microteaching, audio-visual techniques, critical partners' observation and focus group interview.

There was triangulation of data collection instruments which enhanced validation followed by tabulation and data collation to develop themes. Analysis entailed checking theme repetition, indigenous categories and key words in context techniques. Themes enabled the construction of analytical statements which were discussed with reference to the relevant literature, theory and subsequently aligned to the research questions.

Findings from this study include the suggestions that IK can be incorporated into teaching and learning of science concepts through the use of models or practical activities, science language used in the community and some cultural artifacts. The relevance of incorporating such type of knowledge is to contextualize science teaching and learning.

The study therefore concluded that the incorporation of IK into teaching and learning of science concepts; (a) broadens the curriculum as it addresses conceptual progression and cohesion; (b) contextualizes concepts taught; (c) empowers teachers to use a practical curriculum and (d) it also creates space for misconceptions that come with IK to be identified and corrected. The study thus recommends that cultural artifacts and the social science jargon used in the community of the trainee teachers can be used to incorporate IK with WS as these types of knowledge are not mutually exclusive but in fact complement one another.

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LIST OF ABBREVIATIONS AND ACRONYMS

AVT/AT	Audio-Visual Techniques/themes related to activities by trainee teachers
AVT/chall	Audio-Visual Techniques/themes related to challenges faced
AVT/E	Audio-Visual Techniques/themes related to explanation
AVT/E	Audio-Visual Techniques/themes related to exploration
AVT/O	Audio-Visual Techniques/themes related to observation
AVT/P	Audio-Visual Techniques/themes related to prediction
AVT/PW	Audio-Visual Techniques/themes related to practical work
BAAS	British Association of the Advancement of Science
BEd	Bachelor of Education
BETD	Basic Education Teachers' Diploma
CAT	Contiguity Argumentation Theory
CK	Content Knowledge
CPO/chall	Critical Partner's observation and mine/themes related to challenges faced
CPO/PEKEIK	Critical Partner's observation and mine/themes related to prior everyday knowledge, experiences and indigenous knowledge
CPO/WS	Critical Partner's observation and mine/themes related to western science
CPO/WS	Critical Partner's observation and mine/themes related to practical work and models brought by trainee teachers
DPEKE/IKC	Document with Prior Everyday Knowledge and Experiences/ themes related to indigenous knowledge or constructivist ideas
DPEKE/IKC	Document with Prior Everyday Knowledge and Experiences/ themes related to indigenous knowledge or constructivist ideas
DPEKE/IKPEK	Document with Prior Everyday Knowledge and Experiences/ themes related to indigenous and prior everyday knowledge of learners

DPEKE/IKPW	Document with Prior Everyday Knowledge and Experiences/ themes related to indigenous knowledge or practical work
DPEKE/IKSC	Document with Prior Everyday Knowledge and Experiences/ themes related to indigenous knowledge or socio-cultural ideas
DPEKE/LC	Document with Prior Everyday Knowledge and Experiences/ themes related to learner centred approaches
FGI/R_1-R_5	Focus Group Interviews/themes from responses one to five
HCN	Hydrogen Cyanide
IK	Indigenous knowledge
IKS	Indigenous knowledge System
LTSMs	Learning and Teaching Support Materials
M/EPEKEIK	Microteaching/themes related to engagement of prior everyday knowledge, experiences and indigenous knowledge
M/LC	Microteaching/themes related to learner centred approaches
M/PCKPTCK	Microteaching/themes related to pedagogical content knowledge and pedagogical technical content knowledge
M/PEKEIK	Microteaching/themes related to practical work and models of natural phenomena
M/PEKEIK	Microteaching/themes related to prior everyday knowledge, experiences and indigenous knowledge
NIED	National Institute of Educational Development
NNCBE	Namibian National Curriculum for Basic Education
NNCBE/C	Namibian National Curriculum for Basic Education/themes related to constructivism theories
NNCBE/LC	Namibian National Curriculum for Basic Education/themes related to learner centred approaches
NNCBE/PE	Namibian National Curriculum for Basic Education/themes related to prior everyday knowledge

NNCBE/PW	Namibian National Curriculum for Basic Education/themes related to practical work
NNCBE/SC	Namibian National Curriculum for Basic Education/themes related to socio-cultural or social constructivism theories
NPK	Nitrogen, Phosphorous and Potassium
PAR	Participatory Action Research
PCK	Pedagogical Content Knowledge
PEEOE	Predict, Explain, Explore, Observe and Explain
PEK	Prior Everyday Knowledge
PEKAWS	Prior Everyday Knowledge in agreement with western science
PEKAWS	Prior Everyday Knowledge in disagreement with western science
PST/C	Physical Science Textbook/themes related to theory of constructivism
PST/G	Physical Science Textbook/themes related to gender
PST/LC	Physical Science Textbook/themes related to learner centred approaches
PST/PW	Physical Science Textbook/themes related to practical work
PST/PW	Physical Science Textbook/themes related to readability
PST/SC	Physical Science Textbook/themes related to socio-cultural ideas
PTCK	Pedagogical Technical Content Knowledge
SADC	Southern African Development Corporation
TEK	Traditional Ecological Knowledge
TK	Traditional Knowledge
TPCK	Technical Pedagogical Content Knowledge
TPK	Technical Pedagogical Knowledge
WMS	Western Modern Science
WS/C	Worksheet/themes related to constructivism theory
WS/LC	Worksheet/themes related to learner centred approaches

WS/PW	Worksheet/themes related to practical work
WS/Q_1-Q_2	Worksheet /themes from question 1 to question 2
WS/SC	Worksheet/themes related to social constructivism theory
ZFM	Zone of Free Movement
ZPA	Zone of Promoted Action
ZPD	Zone of Proximal Development

CHAPTER ONE

SITUATING THE STUDY

Without evaluation by an adequately designed program of inquiry, mere innovation will tell us little. It is equally useless to collect data and then see what you can make of it; information in itself is of little value (Nisbert & Entwistle, 1970, p. 22)

1.1 INTRODUCTION

This chapter seeks to provide an orienting introduction to the entire research study which investigated trainee teachers' engagement with prior everyday knowledge, experiences and explanations of natural phenomena when teaching physical science concepts. I also discuss the context of the study, learner-centred approaches, the origin of science, its nature and aims, introduce the research goal and questions. Before giving an overview of each chapter, clarification of terms is given.

The above is aimed at situating the study in order to make it possible to come with a program of inquiry as stated in the above epigraph. To situate the study, I start by discussing the context below.

1.2 CONTEXT OF THE STUDY

1.2.1 LEARNER-CENTRED APPROACH

Learner-centredness involves teaching and learning that "emphasizes what the student should know, understand, do and be able to become" (Meier, 2005, p. 78). This approach moves teaching and learning from the traditional way which is authoritative and based on "banking pedagogy" (Freire, 1993, p. 99) to a learner centred approach. Teachers or teacher educators who use banking pedagogy consider learners as passive and incapable of constructing knowledge. Instead, teachers need to be "non –authoritative but active, work as guides, initiators, observers, advisors and facilitators of learners' learning activities" (Nyambe, 2008, p. 16).

So, to shift from the authoritative pedagogy to one which empowers the trainee teachers to use learner-centredness, teacher educators need to use and show an approach with characteristics of learner-centred approaches. By doing so, the dilemma of ‘do as I say’ during school based studies (SBS) and not ‘as I do’ would be solved.

Perhaps, it could be argued that sometimes in our classroom discourses with these trainee teachers we do not use approaches which are aligned to constructivism yet we expect them to do that when they are on SBS. This could be a reason why Kasanda, Lubben, Gaoseb, Kandjeo-Marengo, Kapenda and Campbell (2005) suggest that external factors of school context and the internal factors of teacher qualification constrain the implementation of learner-centred approaches.

The view is that, if we want to allow construction of knowledge to be achieved through learner-centred approaches, an understanding of the origin of science as well as its nature and aims is needed. This will help to contextualize learner centred approaches since it has a foreign connotation if taken raw from those who exported it to Southern African Development Corporation (SADC) countries. Thompson (2012) argues that ‘cultural translation’ needs to be taken into consideration during learner centred approaches in order to be in line with the context in which they are applied. To contextualize using learners’ prior everyday knowledge we need to understand the origin of science as discussed below.

1.2.2 ORIGIN OF SCIENCE

Initially, science was embedded in religion and philosophy until it fragmented from these two disciplines. The reason for this was the need to professionalize science and prevent the prosecution of scientists by the church. Such a need “gave birth to a new organization in 1831” (Aikenhead & Ogawa, 2007, p. 542). The natural scientists through the use of practical work uncovered scientific evidence on how the universe behaved but when they presented it to the society they met severe resistance since religion dominated the world view by then. The view of religion was different. The geocentric theory was prevalent but was later removed and replaced by the heliocentric theory using evidence brought by practical work.

The fear of officials from the church being removed from positions of authority where they controlled and exploited the masses forced them to quarantine some scientists in order to stop them from spreading heresy which would destabilize their reign. Galileo Galilee was put under house arrest after bringing these scientific ideas based on practical work.

The above view of the ontogenesis of science is true for western modern science, modern in the “sense of hypothetical – deductive, experimental approach to science” (Cobern, 1998, p. 7). Western modern science pretends to be cultural deficit even though in time unmemorable WS used other peoples’ culture to arrive where it is today. If we use the lens of culture to look into what science is and consider science as observation of nature in order to stay in harmony with it, then the ontogenesis of science dates back to the time people started to inhabit the earth’s surface. Thus, indigenous knowledge (IK) as knowledge obtained from experiences is not culturally deficit.

Science and science education can then be considered as an aspect of culture and this has led Wilson (1981) to conclude that “ for science education to be effective, it must take much more explicit account of the cultural context of the society which provides its settings and whose needs it exists to serve” (p. 29). Prejudices in IK can then be rectified through the use of practical work or a practical demonstration which has given science the standing it has today.

According to Hodson (1990), curriculum in schools started to use practical work in science classes as from 1882. This was fifty one years after the formation of the British Association of the Advancement of Science (BAAS). However, tangible evidence showing how practical work can improve the acquisition and development of scientific concepts was not manifested. The cause lied in the fact that practical work was used as a method of discovering science concepts without the use of its properties which gives a constructivist character. Sometimes, teachers develop a tendency to use classroom demonstrations only. Yet, practical work has an illustrative character to explain a theory, thereafter, it demonstrates to support a theory or the other way round.

However, in some other types of practical work with which include elements of IK, if used, students are motivated (Kibirige & Van Rooyen, 2006). Investigative types of experiments are made use of which enable students to establish their hypothesis, the theories to explain and laws to connect the parameters in the phenomenon mathematically on their own. Practical activities were instrumental in the ontogenesis of the nature of science. In order to shed more light on how practical work can be useful, we need to look into the nature of science in relation to practical work and this is done below.

1.2.3 NATURE OF SCIENCE

The principal sources of science are the Eurocentric knowledge system, developed in 1831, given a label of BAAS and the indigenous knowledge system, used by different communities to assist them to live in harmony with their environment. The two knowledge sources are “rational perceptions of reality” (Ogunniyi & Ogawa, 2008, p. 178). Both of these are to do with how reality is perceived.

Eurocentric science is a collection of rational perceptions of reality, shared and authorized by a scientific body, the BAAS. Lakatos (1974) agreed with the latter as he wrote that for a theory to be agreed upon as having scientific value, the scientific jury must agree unanimously that there is a practical technique which can enable them to attach a truth value to the scientific conjecture (p. 355).

This also applies to indigenous science since it is viewed as a rational perception of reality, culture dependent and authorized by the community where it is seen and used. The community members act as the scientific juries for any hypothesis brought forward and then taken as a theory and then a law.

The world view on which Eurocentric science is anchored on is the mechanistic view. Explanations are taken from ‘dummies’ of the particular physical parameter or phenomenon in question. An example is the parameter time; a small spherical ball was tied on a string and hung and then allowed to swing forward and backwards. This was taken as a representation of an instrument to measure time and from there a clock was invented. In contrast, indigenous science is anchored on an anthropomorphic model. Anthropocentrism views humans as central under the universe and they can control other components of the universe but sanctioned by a particular religion (Aikenhead & Ogawa, 2007, p. 549).

Eurocentric science uses practical work to avail scientific data which manifest evidence of how the phenomenon in the universe works. Its dual character discussed below and in Chapter Two reveals this. Eurocentric science adopts dual character when it sees that one theory has failed to bring evidence using practical work, but still brings evidence without anomalies when another form of practical work is used with a different lens.

A typical example is the theory of de Broglie. Using practical work, he found that light phenomenon adheres to the formula; $p = mc = h/\lambda$ whereby p represents the momentum which can be obtained by the product of mass and the velocity of light and all is equal to Planck's constant divided by the wavelength λ. This particle approach is used to explain some occurrences in light when wave theories of light fail to do so.

"A scientist, whether theorist or experimenter, puts forward statements, or systems of statements, and tests them step by step" (Popper, 1968, p. 4). Statements are initially in the form of hypothesis. He proceeds to carry out a practical work which then results in the formation of a theory which can sustain human development.

A hypothesis put forward is like a fish net that has been cast. It has the ability to catch fish, but with the condition that it is well positioned in the river. In contrast, sometimes, IK is like a fish net that is not properly positioned in the river. At times IK lacks this practical work approach which can make it fallible. However, IK is based on experiences people have in the society and their perception on the natural phenomena of the environment, has a socio-cultural connotation. These perceptions then allow people to perfect their way of life and live in harmony with nature. Herein lies the essence of this research study.

Well positioning of practical work in conjunction with bringing trainee teachers' socio-cultural view on nature and exploiting its properties will enable trainee teachers to construct science knowledge based on their IK. Statements and hypotheses which come from one's conjectures need to be tested by practical work in order to produce a theory. In short, Ogunniyi and Ogawa (2008, p. 176) argue that "science is a body of conjectures and refutations". And scientists use practical work to polish conjectures and refutations in science. New sources of science knowledge are being put forward as seen above. So, what are the main aims of science?

1.2.4 AIMS OF SCIENCE

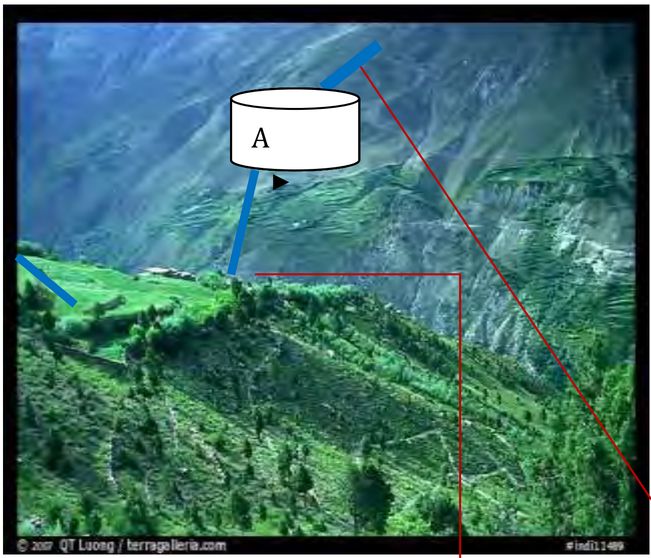
The aims of science education are universal. Millar (2004) points out the following as the main aims of science;

> *To help students to gain an understanding of as much of the established body of scientific knowledge as is appropriate to their needs, interests and capacities. To develop students' understanding of the methods by which this knowledge has been gained, and our grounds, for confidence in it (p. 1).*

The above aims coincide with the aims of science at national level in any country. Millar (2004) argues that the purpose of school science is to make the citizens of any country literate in science so that they could fully participate in issues related to science. Also, novices are science literate citizens who will replenish the labour market where science related skills and tasks are to be performed. How then, can we accomplish the above aims?

We would require an effective method of teaching science which makes one acquire the scientific evidence and knowledge base (Lemke, 2001). These are then put into use as one argues for or against some proposals his/her country puts for debate for the purpose of development which is related to science and affects him/her. A typical example would be a community located at the top of a mountain who benefits from water flowing from another mountain which is at a higher altitude. The two mountains are separated by a valley as illustrated in Figure 1.1 below.

Their experiences are water flowing in a river at a higher altitude has more pressure. Community members pass the flowing water over a gorge by means of the bark of a tree or (dug out) canoes which are open at both ends to reach another point at lower altitude separated from the first by a gorge. Their explanation would then be if the water is allowed to enter into the gorge it would not have sufficient pressure to come out and supply the community on the other lower mountain. Water needs to fill the gorge and then start flowing to the other side. For the gorge to contain water it needs to have some walls and this is hard task to achieve. Instead then, they bring the idea of bypassing the gorge using the bark of trees or (dug out) canoes.



Pipe takes water from a tributary and pours into a tank A

The pipe drains water (H_2O)at high pressure down the valley and supplies it to the community at low altitude.

FIGURE 1.1 HARVESTING WATER USING PROPERTIES OF PRESSURE(ADAPTED FROM TERRAGALLERIA.COM PHOTO # 11489)

Using experiences of their IK, trainee teachers could contribute to the teaching and learning of science meaningfully and understand why it is possible to supply water to a community at a lower altitude using pipes since pressure of water from the mountain at a higher altitude is high and can keep on forcing the water to flow.

It is most likely that the idea of bringing water into *Owamboland* using a canal which flows from the Kunene River was adapted from the indigenous people's ideas about pressure and flow of liquids. The Zambezi River is also a good example where people see how water is tapped from it at a higher altitude and used for watering plants in a garden located at a lower altitude. If flowing water is transported to the community in a way explained above, not all water would be allowed to flow into the Indian and Atlantic Oceans using the Kunene River, Zambezi River and other rivers without people harvesting it for their benefit.

To cross these rivers, people use their IK to identify areas where the water is flowing slowly. Water velocity is low in narrow sections of the river while pressure is high. These can be identified by reeds which will be vibrating at a faster frequency. These wider sections are used as crossing points since the low pressure cannot capsize a canoe even though they are taken further down the river. Learners already have these ideas but sometimes they are not brought into the science classrooms.

The velocity and pressure of a flowing liquid are what WS studies. It establishes its relationship using Bernoulli's theory. However, sometimes our formal curricula do not include it since the belief is that it is too abstract yet curriculum in the wider more embracing sense encompasses experiences both inside and outside the classroom (Kibirige & Van Rooyen, 2006; Rennie, 2011). Rennie elegantly refers to this as blurring of the boundaries between school science and community or environment. Why then does this line of thinking exist when the IK of learners is abundant of experiences related to WS?

As I will argue in Section 2.14, the absence of IK makes our curricula disconnected from people's everyday lives. Yet, IK and WS are not mutually exclusive. Instead, they complement one another. To prevent this from happening we need to incorporate IK into WS. This can possibly enable us and trainee teachers to make our practices learner-centred since in one occasion one of the trainee teachers was found grappling with incorporating IK as explained in the section below.

1.3 PROBLEM STATEMENT

I observed how one trainee teacher on School Based Studies (SBS) was teaching some science concepts relating to pressure: This trainee teacher was asked to explain in modern scientific terms a phenomenon that a learner had experienced in everyday life. One could speculate about the trainee teacher's behavior. Three reasons might be:

a) The trainee teacher was so drilled in her learning about science that she was only able to use the examples given in the textbook. In effect she could not transfer her knowledge of a scientific principle into a new context. b) The trainee teacher might have been able to work it out, but felt no motivation to use the learner's everyday experience as an opportunity to explain a physics concept in modern scientific terms. c) The trainee teacher may in principle see the potential value but really did not know how to integrate this into the lesson.

This experience triggered my interest to investigate how trainee teachers do or might incorporate prior everyday knowledge, experiences and explanations of natural phenomena into science classrooms. I thus framed the purpose of my study as "Understanding trainee teachers' engagement with prior everyday knowledge and experiences in teaching physical science, in particular, the physics section".

1.4 POTENTIAL VALUE OF THE STUDY

This study might strengthen trainee teachers' engagement with every day or indigenous knowledge in science lessons to achieve a variety of objectives, including providing a bridge in some instances to western science but also to give recognition in its own right to some of the discoveries of indigenous cultures. This has implications for both content knowledge and pedagogical content knowledge. That is, the ability of trainee teachers to create a learning experience in learning discourses is likely to be enhanced as content is contextualized. This would ultimately help them to relate science to their everyday lives.

1.5 RESEARCH GOAL, OBJECTIVE AND QUESTIONS

The goal of this research study was to investigate trainee teachers' engagement with prior everyday knowledge, experiences and explanations of natural phenomena in teaching physical science concepts.

RESEARCH OBJECTIVE:

- Develop an exemplar worksheet on pressure that will effectively teach pre-service trainee teachers to incorporate appropriate examples of prior everyday knowledge into their physical science lessons to assist in improving the understanding of and interest in science.

RESEARCH QUESTIONS

MAIN RESEARCH QUESTION:

How do trainee teachers engage with prior everyday knowledge, experiences and explanations of natural phenomena when teaching physical science concepts?

SUB-QUESTIONS

1. What factors enable or constrain the teaching of physical science concepts in the curriculum?
2. How can an exemplar worksheet on pressure facilitate trainee teachers' understanding of incorporation of prior everyday knowledge in physical science concepts?
3. How do trainee teachers identify and design physical science topics with relevant examples of prior everyday knowledge?
4. What ways do trainee teachers use to identify examples of prior everyday knowledge which learners have?
5. What is the relevance of the prior everyday knowledge associated with physical science concepts that trainee teachers come with to science classrooms?
6. What challenges do trainee teachers encounter in designing and delivering physical science lessons

1.6 CLARIFICATION OF CONCEPTS

SOCIO-CULTURAL PERSPECTIVE OF TEACHING AND LEARNING SCIENCE

Language provides the premises for learning science concepts. Trainee teachers acquire language during their youthful stage as social science language for thought and talk as they discuss about the physical world when they are playing. The experiences gained are put in their cultural activities to sustain human existence and development. So, scientific knowledge arises from local contexts and as a response to the needs of the community (Bauman, 1995).

Thus, contextualizing entails the bringing in of culturally constituted conceptual theoretical teaching and learning framework. Such a theoretical framework is the socio-cultural perspective of teaching and learning science where learners' cultural related experiential knowledge is considered.

EXPERIENTIAL KNOWLEDGE

Dewey (1858) and Knowles (1950) support the idea of learning through experiences, reflections and imitations. Perceptions of how certain natural phenomena occur are observed, tested and then we reflect on. So, our experiences are a reservoir of knowledge which we use as prior everyday knowledge. Prior everyday knowledge as experiential knowledge assists communities to move from one stage of development to another. This becomes indigenous knowledge of a particular community which they use as a cultural capital since it has value.

INDIGENOUS PEDAGOGICAL AND TECHNICAL CONTENT KNOWLEDGE

Skills related to how trainee teachers handle science related activities in communities make trainee teachers have classroom skills. I refer to these skills as indigenous pedagogical technical content knowledge. If brought into the classroom, such skills can be useful not only in handling apparatus but because they know them, cultural artifacts can be brought into the classroom as learning and support materials.

Their experiences or prior everyday knowledge comes as a result of the need to explain certain natural phenomena. These can act as representations in science teaching and learning (Halim & Meerah, 2002). Such explanations when brought in classroom discourses act as indigenous pedagogical content knowledge.

WORKSHEET

A worksheet is different from a lesson preparation. In it, prior knowledge of the concept in physical science to be taught is presented. Cultural activities, artifacts, extracts of the social scientific jargon are presented. Opinions are sought from the recipients through use of the, predict, explain, explore, observe and explain (PEEOE) approach (Maselwa & Ngcoza, 2003). Thereafter, a practical activity aligned to the concept under study is done, but using materials from the learners' community. This will then constitute a way of incorporating indigenous knowledge with western science so that science teaching and learning becomes relevant to trainee teachers.

RELEVANCE OF PRIOR EVERYDAY KNOWLEDGE

Roschelle (1995) understands prior knowledge as representations which are brought into the classroom by learners and teachers to aid understanding of concepts taught. Prior knowledge can be based on previous lessons. That is, ideas discussed in the previous lesson which are related to the current lesson are discussed first since they form the foundation of the concept to be taught. However, sometimes, learners have no prior knowledge or do not remember the previous lesson's concepts. It could then be argued that such an approach is sometimes not relevant to the teaching and learning of science concepts.

Olorutengbe and Ikpe (2011) suggest that learners' understanding of everyday phenomena if brought first and discussed in the classroom can make science discourse relevant and learners can relate what we teach. The indigenous ways of understanding or knowing nature act as relevant premises to launch our science discussion to make them relevant (Aikenhead & Ogawa, 1996).

PRACTICAL CURRICULUM

Official curriculum serves as a guideline for trainee teachers, standardize the teaching and learning of science and for assessment purposes. So, can understanding be achieved by learners when concepts brought to them are not relevant and not contextualized?

Ideas related to how we learn science in our communities were neglected as the authors of science textbooks have an agenda of only marketing western science (Badat, 1997) but also to promote it. Practical curriculum takes into consideration the indigenous ways of knowing nature, cultural activities related to science and also the cultural artifacts of a community. What follows is an overview of the thesis in the paragraphs below.

1.7 AN OVERVIEW OF THE THESIS

This thesis documents findings from my research study which was about understanding how trainee teachers engage with prior everyday knowledge and experiences when incorporated with physical science concepts. It consists of seven chapters and the details of each chapter are explained below.

Chapter One situates the study. It introduces the research topic and aims to locate the position of the researcher in the study. It gives an outline description of the background in which learner-centredness, the origin of science, nature of science, aims of science, problem statement, the significance of the study are discussed and the research goal and questions. To conclude it key concepts and thesis outline is done.

Chapter Two is a literature review chapter and looks into indigenous knowledge (IK) which is a component of prior everyday knowledge (PEK), IK properties, where IK can be used, its advantages and disadvantages are discussed. Thereafter, pedagogical content knowledge (PCK) and pedagogical technical content knowledge (PTCK) are discussed. Finally, I consider the role of practical work as the research tries to align it to constructivism and socio-cultural theoretical frameworks which are also discussed.

Chapter Three describes the methodological framework that guided the research process. It discusses the research goal and views. In the methodological section of this chapter it clarifies the position of the researcher by pointing out that it is an action research which it then describes. It further clarifies the sampling techniques and looks into the research site and participants. Instruments used for generating data are discussed which are; document analysis, worksheet, brainstorming, microteaching, observation, audio-visual techniques and focused group interview. Data management, ethics of research and data validation are discussed in this chapter.

Chapter Four presents and analyses data generated from document analysis, brainstorming and worksheet.

Chapter Five presents and analyses data generated from the main data generating techniques. Microteaching, audio-visual techniques, observation and focus group interviews were used generate data.

Chapter Six aims to analyse, interpret and discuss the findings from the data presented in Chapter Four and Chapter Five. Data which had similar themes from different instruments was looked at and then used to understand the views stated in the section of methodology. Analytical statements were constructed from themes and then used for discussing the findings.

Finally, **Chapter Seven** contains a summary of findings, recommendations, reflections and conclusion. It starts with the summary of the research process and then highlights a few critical remarks about the study. It then contextualizes the research goal within the rationale and provides some suggestions for future research in this area.

1.6 CONCLUDING REMARKS

This chapter attempts to locate the study in respect of locale and participants. It also seeks to provide a motivation for this area of research by putting down the goals and rationale. Finally, a thesis outline is given.

The next chapter discusses the literature relevant to my study. To anchor this study to a theoretical framework, constructivism and socio-cultural theories are discussed as well.

Chapter Two

Literature Review

> *Indigenous knowledge systems (IKS) are attempts to put the record straight on several issues, among them those that relate to history, education, architecture, philosophy, language and science" (Mapara, 2009, p. 143).*

2.1 INTRODUCTION

The purpose of this research study was to investigate trainee teachers' engagement with prior everyday knowledge, experiences and explanations of natural phenomena in teaching physical science concepts. It was hoped that this would improve understanding and interest in the learning of physical science concepts. In the context of this research study, I thus developed a worksheet on pressure which was used to teach and scaffold pre-service trainee teachers on how to incorporate appropriate examples of everyday knowledge and experiences into trainee teachers' physical science lessons.

To achieve the above, I reviewed the literature from the Namibian Science Curriculum which advocates the use of prior everyday knowledge, experiences and their relationship with indigenous knowledge (IK) as it aligns itself to the socio-cultural and constructivist theories of learning. I discuss literature on IK that has been published, how indigenous knowledge systems (IKS) are used by people as Mapara (2009) reveals that it is used in history, education, architecture, philosophy, language and science.

I address questions such as what made IKS lag behind as Western Science progressed. I also focus my discussion of IKS on its importance in the education system and I conclude by looking at practical work which teachers use as a mediational tool to support constructivist learning. Pedagogical content knowledge (PCK) and pedagogical technical content knowledge (PTCK) as theories of learning are also discussed followed by some concluding remarks.

2.2 THE NAMIBIAN SCIENCE CURRICULUM

The constructivist world view is advocated in The Namibian National Curriculum for Basic Education (NNCBE, 2010). The NNCBE encourages teachers to use different knowledge sources. Prior everyday knowledge, experiences and western science (WS) are some of the knowledge sources which it states that teachers should use. That is, it embraces the multicultural approach to the teaching of science (Carter, 2007, p. 172). However, the science textbooks used in school science curricula sometimes do not consider indigenous knowledge (IK) or other forms of knowledge. Instead, IK is diminished or considered of lesser value (Milne, 2011; Kibirige & Van Rooyen, 2006).

Although prior everyday knowledge and experiences have been sanctioned as sources of knowledge, little has been done to incorporate them into the actual teaching and learning of science. Furthermore, research has concentrated on “documentation of IK, neglecting its implementation in the classroom” (O’Donoghue & Neluvhalani, 2002; Mokuku, 2004; Shava, 2005). However, when incorporating indigenous knowledge with western science we must not allow IK to be subsumed into mainstream knowledge.

That is, the use of IK as prior everyday knowledge sometimes can promote socio-cultural and constructivist theories of learning. Thompson (2012) argues that IK if used in the classroom can enable the constructivist theory to be implemented. He further goes on to say that IK is suitable to use as a tool to culturally translate learner centred approach which came into sub-Saharan African countries as a misfit since it is not contextually situated. The use of IK can make learner centred adapt to the conditions in countries where it was imported to.

2.3 THEORETICAL FRAMEOWORK

2.3.1 SOCIO-CULTURAL PERSPECTIVE

Indigenous knowledge is dialectically interwoven with culture. So, this research study is also underpinned by a socio-cultural perspective. A socio-cultural approach in science is based on the understanding that, “human activities take place in cultural contexts, are mediated by language and other symbol systems, and can be best be understood when investigated in their historical development” (John-Steiner & Mahn, 1996, p. 2). Learning becomes effective and affective when the cultural resources of participants are acknowledged as capital for learning

(Lemke, 2001). Socio-cultural views come with cultural resources which can be used as learning and teaching support materials (LTSMs) (Czernewicz, Murray & Probyn, 2000).

According to Czernewicz, Murray and Probyn (2000), LTSMs are in different format and nature. For example, an earthenware pot, as a cultural artifact, can be used successfully to explain latent heat of vaporization and also for teaching the concept of evaporation in general as will be seen in Chapter Five during micro-teaching in this study. Similarly, the socio-cultural perspective on learning suggests recognition of cultural elements of learners and leveraging these in the learning process.

Within a particular community's culture is located a micro-culture of science which informs members how they handle science related issues. The community's indigenous knowledge as a micro-culture developed to respond to the cultural needs of that community as they use it to understand and solve issues which are related to the environment. Carter (2007) and Lemke (2001) support this idea as they suggest that indigenous science which is a micro-culture of a particular community developed in response to their culture's needs to understand, predict, and influence its environment.

On the other hand, Lemke (2001) further says science is a component of the community and its culture. This perspective will enable to study "science in action and not ready made science" (Kelly, Chen & Crawford, 1998, p. 27). However, for smooth cultural translation to occur, members who need to acquire it need to be literate in that social language (Leach & Scott, 2003; Thompson, 2012).

The socio-cultural perspective on science, views science as manifested by components of "the community through their actions and interactions with and through oral and written language" (Kelly, Chen & Crawford, 1998, p. 27). Leach and Scott (2003, p. 100) consolidate as they say science entails "internalizing the social language and genres and become able to use them appropriately in various situations".

To develop this social language which is the language of science; science teachers need to pose questions, create arguments and design fruitful experiments. These might pave way for learning science related concepts since the language of science's communal character is exploited by those using it as they are "initiated into a community of practice" (Kelly, Chen & Crawford, 1998, p. 24). Within a community of practice, people think in the science language and this thinking is a talk in science which then develops them in the right direction. Toulmin (1979) clarifies this as follows:

> *To think is to talk with oneself, and each of us talks to oneself because we have had to talk with one another.....Thought is interior language, and interior language originates in outward language. So, that reason [being linked to thought and so to inner speech] is properly both socially and communal (Toulmin, 1979, p. 7).*

What could be achieved by bringing the cultural settings where language is a component is the learning and contextualization of science concepts. Contextualizing according to Kelly, Chen and Crawford (1998) entails "what people are doing and where and when they are doing it…" (p. 26). So, language and beliefs are components of culture. When these components of culture are discussed to science learners contextualization of science concepts occurs. However, as we use these settings to contextualize science, in particular, one needs to remember that context is not stagnant. Instead, it is dynamic and it changes with time and as we move from one locality to another.

The implication of this is that we cannot learn science divorced from the socio-cultural settings. However, the use of extracts of those cultural components need to be done in consultation with the members of that community if one is foreign in it and analyse them to remove those aligned to fallacy (Kibirige & Van Rooyen, 2006).

2.3.2 CONSTRUCTIVISM

Constructivism is a theory of "learning, teaching, curriculum development and teacher professional development" (Hodson& Hodson, 1998, p. 33). In constructivism, science educators are urged to be sensitive towards and attentive to the learners' previous constructions. In this case, it is the prior everyday knowledge or experiences of the phenomenon which the learner might bring into the science class. Two strands of constructivism are discussed and used in this study, namely, cognitive constructivism as propounded by Piaget (1985) and social constructivism by Vygotsky (1978).

COGNITIVE CONSTRUCTIVISM

Piaget, a cognitive constructivist, argued that an individual could construct knowledge until at a certain point of maturation. Furthermore, Piaget (1985) disputed the idea of considering learners as *tabula rasa*. Instead, he advocated that educators need to create tensions between what is known and what is to be assimilated. Different learning techniques are employed by a learner who is viewed as an "autonomous creator of knowledge" (Moll, 2002, p. 6) and learning is an *active process*. It could be argued that people create meaning from different experiences.

Regarding teaching and learning, the constructivist theory supports the central lesson design feature of incorporating practical work and activities in the science lessons and that was the centerpiece of this study. I now discuss social constructivism below.

SOCIAL CONSTRUCTIVISM

Vygotsky (1978), a social constructivist, took a step further from Piaget to redress the issue of learning using social constructivist theory. Here, the view is that cognitive learning develops from social interactions with peers and materials which the teacher or the learners use in a practical work (Moll, 2002).

That is, their zone of proximal development (ZPD) (Vygotsky, 1978) is elevated as learners interact with peers or with the teacher. For a learner to be in a particular zone of maturation, he/she must have acquired it through undergoing social interaction. The zone theory brings in another two zones namely; the zone of promoted action (ZPA) and the zone of free movement (ZFM) (Vasliner, 1997).

The ZPD is the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers (Vygotsky, 1978). These are spectrums of abilities and skills that a person can perform with assistance, but cannot yet perform independently. A peer, an adult or any knowledgeable individual comes in to scaffold learning through collaboration or facilitation.

The ZFM represents environmental constraints that limit freedom of action and thought based on a person's relationship with the structure of a given environmental setting. This is socially constructed by stakeholders in the teaching and learning process. The ZPA symbolizes the efforts of stakeholders, the curriculum or others, to promote particular actions (Goos, 2004; Galligan, 2008).

The implications of these zones are science educators need to consider the trainee teachers potential skills and then scaffold them. The social environment needs to be taken into account when designing activities for the lesson. Finally, the institutional factors must also be considered as we plan activities for the trainee teachers. This will enable us to see what enable or constrain teaching and learning of science.

Learners must be allowed to work in groups, "writing and discussion of ideas with peers is an essential element in learning" (McRobbie& Tobin, 1997, p. 199). One's understanding of a science concept might be in the doldrums but such an engagement with peers takes him to the next stage of development as he/she is scaffolded in the above mentioned zones and sometimes might bear fruits if IK is used as prior knowledge.

Hendricks (2003) suggests that the teacher should do the scaffolding using diagnostic, epistemic, echoic, rhetoric or pseudo-questions (p. 33). Perry (1999) too says that, "learning requires a major personal cognitive investment on the part of the learner" (p. 54).

Social constructivism proposes that there should be interaction socially between the learners in the learning situation. This theory supports another central design feature of the study, viz., the group exploration or a community of practice (Lave & Wenger, 1991). This is first done by the trainee teachers. Later, trainee teachers explore the possibilities and challenges as they construct modern science lessons that use prior everyday knowledge or traditional experiences and explanations of the physical phenomena.

2.4 PRIOR KNOWLEDGE

Roschelle (1995) states that prior knowledge "is a representation of fundamental ideas that enable learners to visualize regularities in the environment" (p. 37). All the other knowledge can then be synthesized from these representations. Prior knowledge can thus be thought of as "students' experiential knowledge" (Srikantaiah, 2005, p. 2). Experiential knowledge is a result of factors directed to an individual.

According to the modified diagram of Weil and McGill (1989, p.28), the factors are as shown in Figure 2.1.

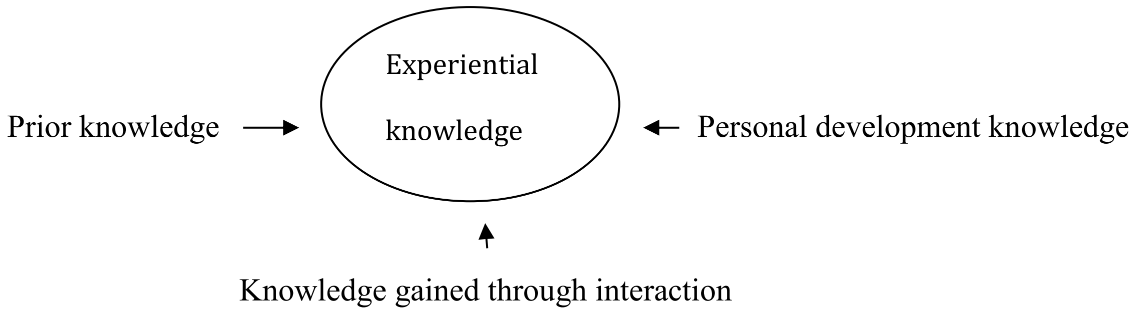


FIGURE 2.1 ELEMENTS CONTRIBUTING TO EXPERIENTIAL KNOWLEDGE (ADAPTED FROM WEIL & MCGILL, 1989, P. 29)

Learners construct meaning of concepts taught if prior knowledge is taken into account. It could be argued that consideration of prior everyday knowledge and experiences would invite and engage learners into a new learning situation. Furthermore, since prior everyday knowledge has an element of cultural background it would raise learners' interest to do science.

Currently, enrollment in science related subjects in institutes of learning is very low. One of the causes could be that students cannot apply science learnt in class to the science at home which forms part of their prior everyday knowledge (Leach & Scott, 2003, p. 102; Oloruntegbe & Ikpe, 2011, p. 268).

The findings of Oloruntegbe and Ikpe (2011) where a high percentage of students could not establish a clear linkage between science concepts learned at school and science concepts embedded in their everyday experiences, despite daily exposure in both contexts. Furthermore, students' socio-economic status was seen to exert little influence on their ability to connect science to real-life experience. Students view that this is attributed to teachers' failure to make explicit connections with these home-learning experiences in teaching science concepts. Oloruntegbe and Ikpe's (2011) findings resonate with Rennie's (2011) who proposes that there is a need to blur boundaries between home and school science. I concur with these views.

I believe that engaging students using their home-learning experiences would make the process of teaching and learning of science devoid of the idea of 'banking' which Freire

(1999, p.99) discourages. The idea of banking is based on the fact that teachers consider learners only as recipients of knowledge. Lending support, Rennie (2011) consolidates by saying science curriculum done in schools must be “the science-related issues students experience in their world” (p. 16). In her work, she found that there was a need to create a partnership between scientists and school communities through the implementation of Scientist in School’s project. This could have the benefit of elevating students’ desire to learn science as they see relevance when we link it with their everyday knowledge. Kibirige and Van Rooyen (2006) too also bring this idea of making the curriculum relevant by bringing learners’ prior everyday knowledge.

In addition, engaging students using their prior everyday knowledge would make the following possible:

- students will know the focus/direction of the lesson;
- it makes it easy for students to start a discussion or team project; and
- it helps students get actively involved as they end up constructing science concepts.

If students’ existing knowledge structures are not engaged, then they might fail to grasp the new concepts. Therefore, as science teachers we need to make use of learners’ prior everyday knowledge and experiences and their experiential or indigenous knowledge. Because experiences are part of knowledge one has as a “reservoir” (Knowles, 1950, p. 10) we need to take them into account during teaching practices. Experiences are used increasingly in building up prior everyday knowledge and indigenous knowledge. The three are related as indicated in the diagram below and these will be used interchangeably in this thesis.

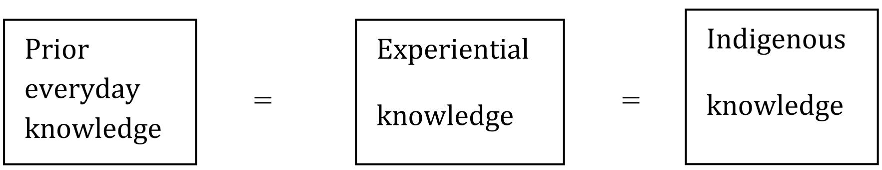


FIGURE 2.2: THE RELATIONSHIP BETWEEN PRIOR KNOWLEDGE, EXPERIENTIAL AND INDIGENOUS KNOWLEDGE (ADAPTED FROM SRIKANTAIAH, 2005, P. 2)

2.5 INDIGENOUS KNOWLEDGE

Even though indigenous knowledge (IK) and prior everyday knowledge have been indicated as more or less the same above, IK is more specific. IK comes into a community as the community members intend to use to better their welfare just as western science. After community members have scrutinized their prior knowledge and experiences, they will then convert it into IK. Kibirige and Van Rooyen (2006) consider IK as "a legacy of knowledge and skills unique to a particular indigenous culture and involving wisdom that has been developed and passed on over generations" (p. 236).

However, IK is still some miles away to reach where WS is. The reasons for my thinking are explained in Section 2.5.2. Also, since it is unique to a specific culture, this implies that other people from other cultures might struggle to understand it and that would require some resources to facilitate its understanding.

IK refers to cultural knowledge that is widely adopted by a given community, and is used as a source of knowledge to sustain their community. IK is taken as prior everyday knowledge in this study. The emphasis of IK falls on different issues from community to community – sometimes with a greater focus on the conservation of ecology (which is referred to as Traditional Ecological Knowledge or TEK) (Kibirige & Van Rooyen, 2006).

IK has a spectrum of uses as indicated in the epigraph of this chapter. To this end, I first discuss properties of IK and thereafter where it is used in those spheres suggested and later practical work.

2.5.1 PROPERTIES OF IK AND WS

On account of IK being underpinned on a 'monistic' world view, it makes itself fallible hence it needs to operate in "harmonious dualism" (Ogunniyi, n.d, p. 4) with western modern science (WMS). IK animates non-living organism thereby classifying them with living organism. As it does so, it creates conditions for the two to coexist as one (Aikenhead & Ogawa, 2007; Ogunniyi, n.d.).

Whereas, according to Hodson and Hodson (1998, p. 38), WMS is "science knowledge which has been subjected to, and has survived, critical scrutiny by members of the community of scientists, using whatever methods and criteria that have been deemed appropriate to ensure the necessary degree of validity and reliability". Ogunniyi and Ogawa (2002, p. 178) too reiterate by saying science is a "collective rational perceiving of reality, which is shared and authorized by the scientific community". Since our senses are used to come up with IK, this will mean that each day we come up with different perceptions of our surroundings. So, it could be argued that IK is not static but dynamic and systematic just as WS since we continuously review what we have and come up with new understanding.

I do agree with the above views on WMS but my point is that WMS became "'universal'" (Hodson& Hodson, 1998, p. 38); (Milne, 2011, p. 5) since it used IK from different areas of the world as a base. Both knowledge and resources were plundered. Aikenhead and Ogawa (2007) reinforce this as they suggest that knowledge was appropriated over the ages from many other cultures. BAAS modified it to fit Eurocentric worldviews, metaphysics, epistemologies, and value systems (p. 54). Agreeing to this is Milne (2011) who suggests that WS as a systematic knowledge has become gigantic and extremely powerful "isolated from the sites of local knowledge from which it emerged" (p. 12).

A deduction from Van Wyk (2002) is that IK has value because in political economy, knowledge is taken as a property or cultural capital and this is in agreement with Bourdieu (1930). I do believe that, if one has the cultural capital, she/he has the ability to kick-start her/his plans to engage his/her IK into use. So, IK has value and this explains why others have taken IK from different communities and personalized it. BAAS know that when it is in their possession, they use it to dominate others. This is revealed below as we look into yet another property of science knowledge related to how science knowledge could be used for dominating other communities.

Badat (1997) argues that on the political theory, IK is "viewed as intimately linked to interest and the domination of power" (p. 306). A community or a community member who is well versed with the IK of his/her community uses it not only to sustain himself/herself but also to expand his/her territory and defend it. Milne (2011) consolidates by saying that if one "has the knowledge then he is associated with power" (p. 10).

The properties of IK discussed above are not the only ones but they are sufficient for us to understand what follows and others will appear as we proceed. What follows is a discussion of why IK has been neglected for so long in the classroom discourse even though it is a strong component of prior knowledge.

2.5.2 THE CONFLICT BETWEEN CHRISTIANITY AND IKS

When missionaries brought Christianity to the rural areas of Namibia or to other countries which were victims of colonization, they denigrated indigenous beliefs. Locals were told that their convictions were unreasonable and based on "superstition" (Mbiti, 1990, p. 10). Yet, the traditional African education system was constituted by the transmission of IK from generation to generation. After the area had been occupied by Europeans and 'civilised' "African education was left exclusively in the hands of white missionaries" (Zvobgo, 1986, p. 16).

The denigration of IK was worsened after people had embraced Christianity and Western education as their saviour in life. They were given a higher social status than those who remained following their beliefs. Many were forced to abandon their practices as they embraced Christianity and western education. Thus made their IK unrecognized. To a certain extent The Roman Catholic Church, allowed and still allows its members to indulge their traditional religion which both brought the WS and removed IK. The Catholic Church does not condemn the use of a moringa oleifera seeds when a member uses it to cure an illness or for water purification (Maes, 1996).

2.5.3 AREAS WHERE IK ARE USED

In the African education system before formal schools, IK was used at local level. Communities employed IK to educate citizens on issues pertaining to food security, human and animal health, natural resources management and conservation. Currently, in Namibia, IK is used to domesticate wild fruit trees such as wild berries. The researchers, in this area of restoration of indigenous fruit trees are guided by locals who have a wide spectrum of knowledge of those trees (Du Plessis, 2001).

Locals know the varieties of suitable trees which grow in their areas because they have the knowledge at hand. This has allowed Namibians to restore forests which were destroyed. Achievement of this is on account of recognition of their IK. The benefit is that their knowledge is put into use, their valuable knowledge will not be lost, and finally this prevents earth's surface from agents of erosion. This occurs if these areas are not reforested by the domesticated fruit trees.

Notwithstanding, the use of IK in Namibian schools sometimes is not taken seriously. This was revealed by Mwetulundila (2007) who considers IK as "informal science" and further argues that, "Although girls too bring informal science learning to school, the curriculum operating on 'socially constructed literacy' disregards it as science" (p. 7). It could be argued that failure to use IK in science classrooms is due to attitudes of teachers, policy in the systems and how the institutions view it.

This is not only manifested in Namibia but in Zimbabwe as well as it is attested by Shizha (2006) who probed how teachers incorporated indigenous knowledge, culture, traditional beliefs, and customs into their science lessons. The following was revealed:

> *What we are teaching is Western science [laughs]. Traditional science has no place in our curriculum in the teaching of science [laughs again]. Beliefs and customs do not have a place in teaching science, but in other subjects like religious and moral education, and social studies, but in science, no [shaking his head]. Traditional knowledge is important only at home. When teaching science, traditional beliefs have to be corrected. We need to correct such beliefs in pupils because here we are trying to explain causes of things (grade 7 teacher) (p. 311).*

Even though, some other teachers distance themselves from IK, it is very much embedded in our culture, and recognizing it will be a goodwill gesture forward in our practices. The sections below show various ways in which people use IK.

2.5.4 THE BENEFITS OF EMPLOYING IK

FOOD PRESERVATION

In some communities food is preserved in dagga and pole houses which are built on elevated platforms using stone boulders to prevent it from getting wet. The roof is smeared with clay and then thatched, and all holes closed to prevent insects from coming in. The grain is removed from underneath or top, but these entrances are always re-sealed with clay. The clay acts as an insulator, and is not combustible. These same principles are used in IK and WS so that stored food is kept dry, rodent and insect free, and insulated. Could then this not serve as a good springboard when teaching about food preservation in schools?

On another note, here is how the other Africans show their ingenuity. The *Owambos* of Namibia are found in sandy soils without stones due to land appropriation by colonialist. To preserve their millet, they select the tender stems of Mopani trees. These can be bent easily as they construct a traditional circular granary. To make this selection, they rely on their IK on mechanical properties of materials. School science, studies properties of materials, but such knowledge is not probed from learners. Yet, this could also act as a catalyst for learners not to learn science concepts in abstract ways but to be able to apply them in their real life context..

To make sure that a traditional granary does not allow the grains to leak out, and is rodent and insect free, they plaster the internal walls with cow dung. Their choice on this material comes also after they apply their IK. Cow dung is impermeable to water and hence protects their food grains. All this can be used by teachers to create stimulating and conducive teaching and learning environments for learners to make meaning of scientific concepts.

Our ancestors never went through any of these missionary schools mentioned above. How then did they manage to live sustainably with their cosmos? Is it not their Traditional Knowledge (TK) which enabled them to live sustainably in their habitats? I believe, when one considers how economically dependent the Namibian agro-economy has become on foreign capital, that the ability to live in harmony with one's natural environment is a skill that should not be lost.

Moreover, I believe that a great step towards preserving IK would be to introduce it into science classrooms. In the above example, if learners were encouraged to talk (Lemke, 2001) about how their ancestors preserved food, it could encourage them to engage with "concrete, intelligible, and plausible concepts" (Posner, Striker, Hewson & Gertzog, 1981, p. 217). Thereafter, this could be followed with teaching the general scientific principles of food preservation and these abstract scientific ideas could thus be more easily linked to their prior knowledge.

I believe, in this way, not only would students learn more effectively, but the wealth of technical knowledge (TK) that Namibian communities, possess would not go to waste. Odora-Hoppers (2001) cautions that we tend to deduce that WS is responsible for distancing us from our prior everyday knowledge and experiences (p. 75). In my view, this could be avoided by considering the inclusion of IK in our classroom discourses.

MEDICINE

In the area of health, much has been said about the efficacy and efficiency of traditional treatments for common human ailments. Some claim that they are at least as effective as WS medicine, and perhaps even better, as they do not contain any harmful/toxic additives or preservatives. I can personally attest to the benefits of traditional medicine, and the importance of TK in preserving its traditions, as is borne out by the following story.

Some years ago, on a Sunday afternoon, I was accidentally burned on the leg by a clothes iron as my sister, Thiyadora was pressing my school uniform. As the clinic was far away and only accessibly via a bus that ran on Fridays, it was my grandmother who eventually came to my rescue three days later. Word had reached her that I was in agony. That Wednesday when she arrived, she asked me to take a hoe. I followed her, limping with pain, and I wondered why she could not just fetch the medicine herself and treat me at home.

Not only did she lead me to the correct shrub, which - when prepared - offered me relief from the pain in my leg, she told me the reason she did not fetch the plant herself. She wanted me to be able to recognize it for myself, so I could pass the knowledge to my children. The problem with not documenting this knowledge though is that in the process of being passed on from one generation to another it could be misinterpreted. The morale of this story above is consolidated by Rudle (1977) who notes that:

> *Traditional system of indigenous knowledge transmission is highly structured and systematic, with either individual or small group instruction. Emphasis is placed on learning by doing through repeated practice over time rather than by simple observation and replication (p. 27).*

In short, IK is passed from generation to generation (Kibirige& Van Rooyen, 2006). However, there are some disadvantages such as considering it as knowledge associated with rural people (see Section 2.5.12). So, it makes IK suitable to be incorporated in science practices in schools in rural settings excluding schools in urban settings. In retrospect, IK is embedded in the culture of the people who own it and may be considered to be transformative since it tries to be inclusive. On account of IK being local, I could not use the same shrub when my daughter, Maravillosa was in the same predicament since I was in an area where the shrub was not indigenous. If it was there, possibly my daughter would have been septic since plants extract different substances in different areas and sometimes they can be poisonous because of the quantity and what they extract from the ground. Even though this occurs we still need to preserve plants which play vital role in medicine.

These days, one of the biggest threat, and challenges to the survival of traditional medicinal practices comes from the global environmental crisis. Unsustainable harvesting of plants, climate change, coupled with poor farming practices and loss of TK, has already seen countless indigenous plants and herb species disappear. Influenced by WS, Namibian local farmers have abandoned sustainable farming methods, poly-culture was practiced but people resort to mono-culture, which encourages the planting of one crop.

To achieve this people weed out all other crops, if left some of these deter predators from invading and also have medicinal value. Use of both selective and non-selective herbicides is practiced, and applying of nitrogen, phosphorus and potassium (NPK) fertilizers, all these cause the destruction of the environment resulting in medicinal plants being exterminated. In the case of fertilizers too, they might cause eutrophication. This artificial eutrophication causes an excess of plant growth in bodies of water which would then deprive the other animals of oxygen for respiration.

Thus, I believe that it is imperative that people become re-educated about the value of their natural resources, so that efforts to save them can begin in earnest. Perhaps, this could be through allowing the dual harmonious coexistence of IK and WS in our teaching and learning activities as proposed by Aikenhead and Ogawa (2007) and Ogunniyi and Ogawa (2008). Below, I discuss the importance of inclusion of IK in science classrooms.

2.5.5 INCLUSION OF IK IN SCHOOLS TO MANAGE NATURAL RESOURCES

In terms of natural resources management, communities have long employed IK to ensure that their resources are not over-used. For instance, there is a strong belief in my community that one must never cut trees near a river or along the banks because it discourages rain and the river will dry up. For years, through following this belief, the community has managed to maintain their water resources.

Of course, WS can explain this belief in physical terms – by saying that the river will absorb a maximum amount of heat from the sun when trees are cut, and so evaporation will occur faster, and the riverbed will become dry and less able to collect rainwater. Herein lies the importance of harmonizing these knowledge systems rather than seeing them as mutually exclusive.

The point is that before learners know anything about the principles of evaporation and the like, their IK has prepared them to understand the principles of proper resource management. Thus, learners can move from the zone of actual development into the zone of proximal development (Vygotsky, 1978). Herein lies how new knowledge can be constructed basing on what learners already know.

The above approach of using IK ensures that learners are moved out of a dilemma of whether to incorporate IK or not to allowing the curriculum to adopt a "conceptual progression and coherence” character (Kriek & Basson, 2008, p. 63). That is, concepts are introduced in a grade and then are revisited in the next grade. Each time the concepts are revisited will serve as prior knowledge for the other concepts to be introduced by the teacher.

Thus, by using IK as a teaching tool in the above example, not only will teachers ensure that learners are cognitively engaged with the content that is being taught to them, but also that invaluable traditional knowledge which is a cultural heritage, is preserved and transmitted to future generations.

2.5.6 IK, INCLUSIVE EDUCATION AND SOCIAL JUSTICE

The goals of the Namibian Education system are; *democracy*, *quality*, *equity* and *access*. If implemented these goals would make it possible to make the education system adopt an inclusive character. Similarly, social justice would be done as we allow the disadvantaged ethnics groups’ culture to be used in the teaching and learning of science. This encourages science content to be taught and learnt so that it becomes accessible and is tailored to the needs of the learners.

Namibia is a home to the marginalized groups of indigenes sometimes derogatorily referred to as ‘bushman’ who need to be incorporated into the democratic education system. They exist very much on the fringes of modern society, and are ‘uneducated’ by western definitions of that term. However, often these people possess real wealth of a lot of cultural capital when it comes to practical traditional knowledge (Bourdieu, 1984). So, why should we not realize the goals of the education system through the use of prior everyday knowledge and experiences?

Attempts have been made in the past to give these people a basic Western education, but so far, these attempts have been largely unsuccessful. This had led many to believe, cynically, that the gap between IK and Western systems of thought is simply unbridgeable, and that it has to be a question of abandoning one for the other (Kunnie & Goduka, 2006).

However, if these indigenes- who possess concrete knowledge of traditional practices are taught from the basis of their own IK, they would become more receptive to the abstract principles and reasoning skills of WS, and would be able to learn the skills and knowledge that Western education has to offer.

Thus, insofar as introducing IK into a school's curriculum would have a 'modernizing' effect on people who simply have been left behind by the global economy. It would also perpetuate the ends of inclusive education and social justice.

2.5.7 CONSEQUENCES OF NOT RECOGNIZING IK IN SCHOOLS AND COMMUNITIES

In issues pertaining to development, it is always advisable that project managers take cognizance of indigenous knowledge. This knowledge must be used in conjunction with WS, as the following case study will attest to that.

Two schools situated in the northern part of Namibia, in semi-flood plains of the Zambezi River, were granted funding to start a fish project. One of the headmasters did not take note of what the learners, the local teachers and the school board members were saying about the area being prone to floods. The locals, consequently, did not feel invested in the project, as they knew that as soon as the floods came, the fish would be swept back into the river and lost forever.

In contrast, the other headmaster involved the staff and students in the project to locate ponds in elevated areas. He managed to consult with some of the stakeholders in the project, and obtained solar transducers to run aeration equipment in the ponds. The second headmaster now had the ideal location and correct technology at his disposal from the locals' IK bank, and the school's fish farm flourished.

This is a graphic illustration of the dangers of ignoring IK when undertaking developmental projects at schools, as well as the benefits of combining indigenous and Western knowledge systems in order to effect successful and sustainable development. Ladislaus (1999) strengthens this by saying, "Anyone who seeks to change the social and economic system of any people should first carefully examine their existing indigenous knowledge and beliefs" (p. 288).

2.5.8 POSSIBLE LEARNING AND ECONOMIC BENEFITS OF USING IK IN SCHOOLS

IK is determined by some economic factors. These can be taken note of and in the case that learning is involving concepts related to economic factors teachers could use them as the base. Take a case such as skin tanning practiced by the *Himba* ethnic group living along the Kunene River in northern Namibia and southern Angola.

If teachers discuss this practice in class, they need to describe the steps followed by the *Himba* when tanning leather and involve students of that community. This involves the stretching of the leather, drying it using sunlight and salt, applying wood ash to facilitate the removal of the hairs. Then they constantly wring the leather to remove the hair. Colouring follows using a red powder made from grinding stones and perfuming using indigenous herbs. Their gaining of popularity on the market will lure students to assimilate WS since they are likely to improve on the processing of leather to improve their economic status.

The moment a teacher mentions that the ash that they use contains traces of calcium hydroxide and they are responsible for removing (corroding) the hair on the skin, they will not forget the Chemistry terminology used since it would have been explained by their other community members to them. Learners are very likely to remember the use of chemical substances whenever they are asked because it is in their existing knowledge. An approach using the western science alone will not bear much fruits since it is not related to what learners know and do in their culture (see Section 2.3). All the other substances used can be understood well once their relationship with the IK is made. In the same vein, however, any misconceptions that might be there would need to be cleared.

Inclusion of IK will make the acquisition of WS possible. McRobbie and Tobin (1997) indicate that "reforms have included calls for making science curriculum for all students in terms of their everyday lives and interests…" (p. 202). Kibirige and Van Rooyen (2006) further add that for a concept to be known and assimilated, we need to restore "enthusiasm and motivation" (p. 241).

2.5.9 MAKING THE CURRICULUM BROADER

Science curriculum in some countries is very thin, for example, the Namibian Science Syllabi. Most concepts are not included. The reason is curriculum planners fear that some science concepts are inaccessible to learners. Implementing of IK as a starting point could make the inclusion of the concepts possible. Some of the inaccessible concepts are embedded in learners' cultural practices which they could exploit to base their arguments in science discourses. By doing so it becomes broader and gives the learners an opportunity to participate and understand fully.

Exclusion of IK leads to frustration of students as they see that what they discuss is "missing a purpose for learning or the concrete real- world reference to the abstract concept being explored" (Chapman, 2006, p. 2). Learners try to link what they have learnt using WS, they cannot establish a link with what they know in a way that they see learning science as not connected to science they encounter in their experiences in their communities (Rennie, 2011).

2.5.10 FACILITATING THE FORMATION OF A PRACTICAL CURRICULUM

The non-recognition of indigenous science in some instances has forced some teachers to come up with an "unwritten curriculum" (Kenli, 2009, p. 1). This curriculum lacks conscious planning since teachers will be smuggling from an indigenous cultural context of learners' values and socialization processes clandestinely without the required pedagogical styles. Giroux (1981) refers to this as "hidden curriculum" (p. 92). He goes further to say "teachers should be actively involved in producing curricula materials suited to the cultural and social contexts in which they teach" (ibid, p. 98). This could empower teachers so that they could come up with a practical curriculum out of the sanctioned one which would be having IK.

The inclusion of IK would not only allow teachers to implement 'trivial' construction of knowledge but would also enable them to implement 'radical' construction of knowledge (Jaworski, 1996, p. 2) (see Section 2.4). Trivial constructivism is implemented when teachers allow learners to actively participate in classroom talk, whereas radical construction of knowledge would add to that by allowing learners to undergo a process of adaptation based on and constantly modified by learners' experience of the world and in our case it is aligned to the "indigenous ways of living in nature" (Ogunniyi& Ogawa, 2008, p. 178).

By so doing, teachers would consider a classroom not as an isolated black box but as something that exists in a dialectical relationship with the wider community to achieve the required assessment (Black & William, 2001). Lemke (2001) goes further by saying it is not beneficial to segregate natural phenomena from social world when studying them. Natural phenomena are studied together with the social world since they are systems in interaction.

The above takes us to socio-cultural constructivism (Section 2.3) whereby knowledge is perceived as "socially constructed and mediated by historical, institutional, and cultural contexts and that knowledge is centered on how language is used in that culture" (Rodriguez, 1998, p. 593). The examples above demonstrate how the introduction of IK into schools would ensure better learning and guarantee that profitable cultural wisdom is retained by the communities in which it is practiced. However, we need to understand the pros and cons of including IK in our schools.

2.5.11 PROS AND CONS OF IK

If we are to take IK into our curricula so that we incorporate it with WS, certain characteristics of it need to be highlighted. IK's and WS's ways of understanding nature do not only have differences and similarities but also have strengths and limitations.

Snively and Corsiglia (2001) and Kibirige and Van Rooyen (2006) point out these characteristics as; IK uses storage and retrieval systems which are totally different from those used by western science and integrate scientific data with spiritual, mythological and even fictional materials). These can pose some pros and cons as the passage below illustrates.

IK is prevalent among the adult population. This is on account of the adult population's perpetual use of IK since from the time they got it orally or any other means from other community members. The young generation on account of being influenced by social, economic, political factors and others they tend not to use it or if they use it, they use one which is inclined to WS. As a goodwill gesture to their persistence use, the adult population is protected from the adverse effects of industrialization.

Toxic substances are spilled into water systems by mining and other industries. This is a threat not only to the human population but to all living organisms. However, the adult population knows the taste and smell of the water they use. Strange taste and smell in water would make them abandon it and seek another source. As they do so they sustain their lives. This may not be true with the young generation who do not believe in the ideas of IK.

So, if IK is brought in a class it has a limiting effect since a teacher in science would have to engage in a dual role; one to teach learners to understand the IK to be used and then to teach the WS which they would be evaluated in at the end of the program. Can this not be a challenge since our classrooms are made up of different ethnic groups?

IK is transmitted orally and stored by individuals. Sometimes there can be consistency with what you hear from one member of the same community to the other. If our classrooms are made up of culturally diverse learners, then this can be exploited to enhance learning of science, but with difficulties. It should be borne in mind that our classrooms are multicultural, hence, the need for the teacher to have a look at each learner's understanding separately. The implication is that a science teacher needs to address or understand the IK of each component of the classroom which would make him/her contextualize what he/she is teaching.

The cultural lenses used in each community are different and this would require IK used to be interpreted by one who is knowledgeable about that culture. Worse still, absence of documentation means teachers whose culture is not the same as the learners would end up moving from community to community in search of the IK. Would the duration of an average lesson of forty minutes be sufficient to do that? I believe it would extend the time duration for a lesson and teachers would not finish what is stated in the official curriculum. At the end, when failure arises, the blame would strongly be laid on teachers.

If IK is to be codified in order to use it with access in the classroom care must be taken since this may lead to the loss of some of its properties (Kibirige & Van Rooyen, 2006). Certain words in certain communities are not available in other communities since we will require a standardized IK which a particular school curriculum would make use of. If it is taken in small pockets, this would drain the coffers of the state since we have in each country some diverse cultures whose IK need to be processed for the benefit of the users. So, this could be a major limitation in the process of incorporating IK in our classrooms.

The parameter time is not well developed in some certain communities. The lack of instruments for measuring time with precision will make a particular community have IK associated with time not well developed. The implication is IK data which are related to time is not precise WS cannot carbon date it as scientists try to establish some relationships of events. Regardless of the pros and cons listed above, I believe that, we can still enhance the use of IK in our classrooms through the inclusion of practical activities or even demonstrations.

2.6 PRACTICAL WORK

2.6.1 PESSIMISTIC AND OPTIMISTIC IDEAS ON PRACTICAL WORK

A lot of ideas have been said about practical work in science. Also, a number of authors share their ideas about practical work in science. Hodson (1990) is pessimistic about the role practical work plays as people use it to know about the cosmos around them. His view is that practical work is "ill-conceived, confused and unproductive" (p. 33). According to Hodson

(1990), this is on account of the views teachers have on practical work. Lakatos (1974) says inductivists use experiments to induce some fundamental laws of nature from it (p. 344).

However, Millar (2004) is optimistic about the changes which practical work can bring in enabling people to know the environment through learning and teaching discourses. It is the objective of this section to explore why these lines of thoughts exist. I put forward the position of practical activity in science in order for it to be harnessed with IK and WS. This enables to come up with a lesson which is aligned to constructivist theory (see Section 2.4) as learners become actively involved while the teacher facilitates the process.

I agree with Millar (2004) who uses the term practical work instead of laboratory work or experimental work. This is a universal term compared to the others used by Hodson (1990). Laboratory work will limit teachers to only do practical work when there is a laboratory facility at their institute of learning. However, this is sometimes not true. Prominent theories were discovered outside the laboratory. Was Archimedes in a laboratory when he ran naked, shouting *eureka*, into a market place when he found theories related to floatation?

This selection of terms prevents science teachers from carrying out practical work when a laboratory is not there. At school level, practical activity is not only looking into suggestions or hypothesis, it also looks into theories and laws. It tries to equip learners with skills to come up with scientific evidence, helping them to construct science knowledge and arrive at the laws in science through the different activities employed by science.

2.6.2 The role of practical work

When certain practical techniques are used in the teaching of science, learners develop skills including the mounting of apparatus to be used, observation, measuring, recording graphical construction and the writing of conclusions. I now look into how one of these practical techniques was used by many indigenous people to detect a poison in a food plant.

FIGURE 2.3. THE CASSAVA PLANT WITH TUBERS OBTAINED FROM: HEKEBUN.FILES.WORDPRESS.COM/2008/10/CASSAVA.JPG

Cassava indicated above is exotic in many communities but indigenous to the Americans. It was brought to those countries where it is exotic by Portuguese traders and slavers. Upon arrival, locals used observations to discover that certain parts of it contain hydrogen cyanide (H-C≡N), a poison which begins to form once tubers have been removed from the plant.

Observation as used above by community members is not the only skill developed during practical activities. Knowledge of community practical activities can develop alternative skills amongst trainee teachers if opportunities for such engagement are offered in the classroom. Some properties of practical work are; it is a medium of communicating ideas and can be achieved graphically, pictorially or symbolically. It has a social constructivist character as I indicated in Section 2.6.11. It allows learning to be carried out while learners are in groups, discussing and arguing about whatever they would have constructed. If carried out individually, learners still come to discuss science ideas which emerged in mind maps done as they try to establish science evidence they would have found. As they do so, “ideas are modified and refined – and so are shaped towards a shared set that makes discourse and collaborative action possible” (Millar, 2004, p. 8).

These ideas are gained as learners use their indigenous ways of learning about nature. Many more properties exist, but how can we best exploit them to bring up a generation which is at the same level with those working at the edges of science knowledge?

We need to develop the habits of mind which scientists have in our learners. Schwartz (2007) indicates that in science, knowledge is developed by not using only one method or approach but through creative and inferential processes where they collect data and make meaning out of it. Habits of mind are then a necessity in learners and can be developed through the use of practical work in an environment of IK (p. 44).

The habits of mind which scientist have are dispositions and are as follows; they are experimenters, describers, conjecturers, tinkerers of knowledge, pattern sniffers which are found in natural phenomenon and apply them in our society for us to have a habitable community. They also develop as they make predictions, explanations, explorations, observations and explanation (PEEOE) (Maselwa & Ngcoza, 2003). Maselwa and Ngcoza (2003) refer to this approach as an essential skill to assist learners in the reconstruction of science knowledge (p. 19).

Students develop scientific habits of mind as they use practical activity which is a tool of scientific enquiry. They ask valid questions during gathering and analysis of information and this would lead them to engage in those habits of mind mentioned.

They understand how to develop hypotheses as they answer questions. They create conditions using practical work, which are models of natural phenomenon and explain anomalies seen and formulate a relationship which exist between the parameters they are investigating and that could constitute a law (Schwartz, 2011, p. 45).

Out of this, students are able to demonstrate communication skills. They disseminate their findings to peers as they interact in different activities using IK. As we develop the above idea of habits of mind using practical work and IK, we facilitate learners to do “border crossing” (Ramorogo & Ogunniyi, 2010, p. 26). The process of moving from what they have experienced in one’s IK to reconcile it with WS is what is referred as border crossing. Aikenhead (1996) further suggests that four types of border crossing exist namely; smooth, managed, hazardous and impossible border crossing.

Smooth border crossing occurs when indigenous worldview and Eurocentric worldview are in agreement. When the two worldviews are different, then managed border crossing occurs. If the two worldviews are divergent then hazardous border crossing occurs. Finally, impossible border crossing occurs when the two said worldviews are not in any way in harmony such that students resist moving from one worldview to the other.

As students harmonize conflicts which arise on account of cultural differences between the two worldviews, students undergo what is referred to as collateral learning (Jegede, 1995). He regards this as the construction of science concepts side by side and no disturbance is seen with their indigenous knowledge.

On the other hand, Ogunniyi (n.d) suggests the contiguity argumentation theory (CAT) which views the five cognitive stages which occur during collateral learning when a learner undergoes border crossing. The five cognitive stages are *equipollent*, *suppressed*, *assimilated*, *emergent* and *dominan*t. Contiguity argumentation theory explains how border crossing takes place since it is all about learning. Also, collateral learning theory explains how learning takes place during border crossing. So, one of the role of practical work is to create premises which encourage border crossing to take place as IK of participants is brought in science discourse.

Namibia is a culturally diverse country in which teachers and learners bring different cultures into the classroom. That is, they bring different IK which they use to understand the world around them into the classroom. Brand and Glasson (2004) support this as they suggest the idea of teachers increasingly finding themselves in classrooms with children from cultural backgrounds very different from their own. When a teacher brings in the cookbook experience about Eurocentric science, learners need to move away from what they believe to the new world view.

Border crossing is necessary in any learning situation since it provokes the creation of tension Piaget (1896) or disequilibrium (feeling dissatisfied) (Dewey, 1859). This can be achieved if practical work addresses some prejudices in science issues which learners bring. To achieve understanding in science, certain objectives must be achieved as advocated by Millar (2004).

If border crossing is to proceed smoothly then, practical work must aim at identifying objects or phenomena to be studied, identify how these are perceived in the community of the learner and use the same materials and ideas to learn WS.

I would be more comfortable if the objective above is referred to as the stage of recognition of objects or phenomena. This can be achieved by implementing a skills type experiment. It enables the learner to acquaint himself/herself with the skills in science. She/he can then enter into the labour market where such scientific skills are required such as engineering and so forth.

The objective of acquisition of facts, we will refer to it as the stage of analysis. An observation experiment can achieve this. The learner positions himself/herself to different forms of observation.

In both IK and WS, observations play a critical role. However, in WS, observations are limited in time but with IK they take longer time. Sometimes, when thirsty, we observe to see if the source of water close to us has some living organisms namely; frogs, crabs and others. This is a barometer used to detect if water is drinkable or not.

Observation arouses learners' curiosity which can be "manipulative, perceptual, epistemic and specific curiosity" (Chalk, 2007, p. 157). Learners' world view change in order not to remain in an uncertainty situation or they do not want to put their cognitive map in jeopardy. By so doing, they align themselves to the scientist's social identity group which they aspire to be in. All these could be achieved by properly selecting the type of practical work which we ask our learners to do.

On the other hand, the objective of learning concepts can be regarded as the stage or level of ordering the concepts taught. It requires the use of a technological type of a practical work. It would equip a learner with the necessary logic, make him identify faulty areas and apply ideas learnt in the previous levels such as through IK. By so doing, learners would modify the existing knowledge structure obtained using the indigenous ways of knowing nature.

Finally, the relationship and theory can be referred to as the deduction and rigour stage respectively. Hypothetical deductions are made to link the abstract domain to the concrete domain. An exploratory type of practical work can achieve this.

Practical work plays both a social role and a psychological role. Socio-cultural theorists bring this idea in different ways. Vygotsky (1978) advocates the fundamental importance of social interaction with more knowledgeable others in the zone of proximal development (ZPD) and the role of culturally developed sign systems as psychological tools for thinking. Practical work serves this social purpose since when doing it, it allows learners to socialize and apprentice them in the culture of established scientists as they learn the tools to become a recognized scientists.

On the other hand, Leont'ev (1981) argues that thought develops from practical, object-oriented activity or labour. Practical work then fits into this psychological aspect since learners are encouraged to enter into a thinking activity as they modify their existing knowledge which would have been challenged by the novel ideas which come after conducting it.

As a discourse in the scientific community, practical work provides a social life where higher mental function activities can develop (Vygotsky, 1978, p. 128). In the discourse, social language related to science language is used. Science language manifests itself as IK and has scientific jargon to promote a science talk.

Leach and Scott (2003) illustrate the case of a drinking straw which uses air pressure and community members use scientific jargon such as suck/pull the liquid up to explain how it works but such experiences are not looked into when teaching such concepts in the classroom (p. 102).

In this study, the focus was on the topic of pressure, in particular, Bernoulli's theorem; how the community's scientific jargon could be used to facilitate its learning. What follows is an explanation of Bernoulli's theorem and some of the natural phenomena in which community members use their IK in daily life applications.

2.6.3 PRESSURE (BERNOULLI'S THEOREM)

In western science, the Bernoulli's theorem explains the relationship between fluid pressure and fluid velocity. If pressure is high then the velocity is less. This culminates into an equation:

$$\mathbf{p_1 + 1/2\rho v_1^2 = p_2 + 1/2\rho v_2^2};$$

where p_1 and v_1 are the pressure and velocity at a given instant and p_2 and v_2 are pressure and velocity at another instant respectively and ρ is the density of the fluid.

Now, in everyday life there are examples of where these same ideas are used in the community to explain certain phenomena which they see happening and these are discussed below.

- When the roof of a hut is detached from the walls by wind some people explain this as a result of air building up inside and forcing the roof to be blown by the wind;
- Members of the community discourage others from standing near a heavy vehicle passing by since the explanation is one can be sucked by air;
- Community members avoid crossing the Zambezi River at a point where it is very narrow. The understanding is at that point the pressure is too high. Instead, they cross the river at a point where it is wide since their understanding is that the pressure of the

water is less and velocity high and these conditions can facilitate reaching the other side of the river; and

- When one is tasked to water a garden using a hosepipe, I he knows that for the water to reach the furthest points one needs to place a finger at the tip and this increases the pressure and make the water have a greater range.

All these examples above constitute some community members' IK they use to understand these phenomena and have been used in the exemplar worksheet (see Appendix 5) that I developed in this study. Thus, the IK can act as a catalyst for pedagogical content knowledge and pedagogical technical content knowledge and I discuss these below

2.7 PEDAGOGICAL CONTENT KNOWLEDGE FOR TEACHERS

2.7.1 WHAT IS IT AND WHAT CAN IT BE USED FOR?

After seeing the role which IK plays and its characteristics, and what it can do I concluded that IK could be used as a vehicle to enhance pedagogical content knowledge (PCK) in our schools. According to Shulman (1987), PCK is.

> *The blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction (p. 8).*

Sometimes this component lacks in some teacher training curriculum. The institutions which train teachers empower them mostly with subject content knowledge and the pedagogical knowledge. PCK is common to both the set of content knowledge and the set of pedagogical knowledge as indicated by the modified diagram in Figure 2.2 which first came with Shulman (1987).

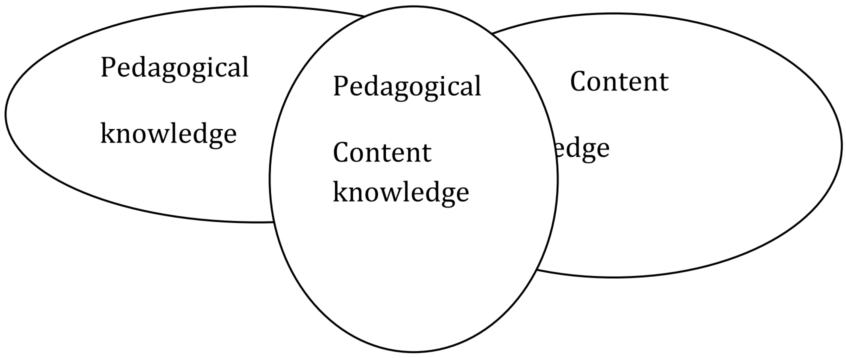


FIGURE 2.4. KNOWLEDGE FRAMEWORK WITH THREE TYPES OF KNOWLEDGE (ADAPTED FROM SHULMAN, 1987, P. 22)

PCK is specific knowledge of teaching practices that can be used to address students' particular needs and it builds on other forms of knowledge such as IK. As seen in the previous paragraphs, no error is committed if we place IK as an element of PCK indicated by Figure 2.4 above.

Thus, the use of IK as a component of PCK would enable teachers to diagnose learners' problems and not to have prejudices of what learners put down as answers to what teachers ask them. The contextualizing ability would enable trainee teachers to be culturally inclusive of each learner's existing knowledge structures. So, their classrooms would become responsive to multiculturalism. It could be argued that in learners' IK there could be skills which could be exploited and used in practical activities. The skills come as pedagogical technical content knowledge discussed below.

2.7.2 PEDAGOGICAL TECHNICAL CONTENT KNOWLEDGE IN PRACTICAL WORK

Out of the analysis done above, we can arrive at further modifying the diagram in Figure 2.4 above. Shulman's knowledge framework diagram modified by (Koehler & Mishra, 2009, p. 4) has technical knowledge instead of technological knowledge which the latter two put forward. The technical knowledge is possessed by science teachers who use it to facilitate science knowledge acquisition by students through use of practical work.

These four knowledge components in this framework are intertwined and have a dialectical relationship with each other and these are represented as content knowledge (CK), technological content knowledge (TCK), technical pedagogical knowledge (TPK), and technical pedagogical content knowledge (TPCK). Skills such as measurement, observation, recording and use of the data obtained to arrive at a conclusion are important in science.

These then come as technical knowledge which the teacher must have and develop in his learners to build the mentioned habits of mind.

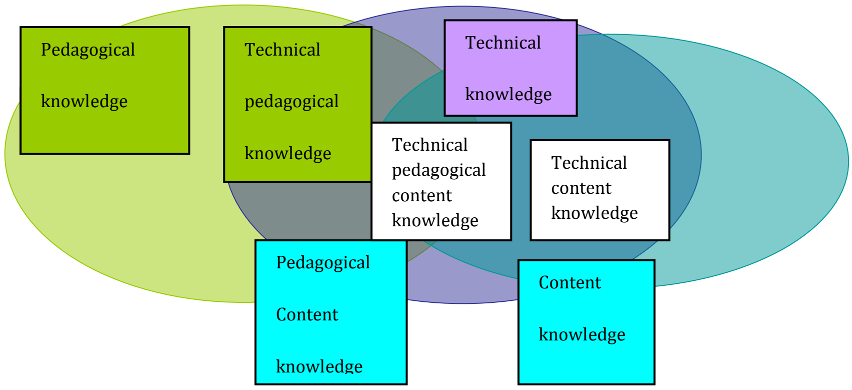


FIGURE 2.7.2: KNOWLEDGE FRAMEWORK WITH THREE TYPES OF KNOWLEDGE (ADAPTED FROM SHULMAN, 1987, P. 22)

2.8 CONCLUDING REMARKS

In this chapter, I reviewed some literature relevant to my study. Science teachers are urged to use a variety of methods when presenting science concepts. Practical work as a method of instruction, IK and WS as systems of knowledge sources should be used to construct one's science knowledge base and these are supposed to coexist. However, certain considerations must be observed. When incorporating IK with WS some of the considerations are, teachers must not prescribe practical work, properties of the knowledge systems should be taken note of and the limitations of IK are observed.

In the following chapter I discuss the methodology of the research study.

CHAPTER THREE

RESEARCH METHODOLOGY

> *Methodology is the range of methods and procedures you use to investigate your topic and find answers to your research questions (Lambert, 2012, p. 101).*

3.1 INTRODUCTION

In this chapter, I discuss the research methodology employed in this study. The importance of the methodology lies in guiding the research and allows others to see how data was generated as it is stated in the epigraph. The research paradigm, case study, methodology, goal and questions are looked into and thereafter the research site and participants. Thereafter, the chapter looks into data generating techniques followed by validity and ethical issues. Finally, data analysis is discussed and some concluding remarks are provided.

3.2 RESEARCH DESIGN AND METHODOLOGY

3.2.1 INTERPRETIVE PARADIGM

This study is underpinned by an interpretivist paradigm (Janesick, 1998; Leedy& Ormrod, 2010). In interpretive paradigm there is no one conclusion and deductions are made based on the data obtained to formulate meaning. The interpretive research paradigm is also characterized by being subjective, studying people in their natural settings and having multiple interpretations (Cohen, Manion & Morrison, 2010; Janesick, 1998). It also seeks accurate summaries of intelligible detailed context from which the meaning of social actions become explicable (King, Keohane& Verba, 1994; Creswell, 2003). There is subjective reality since reality is perceived by people. Morgan (1980) reinforces by saying, "social reality is created and sustained through the subjective experience of people involved in any given practice" (p. 611). What follows is a description of a case study where this paradigm was applied.

3.2.2 CASE STUDY

A case study is one of the various forms of qualitative methods through which social data is organized for the purpose of viewing reality, as it provides a detailed examination of a setting (Janesick, 1998; King, Keohane & Verba, 1994). A particular instant is selected and designed to "illustrate a more general phenomenon" (Cohen, Manion & Morrison, 2010, p. 263). However, the qualitative research conducted for this study was structured through a participatory action research (PAR) approach and is a single case study aimed at promoting "understanding or inform practice for similar situations" (Leedy & Ormrod, 2010, p. 137) .

This case study was about one educational context where sixteen trainee teachers were in a science class. Lesson planning was done by them in groups of four facilitated by the researcher. This was done after trainee teachers received an orientation on how prior everyday knowledge and experiences could be incorporated in the teaching and learning of science and then presented during microteaching.

Also included was an analysis of three research papers discussing the socio-cultural perspective of teaching and learning science and learner-centredness and two textbooks in physical science. Only one chapter on pressure was analysed from each textbook since the research was based on pressure. The three groups were then asked to select any concept in physical science and incorporate it with prior everyday knowledge.

This case study was selected because it was accessible and "bounded by time and activity" suitable for the researcher (Creswell, 2003, p. 15). Also, the other reason of selecting this case study was because the problem of the research arose within a similar situation. Hence, if successful, the knowledge generated in the process would certainly empower trainee teachers in their practice when they go for school based studies (SBS). This purposeful selection of a teaching context involving trainee teachers enabled the researcher to come up with a "natural socio-cultural boundary which paved the way to a face –to- face interactions" (McMillan & Schumacher, 2006, p. 317).

In undertaking the above, the research was guided by the idea that when human systems are studied, they need to be taken in their wholeness as they are not a loose connection of traits and they are dynamic (Cohen, et al., 2010, p. 253). McNiff (1997) views this by suggesting that, "we live in a unified universe, where all things are connected, often in distant ways" (p. 11).

3.2.3 PARTICIPATORY ACTION RESEARCH

The methodological approach adopted in this study was participatory action research. In participatory action research (PAR), participants and researcher identify problems from practice and develop strategies to address them. Strategies are implemented by the researcher and participants who research and reflect on them as a way of addressing the problems with the view to improve practice (McNiff, 2002, p. 5).

Furthermore, PAR is a collaborative socio-cultural process of learning, realized by the participants who are committed to changing their own practice (Kemmis & Wilkinson, 1998). Kindom and Kesby (2007) explain that PAR entails researchers and participants working together to examine a situation in order to change it for the better. The profile of the detailed design of participatory action research for this study is provided in Figure 3.1 below.

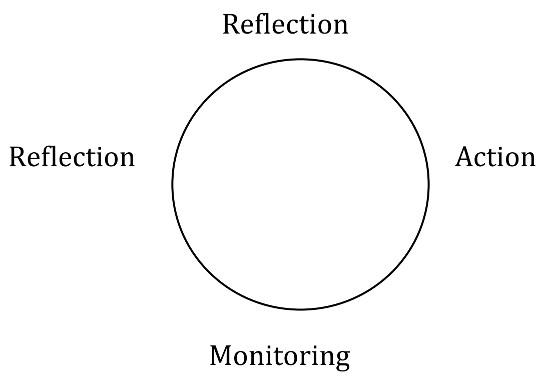


FIGURE 3.1 (ADAPTED FROM WATER-ADAMS, 2006, P. 7)

Given that the goal of this research study was to develop an exemplar worksheet on pressure and reflecting the core idea of using prior everyday knowledge in enhancing science lessons, the appropriate primary design character as mentioned above was thus of a participatory action research (PAR) approach.

3.3 RESEARCH GOAL, OBJECTIVE AND QUESTIONS

The goal of this research study was to investigate trainee teachers' engagement with prior everyday knowledge, experiences and explanations of natural phenomena in teaching physical science concepts.

RESEARCH OBJECTIVE:

The objective of this study was to develop an exemplar worksheet on pressure that would effectively teach pre-service trainee teachers to incorporate appropriate examples of everyday knowledge into their physical science lessons with a view to enhance meaning making and conceptual development in physical science.

RESEARCH QUESTIONS

MAIN RESEARCH QUESTION:

How do trainee teachers engage with prior everyday knowledge, experiences and explanations of natural phenomena when teaching physical science concepts?

SUB-QUESTIONS:

1. What factors enable or constrain the teaching of physical science concepts in the curriculum?
2. How can an exemplar worksheet on pressure facilitate trainee teachers' understanding of incorporation of prior everyday knowledge, experiences and explanations of natural phenomena in physical science concepts?
3. How do trainee teachers identify and design physical science topics with relevant examples of prior everyday knowledge?
4. What ways do trainee teachers use to identify examples of prior everyday knowledge which learners have?
5. What is the relevance of the prior everyday knowledge associated with physical science concepts that trainee teachers come with to science classrooms?
6. What challenges do trainee teachers encounter in designing and delivering physical science concepts in relation to incorporation with prior everyday knowledge?

3.4 RESEARCH SITE AND SAMPLING OF PARTICIPANTS

The research site in this study was *Katima Mulilo* University Campus in north east Namibia, which trains primary and lower secondary school teachers. The participants were twelve second year trainee teachers pursuing a first degree in education and four pursuing a diploma in education. They were purposefully selected from one community because the profile of everyday knowledge is different between communities and the scope of this half thesis does not allow for a bigger and more complex sample.

A 'prototype' sample was selected to see reality (Best & Kahn, 1998, p. 248). This sample was then made up of a total of sixteen trainee teachers pursuing science, mathematics and other modules at *Katima Mulilo* University Campus in north east Namibia. The science modules aim to equip trainee teachers with subject content knowledge and the professional content so that after completion they could take up posts in Namibian schools.

Even though the intention was to use only twelve trainee teachers as participants, four were added for the following reasons. The twelve trainee teachers were pursuing a Bachelor of Education (BEd) degree and they did a module in which indigenous knowledge (IK) was discussed without suggestions on how IK could be harnessed with WS. These twelve were more knowledgeable in IK whereas the added four were pursuing a diploma in education and the pedagogical knowledge they received did not have IK concepts in it but had instead done more in-depth studies in science content knowledge compared to the twelve. Hence, it could be argued that the four trainee teachers complemented the twelve with science content knowledge vice versa. This explains why a careful and purposeful sampling was done in this study.

3.5 DATA GENERATING TECHNIQUES

According to McMillan and Schumacher (2006), this PAR case study uncovered a theory to guide teachers with better teaching practices which could enhance science understanding and directing policy makers. So, like in any case study, some techniques to generate data were selected.

These data generating techniques in this study were, namely, document analysis consisting of six documents analysed, orientation workshop instruments consisting of a worksheet and brainstorming and execution of ideas were two and the last stage was analysis. Thereafter, focus group interviews were used. Table 3.1 below shows the techniques used, data to be generated, what purpose and thereafter their descriptions.

TABLE 3.1 DATA GENERATION TECHNIQUES

Stage	Technique	Data to be generated	Purpose
1	**<u>Document analysis</u>** (i). Analysis of curriculum	(i).Theories on which learning and teaching is anchored. (ii). Finding frequency in	(i).Locating the learning and teaching paradigm in order to obtain the context

	documents from NIED. (ii). Analysis of three research papers discussing IK and socio-cultural perspective of teaching and learning science after they have read a prepared document on IK. (iii). Analysis of chapters on pressure in two physical science textbooks.	which prior everyday knowledge and experiences of learners and other knowledge sources have been included. (iii). Suggestions on how IK and prior everyday knowledge are incorporated in the teaching and learning of science.	of the research. (ii). Exposing IK and prior everyday knowledge to trainee teachers. (iii). Extend ideas of IK it supports practical curriculum by bringing views of learners as example to promote socio-cultural perspective.
2	**Orientation workshop** (i).Worksheet to be presented to trainee teachers. (ii). Discussion is done to find their views on how IK and WS can be incorporated. (iii).Brainstorming of views of trainee teachers on the use of IK and prior everyday knowledge in science teaching and learning.	(i).Exposing views to trainee teachers on how IK, prior everyday knowledge and experiences can be incorporated. (ii). Ways of incorporating different teaching and learning perspectives. (iii) Exposing them to practical activities done in the community and different types of questioning technique to see how IK and WS can be used harmoniously.	(i). To be used in brainstorming sessions when selecting topics they will plan and teach. (ii). Generating data for lesson planning, microteaching and future practices. Promote reciprocal partnership. (iii). Will be used to plan a lesson in which IK is used as pedagogical content knowledge and technical content knowledge.
3	**Execution of ideas** (i). Lesson plans are done in groups and facilitated by researcher. (ii). Microteaching (iii). Observation – trainee teachers are observed while they are doing microteaching in topics they would have selected. (iv).Audio and visual techniques – are used in the capturing of activities undertaken by trainee teachers while doing microteaching in groups. (v). Focus group interviews	(i). To come up with a lesson plan in which IK and WS are used to support teaching and learning of science concepts. (ii).Frequency with which IK, prior everyday knowledge and experiences are used and how. (iii). Ways they use to engage with prior everyday knowledge and experience to teach physical science concepts; With what frequency are the ideas of prior everyday knowledge and experiences brought to the	(i). To find methods to incorporate knowledge sources when they are in total, agreement as it reveals their thinking and behavior. (ii).To understand and see their experiences in the use of the given approach and bring some changes and empowering them. (iii). To provide a picture of the teaching and learning discourse; to find out about trainee teachers' engagement with prior

		attention of others. (iv). Audio-visual data can be followed up with other participants to hear their views about the data produced. (v). Follow up on data generated by the above instruments	everyday knowledge and experiences; to understand how they integrate prior everyday knowledge and experiences in their practices. (iv). Makes possible the documentation of kinesics. The recorded kinesics can be triangulated with verbal data. (v). Finding how they engaged with knowledge sources
4	**Analysis and critique** (i).The selection of the topics (ii).Examples from WS and how they match with everyday knowledge. (iii).Documents analysed (iv).Areas for improvement in the orientation workshop and overall process (v).Fine-tuning of workshop, materials and exemplar lessons	(i). To see if all topics are compliant to the incorporation of IK. (ii). Establishing alternatives if IK and WS do not fit (iii). To see prior everyday knowledge and experiences brought by students, gain ideas for new enquiries. (iv).Brings suggestion which can improve the unit of work used in the orientation and other processes. (v).A sample of a lesson in teaching and learning of science concepts.	(i).Identification of topics which can comply with the use of prior everyday knowledge and experiences. (ii). Understanding issues and challenges in designing such lessons. (iii). Establish if incorporation is done successfully. (iv). Information to improve the module (v). A guide to use IK and WS science teaching and learning.

Each of these data gathering techniques tabulated above is discussed below.

3.5.1 DOCUMENT ANALYSIS

Document analysis is a social research technique which enables “a researcher to obtain the language and words of participants” and the data is “thoughtful, in that participants have given time to compiling" (Creswell, 2003, p. 187). Document analysis reveals what people do or did and what they value. Four curriculum documents were analysed in this study. All the documents analysed were "primary inadvertent sources" (Bell, 2010, p. 68).

CURRICULUM DOCUMENTS ANALYSED

A curriculum document from the National Institute of Educational Development (NIED) in Okahandja was analysed. This curriculum document revealed the policies in line with the use of prior everyday knowledge and indigenous knowledge. This data supported my idea of understanding and empowering trainee teachers' with prior everyday knowledge in classroom practices.

ANALYSIS OF DOCUMENTS ON IK

A document on IK was analysed. This redirected these trainee teachers on how IK could be incorporated in science teaching. Collaborative learning was made use of while I scaffolded the process. To consolidate this process, discussions were done with the trainee teachers. Thereafter, sections on three research papers were analysed.

ANALYSIS OF PHYSICAL SCIENCE TEXTBOOKS

The chapters from the physical science textbooks namely; one used by both grade nine learners and trainee teachers and the other used by trainee teachers in their library to prepare lessons were of the primary type. They were deliberate source documents since they were brought in for the purpose of this research. Since the research problem arose when trainee teachers were teaching a concept of pressure, the chapters selected from the two textbooks were based on pressure. The analysis of these chapters enabled me to see if they complied with what the curriculum document advocated.

3.5.2 ORIENTATION WORKSHOP TECHNIQUE

An orientation workshop was aimed to sensitize the trainee teachers on how exemplar worksheets on pressure could facilitate understanding of incorporation of prior everyday knowledge in physical science concepts. Some various techniques were used and each had a specific role as indicated in the sections below.

WORKSHEET

Some questions that described the knowledge, skills and understanding that trainee teachers had which were related to how they learnt science were developed. The questions were constructed taking into account that in some certain instances, prior everyday knowledge and experiences are sometimes in agreement, partial agreement and in conflict (Ogunniyi & Hewson, n.d, p. 4). The rationale was to facilitate border crossing as well as collateral learning.

Furthermore, engagement of the trainee teachers was achieved by aligning them to the socio-cultural views of teaching and learning science (Carter, 2007; Leach & Scott, 2003). Indigenous science is a micro-culture of a particular community developed in response to their culture's needs to understand, predict, and influence its environment. Ways for achieving this were to predict, explain, explore, observe and explain (PEEOE) (Maselwa & Ngcoza, 2003). A practical activity was also set in which trainee teachers were asked to use their experiences and indigenous knowledge. Finally, there was a section on mind maps to be completed.

BRAINSTORMING SESSION

Brainstorming was used as "a tool of creative problem solving" (Isaksen & Dorval, 2011, p. 3). Its advantages are; criticism is withheld until a later stage, wild and unusual ideas are shared. More ideas are generated which can be useful and lastly combination and improvement is achieved. These properties of brainstorming paved way on how to incorporate prior everyday knowledge in teaching and learning of physical science concepts.

Participants were asked to list topics of their choices and indicate how they could incorporate prior everyday knowledge and experiences, modifying ideas they had seen in the worksheets. The topics with ideas were collected from all trainee teachers and discussed. Three groups, each with five members were involved in brainstorming observing the properties of brainstorming. The sixteenth trainee teacher was sick and so he could not participate.

DISCUSSION

Ideas developed during the above activities were discussed. To make this discussion a success, ways to improve enthusiasm were sought. Davis (1993) suggests that discussions with students can be a success if their enthusiasm, willingness, confidence and interest in the topic are promoted. In the context of this study, groups with five trainee teachers each were told to select their own topics which they had to brainstorm and teach taking into consideration the incorporation of IK and WS. This made them develop some insights into ways one could incorporate prior everyday knowledge and experience into classroom practices.

Each group of five trainee teachers was arranged in semi–circles and I facilitated discussions as I moved from one group to the next. The discussion approach was initially traditional, as the collaborator initiated, waited for response and finally evaluated. According to Zhang (2008), this strategy is known as the initiation, response and evaluation sequence. Diagnostic questions and answers were used. Since the intention was to see or find out trainee teachers' experiences, the discussion approach had to shift from being authoritative to a participative approach in line with PAR (see Section 3.2.3).

The non-authoritative discussion is also referred as the non-persuasive discussion approach. Trainee teachers were persuaded into the discussion. This revealed their personal experience in which knowledge is embedded. Davis (1993) consolidates by saying, "personal knowledge is the only source of legitimate knowledge" (p. 107).

In both non-authoritative and non-persuasive discussion approach, pause time was given to the trainee teachers. This enabled them to come up with answers which were more thoughtful and fitted the discussions. Black, Harrison, Lee, Marshal and William (2003) argue that a longer pause time will make students' responses not merely at a "superficial level" (p. 32).

3.5.3 EXECUTION OF IDEAS

3.5.3.1 LESSON PLAN

To implement the ideas learnt above, the trainee teachers did lesson plans in groups, by doing so they generated relevant data to be analysed and used later. McBridge and Schostak (1995) strengthen this by saying that data can take any form and can be obtained through the use of many artifacts.

According to Woods (2006), one of the limitations of a lesson plan as a data generating tool is that it does not provide an objective truth. However, if lesson plans are contextualized within the circumstances of their construction, they can provide us with information. Lesson plans, for example, do not show the cognitive processes taking place when one is incorporating experiences and indigenous knowledge. Instead of gathering data from the lesson plans, I decided to generate data from micro-teaching done through use of their data they had in the lesson plans.

3.5.3.2 OBSERVATION DURING MICRO-TEACHING

Observation was used as a technique to; “examine a situation as it is”, generates data related to how the trainee teachers incorporated experiences and indigenous knowledge while they were micro-teaching and use it in the research study (Leedy & Ormrod, 2010, p. 183). As a participant observer, I obtained “first hand experiences with participant” and recorded it as it was revealed (Creswell, 2003, p. 186).

Kenny and Hynes (2009) assert that micro-teaching is an active teaching practice and it “focuses on engagement, participation, empowerment and facilitation” (p. 3). In the context of this study, micro-teaching offered useful opportunities for trainee-teachers to develop effective and affective teaching strategies (Lemke, 2001). As they undertook this activity, an understanding of their perceptions and concerns of how they could use prior everyday knowledge and experiences was obtained.

According to Kenny and Hynes (2009), micro-teaching enables “peer observation and peer feedback” to take place (p. 3) and this provided a key element of academic development of the trainee teachers involved in this study. An insight into practice they used as they incorporated experience and indigenous knowledge was gained. However, micro-teaching alone is incomplete to generate data in a participatory action research.

Ways used to engage with experiences and indigenous knowledge was recorded as trainee teachers taught the physical science concepts. Frequency of use of the ideas of prior everyday knowledge and experiences were noted.

Bell (2010) states that observations “reveal characteristics of groups or individuals” (p. 109). While conducting these observations using an observation schedule, consideration of what McBridge and Schostak (1995) suggested was noted that observation is more than just looking and seeing. There was a need to represent a social event in a way which was detectable to the actors involved.

Verbal activities are easy to record. However, one can forget some certain actions or postures assumed by the presenters during micro-teaching. If they become numerous it becomes difficult to remember. This limitation of the observation method was eliminated by the use of audio-visual techniques used in this study and this technique is discussed below.

3.5.3.3 AUDIO –VISUAL TECHNIQUES

Data generated by audio – visual techniques can be observed with other participants and share "reality" (Creswell, 2003, p. 187). The use of this technique made possible the linking of visual movements and the documentation of kinesics. The recorded kinesics was triangulated with verbal data. McMillan and Schumacher (2006) posit that visual techniques, "document nonverbal behavior and communication provided a permanent record" (p. 359).

Each group of five trainee teachers had an opportunity to present during micro-teaching and was recorded. This enabled us to see how each of those actions taken by the presenters was aligned to the goals stated in this research.

According to Rosenstein (2002), audio – visual techniques have many advantages. In this study, it was used as a technique for observation and analysis at a later stage. Rosenstein (2002) further states that, "visual images capture the context as well as the action of an event; they can be interpreted by multiple viewers" (p. 2). This premised a critical partner to identify data which was not visible to the researcher.

Documentation of data was made possible through the use of audio – visual techniques. This was divided into; illustrative, historical and performance assessment purposes. In future, if a follow up is required, the recording could be retrieved and a chance to look into history would be made possible. To assess and give feedback, why one presentation was better than the other or the other was not up to standard, was achieved through the recordings which were analysed. Focus group interviews were used to complete this section as a follow-up.

3.5.3.4 FOCUS GROUP INTERVIEWS

Focus group interviews as a technique were used to gain experiential information and at the same time it allowed me to have "control over the line of questioning" (Creswell, 2003, p. 186). Also, the data from visual techniques served the purpose of data triangulation. Each group was interviewed taking into account that "some participants are likely to dominate the conversations" (Leedy & Ormrod, 2010, p. 152). The purpose of this was to follow up on data generated by the above techniques at the same time to direct trainee teachers on the use of experience and indigenous knowledge.

Focused questions were used to get some insights on how they engaged with the given knowledge sources. The nature and structure of the interview questions were in such a way that they had predetermined questions. Even though, some structured questions were used, there was an inclusion of open – ended type of questions. Woods (2006) suggests that it is wise for a researcher to embrace open – ended questions to permit the cropping up of data which might be very useful in the research. Such an approach enabled me to have data which covered both depth and breadth. Also, such an approach in participatory action research case study addressed some of the challenges associated with carrying out a qualitative research study. UNESCO (2005) points out that there is a need to address both breadth and depth before the analysis of data starts. Bell (2010) suggests that, "the more standardized the interview, the easier is it to aggregate and quantify the results" (p. 93).

3.6 ANALYSIS AND CRITIQUE

The data generated was analysed and subjected to critique with the trainee teachers. This gave me an opportunity to rectify any errors in the data.

McNiff(1997) states that there is a need to "take stock of what happens" (p. 10) when analyzing data. Modification of what was done was achieved by reflecting on what was done. Fine tuning of the exemplar lesson plans was made. This enabled the researcher to suggest a lesson which fits the research problem. However, there was a need to stick to the principles of PAR which are "collaborative and entail group work" (Smith, 2007, p. 4).

McNiff (1997) suggests that learning could be informed by actions implemented in the participatory action research case study. Analysis and critique of activities carried out, judged the worthiness, effectiveness, appropriateness of each and the outcomes of those activities.

3.7 DATA MANAGEMENT

A number of data generating techniques were used in this study. Thus, the resultant data generated for analysis was huge in a way that some proper data management skill was needed. McMillan and Schumacher (2006) confirm this as they state that qualitative research studies are characterized by generating large amounts of data. For a thorough data management the following was done.

Data was coded basing on the technique used. An example can be in the case of NNCBE/SC which refers to document analysis of the NNCBE with themes related to socio-cultural ideas. In a case in which the technique was used several times, a number was added to the acronym.

Solutions to questions in different techniques which sought information close to each other were grouped together and then analysed. The idea which they conveyed was then established. This facilitated identification of data at a time when it was required for analysis and making some informed decisions about analytical statements which I constructed.

Data from document analysis and other techniques used was in the form of texts. Other mechanisms of data gathering made me end up with data which was visual or audio.

Guided by the format of the data, it was stored on the desktop of a laptop. A reservoir of data in the form of a hardcopy was also kept. To avoid disappointment when data disappeared or got lost, some of the data was kept in three memory sticks.

3.8 DATA VALIDATION

On account of it looking into how trainee teachers can use experiences in indigenous knowledge it makes this research valid, Cohen, et el. (2010) reinforce by saying "validity might be addressed through type of participants approached …" (p. 133). In the case of this research study, the appropriate sample was selected and they are as indicated in the sections above and what they were asked to do is within their context of teacher empowerment. Also, some other parameters to judge the validity are explained below.

A natural environment was created to conduct the research – that is, in a way that was totally ordinary to the students and their peers. The nature of the research turned the researcher to be a participant, and this contributed to creating a natural environment where trainee teachers showed their exemplars of lesson plans and hence this addressed the issue of validity.

Woods (2006) strengthens this as he suggests that to address issues of validity, the research process needs to be devoid of interference and a longer time need to be spent doing the research. Finally, the deeper the penetration of the research, the more the representation of it might be claimed to be authentic.

Usage of a number of methods also contributed in addressing validity. Focus group interviews and other techniques were carried out with the students. These were designed to test observations and to increase the sample size of the study. This enabled the study to penetrate deeper into what they did to make it valid. Also, since the trainee teachers were representatives of what happens in a classroom where teaching and learning takes place, their actions represented what they were supposed to do in a real classroom situation.

To reduce errors caused by use of small samples, the number of students in the group doing micro-teaching was increased to sixteen but only fifteen participated because the other fell six. Best and Kahn (1998) argues by saying "One way a test maker can reduce the probability of measurement error and increase reliability is to increase the number of items in a test" (p. 283). The number of participants could not be increased since others were busy in other activities and secondly not to force those who were not willing to participate.

Triangulation in this research was addressed by the use of a number of data gathering techniques. A handful of techniques were used for the purpose of seeing if at any point data from one technique was congruent or aligned with data from another technique. Woods (2006) suggests that such type of triangulation could be achieved by the use of observation and interviews. Also, transcripts of documents they had used were given to participants to double check what they had indicated. The final stage consisted of watching the videos with the trainee teachers and listen to their comments.

3.9 RESEARCH ETHICS

Generating of research data is "personally intrusive" to some other people's life (McMillan & Schumacher, 2006, p. 254). To avoid pitfalls, confidentiality, anonymity and privacy were addressed, and the respect of participants was observed. Creswell (2003) suggests that there is a "need to respect the participants" (p. 64).

Furthermore, I was guided by Woods' (2006) suggestion that a researcher should not harm the reputation of the institution or the participants. It was important and of interest to leave the institution or the participants in a better rather than a worse condition as data gathering progressed. The research site and participants' identities were protected through the use of pseudonyms.

Ryan, Coughlin and Cronin (2007) clarify this as they pointed out that participants are known to the researcher and anonymity cannot be addressed properly if other issues are not considered. Assurance to the participants was given that their identities would not be revealed to the reader and the raw data gathered would not be released to any third party unless if permission is sought from them.

The audio – visual data generated might be of interest to other practitioners since it brings some ways of modifying their practices. The research would not use data obtained by other researchers but in cases where such need arose, permission would be sought from the research participants.

3.10 RESEARCH LIMITATIONS

Delayed techniques could have been used to gather data on how trainee teachers behave in a real classroom situation were a necessity. On account of the time given to carry out this research, I could not bring data from such techniques to relate to my questions. So, it limits this study. However, data from delayed interviews and observations could have assisted to see how the trainee teachers handled the acquired perspective under study with learners in a real classroom situation.

The research investigated issues related to culture and how science teaching and learning can benefit from such a socio-cultural perspective. Sometimes, issues related to culture are intrusive with other people. It is mostly likely that other data linked to sensitive cultural issues was shielded from the researcher to protect some cultural issues. So, if given an opportunity, I need to first break these cultural barriers.

3.11 CONCLUDING REMARKS

In this chapter, I outlined the research methodology, as well as the goals that have focused my study, and the educational values and philosophies that have inspired it.

In the next chapter I present and analyse data from baseline techniques.

CHAPTER FOUR

BASELINE DATA PRESENTATION AND ANALYSIS

> *Summaries of information cannot be considered completely impartial or objective. A fair summary, therefore, is relative; it depends upon purpose and person. You need to be sure not only that the research provided a fair description given the purpose of the study, but also that the description is fair for your purpose (Katzer, Cook & Crouch, 1991, p. 115).*

4.1 INTRODUCTION

In this chapter, I present the baseline data taking note of what is said in the above epigraph. The data presented in this chapter emerged from document analysis, a worksheet and the brainstorming session. A variety of data gathering techniques were used to gather baseline data so that they could complement one another as well as for triangulation purposes.

In the case of document analysis, the Namibian National Curriculum for Basic Education (NNCBE); extracts from documents on indigenous knowledge and socio-cultural perspective of teaching science and chapters on pressure from two physical science textbooks were analysed (see Section 4.2 and Appendices 1, 2.1 to 2.3, 3.1 and 3.2). This was followed by a worksheet that I had developed based on my view on how prior everyday knowledge and experiences could be incorporated during teaching and learning (see Section 4.3 and Appendix 4). Also, Kibirige and Van Rooyen (2006) confirm that stories related to science in the community are not sufficient enough to incorporate IK with WS. This worksheet was part of the unit of work that I developed as an exemplar to guide and scaffold trainee teachers. The brainstorming session will be presented in the last section (see Section 4.4 and Appendix 5).

4.2 DOCUMENT ANALYSIS

As mentioned in Chapter Three, three sets of documents were analysed in this study. The Namibian National Curriculum for Basic Education (NNCBE), extracts from three research papers discussing prior everyday knowledge and experiences analysed created a requirement to check what chapters on pressure from two physical science textbooks can be analysed for this study. One of these textbooks is kept in the library to be used by trainee teachers. The second one is a component of the official curriculum for learners in grade 9. It is also used by trainee teachers during lesson preparations as a reference. The data generated from these documents is highlighted in the sections which follow below.

4.2.1 EXPECTATIONS OF THE NNCBE

The NNCBE (2010) has its foundation on the experiences and achievements of the first cycle of Namibian curricula and syllabi that were introduced in the 1990s. Some of the categories it addresses are tabulated in Table 4.2.1 below. These were extracted from the section of teaching and learning (see Appendix 1) since it is the section where this study is centred.

TABLE 4.2.1 DATA FROM NNCBE

Number	Category	What emerged out
1.	Learner-centred NNCBE/LC	1. Appropriate learner-centred methods are used; positive discipline will ensure (p. 29). What? 2. Inclusive education is a learner-centred concept (p. 28). 3. Learner-centred classroom is a text-rich and a visually and tactile-rich learning environment (p. 27).
2.	Socio-cultural NNCBE/SC	1.We are situated in a natural and cultural context with which we interact, which affects us and which we draw upon to construct understanding (p. 29)
3.	Constructivism NNCBE/C	1. Learning is an individual and collaborative experience (p. 29). 2. Learners do not come to school like empty buckets to be filled with information (p. 29). 3. Co-operative and collaborative learning should be encouraged (p. 26). Learners learn best when they are actively involved in the learning process (p. 26).
4.	Practical work	1. Must understand the importance of mutual respect and equal sharing of

	NNCBE/PW	practical work (p. 28). 2. Developing the learners' familiarity with ease in using, the terminology of the subject and its discourse (p. 29). – 3. Improvise teaching and learning materials from easily available and inexpensive objects in the immediate environment, such as sticks, string, and bottle tops (p. 27). 4. Learners use simple scientific models, methods and skills to make scientific sense of the natural environment; and themselves (p. 25).
5.	Prior knowledge/ Experiences/ NNCBE/PE	1.If they are taught in a way which builds on what they already know and have experience, and relate new knowledge to the reality around them, they will learn that learning in school can be meaningful (p. 29). 2. Relate to, involve, and extend the learners' prior every day knowledge and experiences (p. 30). 3. Helping the learners realize what they might already know about something, or what ideas or questions they might have (p. 30).

The above data which was extracted from the section of teaching and learning of the NNCBE (2010) informs the study with the views of the NNCBE (2010). As indicated in Chapter Three, the views inform us to check and understand the theories on which they are anchored on (see Table 3.1 and Appendix 1). This takes us to the extracts of documents with socio-cultural perspective and on the teaching and learning of science and what they say about the categories which emerged above which they also discuss.

4.2.2 DOCUMENTS WITH PRIOR EVERYDAY KNOWLEDGE AND EXPERIENCES AND SOCIO-CULTURAL PERSPECTIVE OF TEACHING AND LEARNING SCIENCE

Elicitation and integration of learners' prior everyday knowledge, which eventually may form part of a communities' indigenous knowledge (IK), is advocated in the extracts of research papers that I analysed (see Appendix 2.1). The themes which emerged are tabulated in Table 4.2.2 below.

TABLE 4.2.2 DATA FROM DOCUMENTS WITH PRIOR EVERYDAY KNOWLEDGE AND SOCIOCULTURAL PERSPECTIVES OF TEACHING AND LEARNING SCIENCE

Number	Category	What emerged out
1.	Learner-centred DPEKE/LC	Teacher was centrally involved in developing and implementing the teaching approach (p. 98).
2.	Socio-cultural DPEKE/IKSC	Scientific knowledge is also socially validated by the scientific community (p. 91). Meaning making is portrayed as originating in social interactions between individuals, with cultural products that are available to trainee teachers in books and other sources (p. 93). Experiences of living on earth with the cultural image of the earth (p. 93). Product of science learning is cultural (p. 94). How scientific knowledge is talked into existence (p. 103).
3.	Constructivism DPEKE/IKC	Interaction with peers might result in a different learning pathway (p. 95).
4.	Practical work DPEKE/IKPW	Findings from analysis of video tapes of students engaged in lab work (p. 95). Experimental teaching approach indicated 20% better (p. 97). Language and other semiotic mechanisms provide the means for scientific ideas to be talked through (p. 99) Involves the development of models which provide a simplified account of phenomenon in the natural world (p. 99) Practical activity has replaced traditional approaches (p. 104).
5.	Prior everyday knowledge/ Experiences/ indigenous	Students' characteristic ways of thinking and talking about the natural world is potentially usefully in informing teaching (p. 96). Students' learning is influenced by their existing knowledge (p. 98). Way of talking about the natural world which is termed science (p.

	knowledge DPEKE/IKPEK/IK	99). I have used up all my energy (p. 100). Drinking through a straw often creates problem for learners (p. 102).

The sections that were analysed were those discussing about the socio-cultural perspective (see Section 2.3.1, 2.4 to 2.5.6) on teaching and learning science, prior everyday knowledge and experiences. This technique provided some suggestions on how indigenous knowledge and prior everyday knowledge could be incorporated in the teaching and learning of science.

The main categories are written down as indicated. As Table 3.1 suggests, it exposes indigenous knowledge and prior everyday knowledge to trainee teachers. This warranted the insider researcher and participants to find what was in the physical science textbooks used in order to align teaching and learning of physical science concepts to the socio-cultural perspective found in the documents analysed in the previous sections.

4.2.3 PHYSICAL SCIENCE TEXTBOOK 1

The concept of pressure was analysed in two physical science textbooks which trainee teachers use in the library, or use even when they are on school based studies (SBS) to plan their science lessons. The categories looked into in the previous documents were also looked for in the two textbooks. The data generated is tabulated in Table 4.2.3 below.

TABLE 4.2.3 DATA FROM PHYSICAL SCIENCE TEXTBOOK 1

Number	Category	What emerged out
1.	Learner - centred PST/LC	1. Find the area you stand on by counting the squares inside the outline of your shoes (p. 53). 2.Connect two syringes together as shown (p. 56) 3. Connect a manometer to a vacuum pump. (p. 60).
2.	Socio-cultural PST/SC	1.Find your weight from a balance or a scale (p. 53) 2. It cannot be the vacuum that is “sucking” the two halves together (p. 61).

3.	Constructivism PST/C	1. Using manometers (p. 59).
4.	Practical work PST/PW	1. Liquids transmit pressure (p. 56). 2. Using manometers (p. 59). 3. Does the air around exert a pressure on us (p. 60)? 4. How great is the pressure of air around us (p. 60)? 5. More evidence of the atmosphere's great pressure (p. 61). 6. How does the volume of trapped air change as the pressure on it is increased (p. 64)? 7. Looking for pattern is this complete?
5.	Prior everyday knowledge/ Experiences PST/PW	1.Cannot push your thumb into a table but with the same force you can push a drawing pin into wood (p. 53) 2. Water in a home aquarium is surprisingly heavy (p. 54). 3. Fill a bicycle pump with water (p. 55). 4. Car brakes (p. 58). 5.Take an old metal can, fit it with a cork and a tube (p. 60)
6	Gender issues PST/G	1. Diagrams of human beings used, do not in most cases bring a distinction between male and a female figure. In instances where this comes out a male figure is portrayed. 2. The apparatus or materials used in the diagrams are those used by males. 3.The text in the section does not include discussions which are related to those encountered by females but only those encountered by males
7	Readability PST/R	1. Simple language is used to motivate and bring interest in the readers. 2. The technical language is not italized, not bolded to let the reader take note of it and recognize it. 3. The formulae are written apart from the other text meant for discussion and in some instances are enclosed in boxes. 3. The technical language density is six words per page. 4. Legibility is addressed by writing the formulas separated from the rest of the text.

		The sentences are not of the complex type

Categories were checked and listed as indicated. Ideas related to what extent the first physical science text book supported practical curriculum by bringing views of learners as examples to promote socio-cultural perspective were examined. As seen from the table above, it brings a lot of experimental activities to be done. However, these practical activities are not linked to the activities in the learners' communities which they know and apply so that they could relate to western science with ease. Also themes related to gender and readability were checked.

4.2.4 PHYSICAL SCIENCE TEXTBOOK 2

The second physical science textbook analysed is a component of the official curriculum for grade 9. Trainee teachers find this textbook convenient since it is in the library and hence they use it for planning their lessons. On the other hand, learners use it during class activities in schools, for example, as a resource to do their homework and to familiarize themselves with western science concepts. It is in this textbook where the concepts of pressure appear for the first time. From grade 0 to grade 8 this concept of pressure is not there. The categories that emerged are tabulated in Table 4.2.4

TABLE 4.2.4 DATA FROM PHYSICAL SCIENCE TEXTBOOK 2

Number	**Category**	**What emerged out**
1	Learner centred PST/LC	1. Discuss in pairs. First and teacher will discuss with you as a class. 2.Do the following in groups
2	Socio-cultural PST/SC	1. Spoors of light animals are usually visibly deeper than those of heavy animals. 2. Fill in one syringe with air and another one with water. 3. Explain why it is possible to suck up liquids with a straw. 4. Explain the feeling on your thumb when you use a bicycle pump.
3	Practical work	1. Investigating relationship between pressure and surface area.

	PST/PW	2. Investigating liquid pressure at a particular level. 3. Investigating liquid pressure at different levels. 4. Investigating liquid pressure exerted by different liquids. 5.To show that liquids transmit pressure. 6. Demonstration of existence of atmospheric pressure. 7. Inverted jar experiment 8. Measuring gas pressure using a manometer 9. Measuring atmospheric pressure. 10.Effect of pressure on gas temperature
4	Prior everyday knowledge/ Experiences PST/PW	1. Common features in hydraulic brakes and a car brakes. 2. Scuba diver experiences great pressure. 3. Air let out of a tire is cold
5	Gender issues PST/G	1. Diagram of a lady wearing a pair of stiletto shoes demonstrating factors of pressure. 2. Diagram of a kitchen knife being used to cut meat. 3. Sharp knife has a cutting edge which is sharp. 4. Diagram of school girls demonstrating factors of pressure. 5. Diagram of a girl demonstrating how a manometer works. 6.Dents made on wooden floors when one moves over it with a pair of stiletto shoes 7. Protectors with large surface area placed on placed under the legs of pianos and other heavy furniture.
6	Readability PST/R	1. Simple language is used to motivate and bring interest in the readers. 2. The technical language is italized and in other instances it is bolded to let the reader take note of it and recognize it.

		3. The technical language density is two words per page. 4. Legibility is addressed by writing the formulas separated from the rest of the text. The sentences are not of the complex type.

The purpose of this technique was the same as in the previous section. Also, the categories obtained are similar as those obtained in the other textbook analysed. Such results, paved way to use the worksheet discussed below.

4.3 WORKSHEET

The worksheet (see Appendix 4) consisted of seven questions. Questions one to five sought to understand the relationship between prior everyday knowledge and experiences with western science. The sixth question was based on a practical activity to enable trainee teachers to link their indigenous knowledge (IK) and everyday experiences with the theorem of Bernoulli (see Section 2.6.3). Question seven aimed at establishing a relationship between explanations based on prior everyday knowledge and experiences and western science as well as themes related to Bernoulli's theorem (see Section 2.6.3).

Initially, trainee teachers were instructed to predict and explain the movement of the cans when air was blown in between them using a bicycle pump. This initial stage was chaotic until at a point when structured instructions were brought in order to engage them in exploration, observation and explain their findings. This directed the trainee teachers to analyse how the cans moved and why they moved in that direction.

In addition to this, the trainee teachers were required to construct mind maps of what emerged from the worksheet activities and thereafter relate that to the other physical phenomena presented in the worksheet. The aim was to apprentice trainee teachers and enculturate them in both WS and IK (Hodson & Hodson, 1998). The data obtained is indicated in Table 4.3 below.

TABLE 4.3 DATA FROM WORKSHEET

Questions WS/Q1-Q7	**Responses**	**Number**	
		Agreeing	**Disagreeing**
a.i.Where will we have the greatest pressure, above the roof or inside the hut?	Inside the roof.	**16**	**0**
ii.Why do you suggest that?	It is lighter outside where there is less pressure.	**16**	**0**
b.i.Where does the wind have greater velocity, above or inside the roof?	Outside the roof	**16**	**0**
b.ii.Why?	Air has free movement.	**16**	**0**
2. a. What does he need to do to have water from hosepipe have a greater range?	Place a finger or reduce diameter at the end.	**16**	**0**
b.What will happen to the parameters below as he performs that activity in 2.a?			
i. Pressure of water at the end.	Pressure increases.	**16**	**0**
ii.Velocity of water at the end.	Velocity decreases.	**16**	**0**
3. a.i.Where do you think there is greatest pressure when a bird is flying below or above the wings?	Below the wings	**16**	**0**
ii. Explain your answer.	Pressure pushes it upwards	**16**	**0**
iii.Give reason for your suggestion	Objects move to areas where there is less pressure.	**16**	**0**
b.i.Do you think a bird uses principles in pressure when flying?	Yes	**16**	**0**
ii. Explain why it uses pressure?	Where there is less pressure that is where it moves.	**16**	**0**
4.a.i.What will happen if he is very close to a fast moving train or truck?	He will be sucked into the track.	**16**	**0**
ii.Why does this happen?	Air between man and train is less.	**16**	**0**

b.i.Where is the greatest pressure?	Behind the man.	**16**	**0**
ii. Why do you suggest that?	Pressure behind remains constant, not disturbed.	**16**	**0**
5.a.i.At which point do these people cross the river?	Point A.	**16**	**0**
ii. Explain your answer.	There is less pressure.	**16**	**0**
iii.Does the velocity of water determines where people cross a river?	Yes	**16**	**0**
iv.Explain how it does?	People cross a river where the water is moving slowly.	**16**	**0**
6.a.i.Predict the direction of movement of cans when air is blown between them.	They move apart. Move towards each other.	**8** **8**	**8** **8**
ii.Explain your prediction.	Blown air pushes them aside. Less pressure between the cans.	**8** **8**	**8** **8**
b.i.Blow air between them, explores, observe and explain what happens?	They move towards each other.	**16**	**0**
ii.Suggest why that happens?	Pressure is less between the cans.	**16**	**0**
c.i.Where is more pressure?	External walls of the cans.	**16**	**0**
ii. Where is less pressure?	Between the cans.	**16**	**0**
iii. Why does displacement of cans occur?	Objects move to where there is less pressure.	**16**	**0**
7.a.i. Can explanations in question 6 be used to understand what is happening in question 1-5?	Yes	**16**	**0**
ii.Explain why this happens?	All phenomena are based on pressure.	**16**	**0**
b.i.Can experimental work above be represented by mind maps below?	Yes	**16**	**0**
ii. Suggest a reason for this.	It shows what concepts are involved and they are those seen in the experiment.	**16**	**0**
iii. Add more ideas in the mind	Partial vacuum between cans, high	**16**	**0**

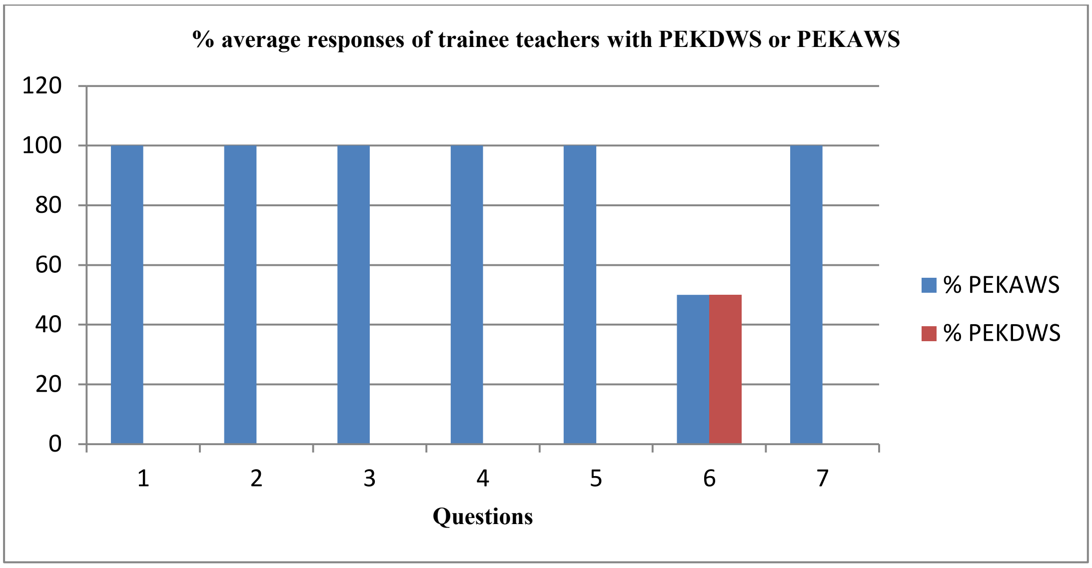
maps	velocity between cans, constant pressure outer walls		
c. What relationship exists between velocity and pressure?	If velocity is high then pressure is low	**16**	**0**

The numerical data from the last two columns was reorganized as in Table 4.3.1. The aim was to relate the questions answered to the percentage average of responses of trainee teachers whose prior everyday knowledge and experiences were (a) in agreement with western science (PEKAWS) (b) in disagreement with western science (PEKDWS) (see Bar Chart 4.1). The percentage is represented on the y (axis) and the question number is represented on the x (axis) in the diagrams below.

TABLE 4.3.1 NUMERICAL DATA FROM THE WORKSHEET

Question number	**% average of responses of trainee teachers whose prior everyday knowledge and experiences are ;**	
	in agreement with western science **(PEKAWS)**	in disagreement with western science (**PEKDWS**)
1	100	0
2	100	0
3	100	0
4	100	0
5	100	0
6	50	50
7	100	0

BAR CHART 4.1 ***GRAPHICAL REPRESENTATION OF RESPONSES OF TRAINEE TEACHERS***



The blue colour in Bar Chart 4.1 shows the percentage number of students whose prior everyday knowledge was in agreement with western science (PEKAWS) in each question. The red colour represents the percentage of students whose responses to question 1 to 7 using their prior everyday knowledge were in disagreement with western science (PEKDWS). Thereafter, the trainee teachers were engaged in a brainstorming session so that they could find ways to incorporate prior everyday knowledge and experiences into physical science concepts of their choice.

4.4 BRAINSTORMING SESSION

The brainstorming session was aimed at finding physical science concepts which could be incorporated with prior everyday knowledge and experiences with western science (WS) during teaching and learning (see Appendix 5). Three groups of trainee teachers with each having five members were involved during the brainstorming session. Here, they went further than what was in the worksheet. They suggested to; (a) bring models to illustrate physical science concepts they were to teach (b) extract the science from some cultural activities and use that science as the basis of teaching and learning western science. What emerged from each group is indicated in Table 4.4 below.

TABLE 4.4 DATA FROM THE BRAINSTORMING SESSION

Group	Concept selected	Narrowed concept	Categories that emerged			
			Constructivism WS/C	**Socio-cultural WS/SC**	**Learner-centered WS/LC**	**Practical work WS/PW**
1	Measurement	Length, mass and time	i . Participants show how community members measure: length; mass and time. ii. Participants measure each of those parameters using convectional instruments. ii. Teacher checks progress and ask those with ideas to assist those lagging.	i. One pace is equivalent to one metre. i. People measure weight using a balance at the hospital instead of mass. iii. Sun above the head is 12 noon.	i. Learner or teacher shows how a circular hut of the same diameter can be reproduced using two sticks and a rope. ii. Learner demonstrates how a shadow can be used to measure time. iii. Learner shows how two hands can be used to gauge the mass of a given object.	i. Teacher arranges a practical activity for each parameter to be learnt where peers can observe predict measure. ii. Record findings iii. Explain their findings.
2	Change of	Evaporation and	i. Participants show how the idea of evaporation is seen in the community as they look into water in pools; water in an earthenware pot becomes very cold compared to one in another	i. Water in the pool has gone down. ii. Water in a pool will not last during hot seasons iii. Hang a urine spoiled blanket on	i. Participants measure temperature of water in two containers made of different materials. ii. Participants answer questions on	i. Teacher arranges two containers and leaves them outside for use in the lesson. ii. Teacher arranges some apparatus

	state	sublimation	container of different material. ii. Participants engage with thermometers. iii. Use a chamber pot and a urine spoiled blanket to explain sublimation	the sun in the morning to remove smell of urine. iv. Chamber pot is emptied and left on the sun to prevent it from smelling.	the anomalies seen in the amount of water and the difference in temperature. iii. Participants answer the reason of putting urine spoiled materials on the sun. iv. Participants discuss possible explanation of how urine leaves a spoiled material through use of chemical equations.	to use to explain how evaporation occurs. iii . Teacher tasked participants to observe what remains in a chamber pot and comment if deposits present still smell after left on the sun.
3	Force	Frictional force	i. Participants are shown model and asked to explain changes taking place.	i. See-saw will always need replacement of the horizontal beam. ii. Cannot move fast in sandy area. iii. Use hard materials where materials are rubbing against	i. Peers answer questions on change in structure of the beams. i. Participants to look into advantages and disadvantages of frictional force- advantage (start fire) iii. Participants to discuss	i. Brings a model of a see-saw. ii. Peers asked to predict, explain, explore observe and explain why the central hole in the horizontal beam becomes wide.

				each other.	uses of frictional force	

In both groups, the physical science concepts selected were very broad and also were the prior everyday knowledge related to the trainee teachers as they brought and discussed them. However, on the understanding that their presentations needed only half an hour, they selected the best to fit the time duration. This scenario was also observed in the mind maps constructed. They accommodated the contingency issues which they expected the peers would ask as they engaged in more understanding of the concepts.

4.5 CONCLUDING REMARKS

In this chapter, I presented and analysed the baseline data. The documents analysed brought some suggestions on how to align the curriculum to the socio-cultural perspective of teaching and learning science. On the other hand, analysis from the textbooks suggests that there are still premises to align the texts presented for discussion to the socio-cultural perspective of teaching and learning science. This would then accommodate learners' prior everyday knowledge and experiences. The worksheet gave the trainee teachers some suggestions on how the incorporation of prior everyday knowledge and experiences with western science could be done. Finally, the brainstorming session aimed at seeing how the trainee teachers would incorporate prior everyday knowledge and experiences with western science.

In the next chapter I present data generated using the main data generation techniques, namely; microteaching, audio-visual techniques, observation and focus group interviews.

CHAPTER FIVE

MAIN DATA PRESENTATION AND ANALYSIS

> *Data reduction is not something separate from analysis. It is part of analysis. The researcher's decisions on which data chunks to code and which to pull out, which evolving story to tell are all analytic choices. Data reduction is a form of analysis that sharpens, sorts, focuses, discards, and organizes data in such a way that "final" conclusions can be drawn and verified (Miles & Huberman, 1994, p. 10).*

5.1 INTRODUCTION

In this chapter, I present data that was generated from the trainee teachers' micro-teaching, audio-visual techniques, observation and focus group interviews taking note that it is my decision to find which data "chunk to code and which to pull out, which evolving story to tell" (Miles & Huberman, 1994, p. 10). A variety of data gathering techniques were used so that they could complement one another as well as for triangulation purposes.

5.2 MICRO-TEACHING

For micro-teaching purposes, three lessons were taught by the trainee teachers (see Table 3.1). One after the other, the trainee teachers presented their topics to fifteen peers. Each presenter took about half an hour and thereafter gave the floor to the other presenters. The other lesson was conducted the following day by the presenter from group three and it also took about thirty minutes (see Appendices: 6.1; 6.2 and 7).

From the sixteen trainee teachers involved in the study, three groups were formed, and from each a presenter was selected to present a lesson. Their presentations formed the focus of the observation activity in the study. The choosing of the presenters was based on their gender, this sampling yielded two males and one female trainee teacher. The two male trainee teachers were those who had studied science for a longer period but only came to know the details of indigenous knowledge during the orientation stage of this research. The female trainee teacher had not studied a lot of science, but had more ideas of indigenous knowledge because her group had done a module on IK. I had taught her group before and had consolidated the concepts of IK during the orientation session. What follows in Table 5.1 is what emerged as the trainee teachers did micro-teaching.

TABLE 5.1 DATA FROM MICRO-TEACHING

Group	**Categories which emerged**				
	Establishment of learners' prior knowledge M/PEKEIK	**Matching learners' prior knowledge with relevant concepts M/LC**	**Pedagogical and technical content knowledge M/PCKPTCK**	**Engagement with prior knowledge M/EPEKEIK**	**Practical work or models of phenomena M/PMP**
G1	i. People in the community use body parts to enable them to know how long or wide a given distance is. i. Midday is determined by the position of a shadow or the sun. iii. Time of the day can be detected using sound produced by animals. iv. Compared the mass of two objects in his hand.	i. Same value of length is obtained when a tape measure or ruler is used. iii. Same value can be obtained when using body parts if the body parts are standardized. iv. Two peers were sent outside.	i. Placing of fingers on object to be measured. ii. A hut of the same diameter can be reproduced in any area if a person makes use of the same length to draw the locus of points in another area. iii. Estimating the time while the two peers are outside. iv. Discussion of differences noted..	i. Peers were asked to measure the length of tables in the classroom, some shapes he had brought drawn on his worksheet using their hands. i. Differences seen were discussed. iii. Peers were asked to state why many people opt to use a ruler or a tape measure. iv. Same value of length is obtained when a tape measure or ruler is used.	i..Peers recorded values obtained after measuring. ii. Use of tape measure. iii. Stop watches were used. iv. Spring balance used to measure objects.
	i. Orientation to peers is given. ii. Do you expect the quantity of water	i. Asked why anomalies were observed. ii. Drew an evaporation	i. The difference in volume pointed. ii. Explanation of concept of	i. In both, water is lost through the mouth of the container but also through the walls in an	i Peers observe containers placed outside the previous day.

G2	to be still one liter in both containers and if not why? iii. Plastic container lost more water. iii. Water requires heat energy to change from liquid to gas. iv. Brought a blanket and a chamber pot iv. Urea leaves the chamber and the blanket.	dish with water in it and a burner supplying heat. iii. Water evaporates first leaving behind solid urea. iv. Brought in some naphthalene	evaporation. iii. Urine is solid so it changes to gas. Iv. Vanishes into gas as the smell diffuses into the surrounding air.	earthenware pot. iii.Urea(s) $\rightarrow$ ammonia (g)+ carbon dioxide (g). iv. Naphthalene behaves like urea.	ii. Measuring the temperature of water in the two containers iii. Models of materials spoiled with urine. iv. Does the naphthalene ball remain the same size?
G3	i. Makes analysis of what happens when playing on a see-saw. ii. Why is it difficult to move faster in a sandy area? iii. Application of frictional force in facilitating motion to take place. iv. Explanation of why pair of shoes get worn out but one's feet are never taken to the cobra.	i. Rubbing causes the parts in contact to wear. ii. He discussed how brakes in a car function. iii. What happens to their clothes or object they sit on as they slide from a high point to a lower point on a hill. iv. Discussion on the hardening of the small finger in the foot or under it	i. Use of harder materials in the parts of a scotch cart which rub against each other. ii. Surface area in contact is greased. iii. Surface in contact is made smooth. iv. Assembling of materials brought is not a challenge v. Explanation of application of pressure is easy as he moves from how the community explains to how	i. What happens to the hole and the sharpness in the bars as they play? ii. Hole gets bigger and the vertical bar gets sharp. iii. Discussed possibility of locals knowing existence of copper ores as they used this metal for reducing friction before settlers came in. iv. Factors affecting friction are looked into as trainee	i. A model of a see-saw was brought into the classroom. ii. The edges of a shoe are analysed to see why they wear fast than the other parts of it. iii. Brought four laminas in which one pair is smooth and the other is rough and then move then over each other

	v. Why a hoe used for tilling in a sandy soil without stones gets sharper as one keeps on using it.	due to friction.	western science explains	teachers looked into; wearing of parts of a shoe.	

The presentations from the three different presenters engaged the peers. Each presenter asked questions such as, "*is this science extract from the community matching with what we read in our science textbooks about the physical phenomenon*?" to their peers. Follow-up questions were also used throughout in their presentations. This could be attributed to the fact that the presenter knew what knowledge the other lacked to answer since in each case he used prior everyday knowledge as a base to explain and understand western science.

As the above lessons were presented, I observed them together with a critical partner. The data in the following section reveals what emerged from this technique.

5.3 CRITICAL PARTNER'S AND MY OBSERVATIONS

The invited critical partner did participatory observation (see Section 3.5.13). She contributed and witnessed data generation during this participatory action research process. The data she generated as well as the data I generated while observing micro-teaching sessions is recorded in Table 5.2 below.

TABLE 5.2 DATA FROM CRITICAL PARTNER'S AND MY OBSERVATIONS

Group	Categories which emerged			
	Relevance of prior knowledge used CPO/PEKEIK	**Challenges CPO/Chall**	**Relate to western science CPO/WS**	**Practical work or models used CPO/PWM**
	i. Measurement of time is done using; body parts, ropes and comparisons with known values and these are related to the topic of length	i. Delay in bringing apparatus for measuring from the storeroom but still went to use cellphones when they were	i. Diagnostic questions used made it possible to relate IK to western science. ii. Difference of value obtained when using prior	i. Each quantity discussed was linked to an experimental work. ii. Peers recorded lengths measured. iii. Peers observed and analysed the readings on

G1	measurement. ii. Shadows and sound of animals are used to measure time and are connected to time measurement iii. Idea of weight is brought in and is relevant to mass as community talk of weight as mass	discussing time. ii. Non-functional apparatus delayed measurement of time but still went to engage with those which were working	knowledge made the linking of WS and IK possible. iii. Open and closed ended questions provided the bridge for the two knowledge sources	the apparatus they were using
G2	i. Constructed knowledge on their own since he asked them questions. i. Respondents answered questions.	i. Shy as he brought the chamber pot and a model of a urine spoiled blanket but later happy when the peers agreed with him.	i. Used diagnostic questions. ii. Do Naphthalene balls behave like urine?	i. Use of an earthenware pot. ii. Observation done, thermometer used to measure and record findings. ii. Drew models of beaker with water and a Bunsen burner underneath. iv. Brought naphthalene balls
G3	i. Peers were in a position to discuss even though it was very short. ii. More questions asked revealed that she was in the right direction since it ignited the class discussion	i. Insufficient content knowledge nearly made the class discussion come to an end.	i. Application of frictional force in the community was discussed.	1. Model of see-saw brought into the classroom. ii. Drew model of brake system of a car.

Trainee teachers quickly detected faulty balances brought by the laboratory assistant before the lesson started. They indicated this by using sign language used in the community when they talk of mass. In a lesson presented by group two they were all eager to know why water in an earthenware pot became colder than one in a plastic container. Two containers with one thermometer each were placed outside the classroom the previous day.

In a presentation made by group three, the critical partner had to intervene when she observed that answering questions on advantages and disadvantages of frictional force was not answered properly because of the language barrier which the presenter had. Instead, she restructured the questions and stated them to the class.

At the end of these three presentations, I asked my critical partner which of the three could be used as an exemplar lesson in which the group successfully incorporated IK and WS. She said,

> *I cannot tell which one is the best. Each one of them have ideas well fitting into what they intended to teach. All of them are all good since they made the participants to construct knowledge.*

5.4 AUDIO-VISUAL TECHNIQUES

Data was also generated using audio-visual techniques when the trainee teachers were using the worksheets and during micro-teaching. All that data is given in the two sections below and Tables 5.3.1 and 5.3.2 are used respectively.

5.4.1 DATA FROM AUDIO-VISUAL TECHNIQUES WHILE USING A WORKSHEET

When verbal instructions were given to predict, explain, explore, observe and explain (PEEOE) (see Section 2.6.2) while conducting a practical activity, the data which emerged is in the first two columns of the table below. The PEEOE approach was encouraged during the practical activities. Thereafter, all trainee teachers went into two groups and started to blow air between the two cans. Initially, they did not do it successfully but with further instructions from me (the researcher) and critical partner they managed. Their observations and explanations have been recorded in the last two columns of Table 5.3.1.

TABLE 5.3.1 DATA FROM AUDIO-VISUAL TECHNIQUES WHILE USING A WORKSHEET

Prediction **AVT/P**	**Explanation** **AVT/E**	**Exploration AVT/AT**	**Observation** **AVT/O**	**Explanation** **AVT/E**
i. Cans will move towards the centre as we pass air between the two. ii. They will move away from each other. iii. No, the palms of hands are moved Apart.	i. The air which we blow between the cans will force them together. ii. The air we blow is like a force which will push the cans apart. iii. No, you push air away so there is a region of low pressure, so the cans will move towards each other.	i. Air is blown between the two cans continuously. ii. Stop blowing and wait for the teacher to explain further iii. The bicycle pump is pushed down slowly while others lean forward and observe. iv. The action is repeated and they arrive at a conclusion as they discuss about the movement.	i. In both groups they all agree that the cans move towards each other as air is blown through the space between them	i. The principle which apply in a truck and a passenger is also applying here. ii. There is more pressure on the inner walls where air pumped from the bicycle pump passes through and pushes the can.

Trainee teachers were asked to group themselves and use apparatus on their tables before completing the worksheets. I observed them beckoning and calling,

> "*come in this group where I am, I show you how in our village we explain these occurrences presented in the worksheet which are all about natural phenomena we see taking place in our community*".

For these explanations see Appendix 4.

5.4.2 DATA FROM AUDIO-VISUAL TECHNIQUES DURING MICRO-TEACHING

This section presents data which was generated using audio-visual techniques during micro-teaching by the trainee teachers. The data which emerged is recorded in Table 5.3.2 below.

TABLE 5.3.2 DATA FROM AUDIO-VISUAL TECHNIQUES WHILE USING A WORKSHEET

<table>
<tr><th rowspan="2">Group</th><th colspan="3">Categories that emerged</th></tr>
<tr><th>Prior knowledge AVT/PK</th><th>Challenges AVT/Chall</th><th>Practical work AVT/PW</th></tr>
<tr><td>1</td><td>i. Explains how congruent circles can be drawn in the community.

ii. Presenter used hands as he showed peers how people in the community use body parts to compare mass of fish sold to other members of the community.</td><td>i. The chalk board is only used sometimes since most of the time they are discussing.</td><td>i. Many handed their hands up when he was asking questions related to the practical they were- doing.

ii. Those with non-working instruments went to grab those which others had used which were working and started measuring the mass.

iii. Normally, they do work pairing according to friendship but in these practical activities they were mingled.</td></tr>
<tr><td>2</td><td>i. Most students laughed as he brought a chamber pot and a blanket which he presented as urine spoiled.

ii. In the case of evaporation, one trainee teacher explained further that an earthenware pot has similar properties to a gourd used as a container to store water in the community.</td><td>i. Chalk board used only when he explained the equation of decomposition of urea as it sublimes.</td><td>i. Use of naphthalene balls made the trainee teachers enquire more.

ii. A sketch diagram of how evaporation is viewed in western science was drawn.

iii. Everyone wanted to take the readings on the thermometer.

iv. Graduated beaker by the presenters' table</td></tr>
<tr><td>3</td><td>i. Presenter chose the last minute but she still managed to make the others talk about frictional force in a see-saw and later its uses and its limitations.</td><td>i. She never used the chalk board.</td><td>I. Only a model was brought into the classroom.</td></tr>
</table>

Various models used by community members were brought by groups one to three. Some of the models were not used since the time was not enough to discuss all of them. However, all models and suggestions brought are used in communities and they have science embedded in them which could be extracted for teaching and learning science.

5.5 FOCUS GROUP INTERVIEWS

This was the last data gathering technique used during this participatory action research process. Data was generated using three groups which presented the lessons during micro-teaching. Five questions were asked from each focus group. However, in addition to the questions, some follow-up questions were asked. The data generated was grouped into similar themes and then tabulated in Table 5.4 below.

TABLE 5.4 DATA FROM FOCUS GROUP INTERVIEW

Number	Question	Responses FGI/R1 –R5
1.a	What evidence is there that suggests that the use of prior everyday knowledge, experiences and explanations of natural phenomena can be of importance or not in the teaching and learning of physical science?	i. Most of us managed to do an activity in the classroom. ii. It made it possible that practical work was brought in without ourselves aware that we are to learn using the practical activity approach. iii. Most of us want to give our views since what he brought in is known by all of us. iv. We gave our views in which most of them were used as a tool to explain the phenomenon and skills we have on it made it possible to handle the practical activity.
b	What challenges can a teacher encounter if : i. He uses learners' prior everyday knowledge in a class?	i. If the classroom is made up of learners from different cultural background then each learner's prior knowledge must be used for that particular learner. ii. If the teacher is not native to that community it becomes difficult for him to engage in the learners prior knowledge since he needs to first source it from the community members.
	i. He does not use it?	i. Knowledge presented to them appears abstract. ii. Engagement of learners is not achieved. iii. It will never be learner centred.
c	How can a teacher overcome those challenges you have mentioned in i and ii?	i. Must include every learner's prior knowledge. ii. Must probe the prior knowledge from community members. iii. I think we must make use of whatever knowledge is there in the community to improve understanding since

		there is more engagement of participants.
2.a	State examples of prior everyday knowledge and experiences you brought and used during the presentation of the topic you selected.	i. The use of body parts to measure length. ii. The use of shadows, animal sound and even position of the sun to measure time by community members. iii. How an earthenware pot cools water as it evaporates. iv. The use of the concept of sublimation by community members as they allow urine on a blanket or a chamber pot to sublime as they hang these materials outdoors. v. The use of a model of a see-saw used by community members as they are in the playing fields.
a.i	Were the prior knowledge and experiences relevant to the topics you imparted?	i. They were very much useful
a.ii	Give a reason for your answer.	i. Ideas learnt become concrete and made peers participate.
b.i	Can your prior everyday knowledge and experiences be different from that of your learners	i. It can be very much different and is manifested in societies which are culturally diverse.
b.ii	What will you do if your experiences differ from those of your learners?	i. There is a need to discuss prior knowledge and experience of each learner in the classroom.
3.a	What evidence do you have which suggest that the topic you presented had relevant examples of prior everyday knowledge and experiences?	i. Examples of prior knowledge selected were a perfect fit of how the same concepts selected are explained in western science.
b.	At which stage during presentation of the lesson do you think prior knowledge and experiences clearly illuminated physical science concept you selected and presented?	i. At the point where a practical related activity was introduced and at the time when we were explaining how those concepts are discussed and seen in the community.
4.	Can a physical science lesson be designed using prior knowledge and experiences?	i. Did not see anything wrong since when it was introduced it made all of us see what we are talking of and we were all involved.
5.	What challenges are encountered if prior knowledge and experiences are used in designing physical science lessons?	i. Disadvantages those whose prior knowledge is not used. ii. Difficult to use in an urban school where learners are from different cultural groups.

		iii. If prior knowledge and experience explanation of the phenomena are different from western science then the teacher will need to scaffold.

To follow up the data generated by all the instruments and also find the trainee teachers' perceptions on incorporating prior everyday knowledge and experiences in teaching and learning physical science concepts, they were put in those groups they were in during lesson preparation and interviewed. Answers obtained did not come from one trainee teacher. Each participant had his/her view about the incorporation of prior everyday knowledge with western science. Each response from each trainee teacher was placed into a category it fitted in as shown above.

5.6 CONCLUDING REMARKS

This chapter presented the data that emerged from the micro-teaching, critical partner's and my observations, audio-visual techniques during microteaching and orientation while using a worksheet as well as from focus group interviews. The tabulated data shows clearly that trainee teachers endeavoured to use prior everyday knowledge and experiences related to the phenomena they presented. It was also clear that peers were engaged in scientific discourses through activities such as practical activities and models.

The different themes and findings that emerged from these data sources are further discussed in Chapter Six.

CHAPTER SIX

INTERPRETATION AND DISCUSSION OF FINDINGS

> *Analysis is a breaking up, separating, or disassembling of research materials into pieces, parts, elements, or units. With facts broken down into manageable pieces the researcher sorts and sifts them, searching for types, classes, sequences, processes, patterns or wholes. The aim of this process is to assemble or reconstruct (Jorgensen, 1989, p. 107).*

6.1 INTRODUCTION

In this chapter, themes that emerged from Chapter Four and Five which have been made manageable as stated in the epigraph are interpreted and discussed. The three sets of documents analysed were the NNCBE (2010), three extracts from research papers where one of this paper brought a concept of pressure (which is the focus of this study) and others brought the socio-cultural perspective of teaching and learning science. The remaining set of documents was sections on pressure from two physical science textbooks.

After the analysis of data from the above documents, data from an exemplar worksheet and then brainstorming session were analysed. All the above generated data formed the baseline data for this study.

I also analysed data generated from micro-teaching, critical partners' observation during the implementation of the exemplar worksheet and during micro-teaching and audio-visual techniques. In addition to this, focus group interviews with the trainee teachers also formed part of the data. All these were aimed at finding the themes which came out if prior everyday knowledge and experiences were incorporated into the teaching and learning of science concepts.

The categories that came up were tabulated and collated to constitute some themes. The themes were identified by checking for word repetition, prior everyday knowledge categories and key words in context techniques. The themes numbered below enabled me to construct some analytical statements. These are discussed with reference to the relevant literature and aligned to the research questions.

6.2 THEMES THAT EMERGED FROM ANALYSED DATA WERE:

(a) Enablers empower trainee teachers with pedagogical skills while constraints incapacitate them.

(b) Practical activities or models can be used to incorporate indigenous knowledge with western science and address learner-centredness.

(c) When prior everyday knowledge of participants is the same with what western science explains, it is possible to relate the two.

(d) Documenting science related activities and explanations in the community allow one to see their importance in science teaching.

(e) Socio-cultural views in science teaching allow incorporation of western science.

(f) Relevance of incorporating prior knowledge in teaching and learning is seen in curriculum broadening, empowering trainee teachers with pedagogical skills and addressing learner-centredness.

To come up with analytical statements below from the above themes, a claim was made and then supported by factual evidence. These are tabulated in Table 6.1 together with data source from where they emerged from and research questions they are related to.

TABLE 6.1 RELATIONSHIP BETWEEN DATA SOURCE, ANALYTICAL STATEMENT AND RESEARCH QUESTION

Data source	Analytical statement	Research questions
Document analysis: NNCBE, three portions from some research papers which discuss on prior everyday knowledge and socio-cultural perspectives on science and two chapters on pressure from two physical science textbooks	Enablers and constraints influence teaching of science.	What factors enable or constrain the teaching of physical science concepts in the curriculum?
Document analysis: chapters on pressure in physical science textbooks; a worksheet,	Relevant examples of prior everyday knowledge to	How can an exemplar worksheet on pressure facilitate trainee teachers' understanding

brainstorming session and observations from insider researcher and critical partner	illuminate physical science concepts promote learner-centredness	of incorporation of prior everyday knowledge in physical science concepts?
Brainstorming session, micro-teaching observation from insider researcher and critical partner	Trainee teachers have an abundant storage of prior everyday knowledge	How do trainee teachers identify and design physical science topics with relevant examples of prior everyday knowledge?
Brainstorming session, micro-teaching and observation from insider researcher and critical partner	Documenting socio-cultural views on science promotes use of cultural artifacts models	What ways do trainee teachers use to identify examples of prior everyday knowledge which learners have?
Worksheet, brainstorming session, micro-teaching and observation from insider researcher and critical partner	Curriculum broadening, empowering trainee teachers with pedagogical skills manifest relevance of incorporating indigenous knowledge.	What is the relevance of the prior everyday knowledge associated with physical science concepts that trainee teachers come with to science classrooms?
Focus group interviews, observations from insider researcher and critical partner audio-visual techniques	Prior everyday knowledge is specific as it looks into a specific socio-cultural view. .	What challenges do trainee teachers encounter in designing and delivering physical science concepts incorporated with prior everyday knowledge?

6.3 ANALYTICAL STATEMENTS

The discussion of the above analytical statements was done by first explaining the analytical statements which emanated from the baseline data thereafter those from the main data. The discussion will facilitate the writing of recommendations in Chapter Seven.

6.4 DISCUSSION OF FINDINGS: ANALYTICAL STATEMENTS EMANATING FROM THE BASELINE DATA

6.4.1 ANALYTICAL STATEMENT 1: ENABLERS AND CONSTRAINTS INFLUENCE TEACHING OF SCIENCE

The use of a variety of knowledge sources is what the NNCBE (2010) encourages teachers to do (see Section 2.2). The benefit of using a variety of knowledge sources lies in making learner-centered approaches a success (see Section 1.2.1). The knowledge that learners bring into the classroom make the teachers non–authoritative but active, work as guides, initiators, observers, advisor and facilitator of learners' learning activities (Nyambe, 2008, p. 16).

Some trainee teachers indicated that their experiences as science learners were that they understood science concepts each time they related the concept the teacher discussed with them to how their communities explained it (Roschelle, 1995; Oloruntegbe & Ikpe, 2011). If misconceptions in the way they have learnt the physical science concept in question exist, ways were created to find why they existed and then this created premises to understand concepts better. They said this was on account of them being able to engage in cognitive activities which always led them to answer why western science perceived it that way. However, they indicated that they did not bring experiences of their learners hence constrain the teaching and learning of science.

That is, the process of linking the two enabled them to reinforce science knowledge they had constructed before and then reconstructed it in line with what the teacher would have said. From this, one can say that the knowledge sources enable the trainee teachers to facilitate understanding since they can work in "harmonious dualism" (Ogunniyi, n.d., p. 4) to promote learner-centred teaching and learning. Basing on IK property of being fallible (see Section 2.5.1), it needs another universal knowledge system to use as a pillar. Western science (WS) meets this requirement; hence the two knowledge systems can work together.

So, if learner-centredness is used properly, it enables participants to be engaged in the process of teaching and learning since it provides a rich learning environment (see Table 5.3.1).

It should be borne in mind also that each community has its rich source of indigenous knowledge which it uses to interpret the natural phenomena of the environment of which natural science studies (see Section 2.5). This is what Aikenhead and Ogawa (2007) refer to as a community's "indigenous ways of living in nature" (p. 556). In some instances, the explanations to these occurrences using indigenous knowledge as prior knowledge are very much the same as in western science but some explanations are not.

This was seen, for example, in the worksheet (see Section 4.3) where trainee teachers agreed that the phenomena of pressure presented could be explained using principles of pressure which surfaced when a practical activity was used to relate western science to their indigenous knowledge. Therefore, can the use of indigenous knowledge not act as an enabler of teaching and learning of science?

Learner-centred approaches entail the participation of learners in constructing knowledge (see Section 1.2.1). This is a view which the document with prior everyday knowledge and experiences also revealed (see Section 4.2.2 and Appendix 2.2).Thus, teachers need to be centrally involved in developing and implementing the teaching approach. The physical science textbooks analysed cannot alone allow teachers to achieve learner-centredness since in the analysis done, it became clear that the starting point is prior everyday knowledge but it is not relevant to the participants since it is not within their context. Hence, to some extent it then acts as a constraint (see Section 2.6.2).

Likewise, context is socially constructed basing on what is done in the community (Lemke, 2001; Carter, 2007; Kelly, Chen & Crawford, 1998) see Appendices 2.1 to 2.4. So, examples used in the physical science textbooks that were analysed in this study are exotic but not indigenous to trainee teacher see Appendices 3.1 and 3.2. That is, they have the potential to constrain learning rather than enabling it. There were only a few cases that were used to bring learners' experiences into the classroom. The author of one of the physical science textbooks analysed discusses the idea of the spoors of wild animals. Spoors of big animals penetrate deeper into the soil if they are of small surface area. If wide, they penetrate less and are difficult to track. Instead of scientific concepts appearing concrete in the minds of the learners, they become very much abstract if such ideas are not taken into account.

According to Posner, Striker, Hewson and Gertzog (1981, p. 217), engagement with all knowledge sources makes concepts to be learnt "concrete, relevant, intelligible, and plausible" (see Section 2.5.4). Furthermore, in the community scientific knowledge is talked into existence as revealed in the extract from Leach and Scott (2003) see Appendix 2.3. Also, Appendices 5.3 to 6.3 from audio visual techniques and brainstorming highlight this idea. Therefore, if the scientific social jargon in the community is neglected this might constrain the teaching and learning of science.

Sometimes, science teachers view the acquisition of science concepts as only possible through the use of sensory organs and this can act as a constraint since this distances teaching and learning of science from participants' culture. Carter (2007) suggests that science is a product of culture. Aikenhead (2007) has the same view too indicating that both western science and indigenous knowledge are culture laden even though western science pretends not to be. Teaching and learning science without taking cognizance of culture is a socio-cultural genocide (Kelly, Chen & Crawford, 1998, p. 27). In the context of this study, its recognition made trainee teachers bring the pedagogical strategies which facilitated assimilation of science concepts (see Section 2.3.1 and Appendix 2).

Seldom, in the physical science textbooks analysed, concepts in pressure are introduced using some certain scientific jargon which the author employed as he showed how mass and weight are talked about in the community. He seems to have deliberately written "*Find your weight from a balance or a scale" and "vacuum sucks the two halves of the hemisphere together*". A balance measures the mass of matter whereas weight is measured using a force meter. He might have discussed it to seek clarification using the socio-cultural perspective on how science is constructed in the community. This shows that everyday spoken language could have a negative impact on scientific understanding.

All this was done to have a starting point where the participants are aware of what they are discussing and scaffold them to do border crossing (see Section 2.6.2). Ogunniyi (n.d.) suggests that border crossing is "a learning experience brought about by relating one worldview to another" (p. 8). Such pedagogical approaches enliven the teaching and learning of science concepts as has been evidenced in this study. For example, when the trainee teachers presented the concept of measurement to their peers, they were interested as to why different measured values were obtained when one uses methods used by community members to measure given lengths yet western science brings only one same value. One of the trainee teacher responded that western science also brings different values when measuring. For one to strike precision, one needs to carry out at least three measurements and thereafter calculate the average.

So, there are some factors which might constrain learning. On the other hand, there are also those which enable the incorporation of a variety of knowledge sources to facilitate science knowledge construction.

6.4.2 ANALYTICAL STATEMENT 2: RELEVANT EXAMPLES OF PRIOR EVERYDAY KNOWLEDGE TO ILLUMINATE PHYSICAL SCIENCE CONCEPTS PROMOTE LEARNER-CENTRED APPROACHES

The analysis of the second physical science textbook used in schools revealed that the author still believes in what Mwetulundila (2007) suggests that IK is labeled as informal science brought by girls (see Section 2.5.3). Science brought from home is regarded as informal science hence it is not considered, yet it informs the existing knowledge of participants. This is also the view which the trainee teachers had before they engaged with the worksheet I gave them.

Prior knowledge considered is based on content related to pressure but from other sections in western science. Of course, it is a good gesture forward. It must be discussed after discussing science from the community that is after relating to what the participants brought from home. The exotic nature of the prior knowledge used in the section on pressure, in my view, prevents learners from learning in a learner-centred way. That is, the section of this textbook on pressure distanced the learners' indigenous knowledge from western science as pointed out by Odora-Hoppers (2001) (see Section 2.5.4).

The distancing of IK which could be used as prior knowledge when teaching WS can create a condition in which some lessons are designed with socio-cultural views, but trainee teachers do this with fear since they lack the skills. This result in trainee teachers executing lessons which are not learner-centred. In other words, internal matters of teachers' qualifications constrain the implementation of learner-centred teaching and learning (Kasanda, et al., 2005) (see Section 1.2.1). Learners might end up not participating and others withdrawing from the teaching and learning process. The implication is, engagement is not possible if prior everyday knowledge and experiences are neglected. This has created a condition in which enrollment in science related subject is very low as they see this subject as very abstract (Oloruntegbe & Ikpe, 2011) (see Section 2.4).Students or learners end up not establishing a clear linkage between science concepts learned at school and science concepts embedded in their everyday experiences, despite daily exposure in both contexts.

In this study, the two textbooks analysed showed that what only needs to be taught and learnt is western science since indigenous science has no place in the curriculum as suggested by Shizha (2006) (see Section 2.5.3). This is evident from the type of questioning approaches which of course are of the right type, diagnostic in nature with a mixture of open ended and closed ended questions (see Section 4.2.3 and Table 4.2.4). However, the passages in the textbooks still could not engage learners' home-learning experiences. Rennie (2011) suggests that relating western science to home learning experiences will make the process of teaching and learning of science relevant. If not relevant to the participants, teaching and learning is like "banking" of knowledge which (Freire, 1999) discourages since it does not promote learner-centredness (see Section 2.5.3).

However, some passages in the textbook used by learners at school which the trainee teachers also used outline ideas which bear elements of learners' prior everyday knowledge. For example, "Explain your experience when you push on a hard surface with a sharp object and when you use a blunt object" (see Table 4.2.4). The author puts his pedagogical strategies into practice; however, such statements are few.

The worksheet revealed that most of the explanations used in the community as trainee teachers explained natural phenomena were similar to how they were explained by western science. According to the responses from questions one to five and seven in the worksheet, trainee teachers agreed that their prior everyday knowledge and experiences were in line with what western science says. However, there was an exceptional case in number six where eight of the trainee teachers were in agreement and the other eight disagreeing (see Table 4.3).

No section of the worksheet was left blank as they were answering. A deduction which could be drawn from this is that trainee teachers do have the science language (community science jargon) as revealed in Table 4.2.2 to use when asked to relate science concepts using their indigenous knowledge as prior knowledge and experiences. When asked to make mind maps, a number of science concepts emerged and could not have come up if they were asked authoritatively, that is, in a teacher-centred manner (see Table 4.2.4).

The relationship between pressure and square of the velocity of a fluid were seen to follow a trend. Using the predict, explain, explore, observe and explain (PEEOE) approaches as proposed by Maselwa and Ngcoza (2003), the trainee teachers found that the natural phenomena they explained using their indigenous knowledge and experiences could still be explained using what they found during the hands-on practical activities. The worksheet activities thus enabled the trainee teachers to put their hypothesis, change them into theory since they ended up describing Bernoulli's theory as Schwartz (2007) suggests (see Section 2.6.2).

So, after the brainstorming session, trainee teachers brought relevant topics of physical science concepts incorporated with prior everyday knowledge by first;

- checking the topics in the textbook, narrowed the topic selected for it to be taught within a specified duration of time;
- find explanations in the community about the topics selected;
- look at the gaps which excluded their explanations from the community;
- record them down and identify activities in the community which illustrate the phenomena; and
- collect the materials which are used with it to facilitate a practical activity.

Finally, they presented their ideas.

6.4.3 ANALYTICAL STATEMENT 3: TRAINEE TEACHERS HAVE AN ABUNDANT STORAGE OF PRIOR EVERYDAY KNOWLEDGE

While brainstorming, trainee teachers revealed that each physical science concept selected for presentation had some substantial amount of indigenous knowledge which could be used to explain it (see Table 4.4). A typical case was that on the explanation of the concept of sublimation using scientific jargon in the community and it was found to be in line with what Leach and Scott (2003, p. 99) suggest (see Appendix 2).

Models were selected in cases where trainee teachers presented;

- the idea of a model of a urine spoiled blanket or a chamber pot as examples of where sublimation takes place;
- two pegs joined with a rope as a model of an instrument used for measuring length; and

- the model of a see-saw to illustrate and study frictional force and as a phenomena which can be used to start fire.

The idea of constructivist theory (see Section 2.3.2) which encourages science educators to be sensitive toward and attentive to the learners' previous constructions also came up since in each session of brainstorming using the three groups many themes related to constructivism emerged as seen in Table 4.4. As a matter of fact, all groups had ideas which portrayed some elements of constructivist teaching and learning as evidenced by the inclusion of practical activities which are also in line with the same theory of constructivism.

The analysis of themes which emerged from the brainstorming session brings the analysis of base line data to the end. What follows now is an analysis of themes which emerged from the main data and analytical statements constructed out of these themes.

6.5 MAIN DATA

Data generated from the main data gathering techniques has been presented in Chapter Five. I now discuss the analytical statements which emerged from these data gathering techniques and such analytical statements are presented in the same order as they have been used in Chapter Three and Chapter Five.

6.5.1 ANALYTICAL STATEMENT 4: DOCUMENTING SOCIO-CULTURAL VIEWS IN SCIENCE PROMOTES USE OF CULTURAL ARTIFACTS MODELS

Micro-teaching offered useful opportunities for trainee-teachers to develop effective and affective teaching strategies (see Section 3.5.3.2). As suggested by Kenny and Hynes (2009),an understanding of the trainee teachers' perceptions and concerns of how they could use prior everyday knowledge and experiences was obtained. Prior everyday knowledge of peers was solicited and discussed. Thereafter, practical activities and/or models were brought to relate this type of knowledge to western science. Diagnostic, open-ended and closed-ended types of questions were used to bridge the gap between these two knowledge systems. This resonates with Rennie's (2011) suggestion that there is a need to blend home experiences and school science.

Out of this effort the trainee teachers managed to incorporate the two knowledge systems as suggested in Chapter Two (see Sections 2.5.9 and 1.2.4).Instead of discussing how the community viewed natural phenomena related to sublimation, it became a worthwhile experience for the trainee teachers they also looked into what WS is embedded there. It did not only end up with concepts they had prepared. Instead, a discussion of the structural formula of urea in urine was done (see Appendix 6.2). This was on account of these experiences offering "enthusiasm and motivation" to trainee teachers (Kibirige & Van Rooyen, 2006, p. 7) and also being affective (Lemke, 2001).

What emerged with the use of prior everyday knowledge was that the presenters needed to come armed with contingency knowledge to answer questions which were at a higher level from the concept they had prepared. Such a condition enabled deep teaching and learning to take place.

Discussions done while engaging socio-cultural views (see Section 2.6.2) encouraged scientific jargon prevalent in their communities to be used as seen in a response where one participant responded that "*urea evaporates from the chamber pot and blanket*"(see Table 4.5). This participant was scaffolded to use the proper scientific term 'sublimation' (see Section2.3.2 and Appendix 6.2). As the trainee teacher presented his social-class dialect it also promoted them to have an extend science talk as they were trying to come to establish the proper terminology associated with the concept under discussion (Lemke, 2001). The bringing in of IK ideas into classroom discourses still consolidates what Lemke (1990) wrote that learning science entails, "to communicate in the language of science and act as a member of the community of people who do so" (p. 1).

This encouragement of use of whatever is talked of as science in the community enabled to establish the participants' prior everyday knowledge which was then bridged with western science as trainee teachers brought alternative pedagogical strategies related to their indigenous knowledge. The use of participants' prior everyday knowledge reinforced their pedagogical content knowledge and pedagogical technical content knowledge which was needed in the teaching and learning of science concepts (see Sections 2.7.1 and 2.7.2). Pedagogical content knowledge and pedagogical technical content knowledge are the "interests and abilities of learners, and presented for instruction" (Shulman, 1987, p. 8).

Even though it is encouraging that pedagogical content and technical knowledge are tapped from the community through the use of socio-cultural views, the presenter went through a dual role, created when prior everyday knowledge and experience were used. He needed to look and explain the language of science in the community and also to scaffold his peers to the language of science accepted by the community of scientists. Such an approach in which participants' prior everyday knowledge was established, matched with relevant concepts in western science. The presenter exploited the already existing pedagogical content knowledge and technical content knowledge. This made engagement of the other trainee teachers possible as they used practical activities and models in science learning from the community.

Practical activities paved way for the trainee teachers to have their hypothesis about natural phenomena in their communities have some explanation (theory) (see Section 2.6.2). Perhaps, it could be argued that the practical activities used, made border crossing possible (see Section 2.6.2) and also "ideas were modified and refined – and so were shaped towards a shared set that made discourse and collaborative action possible" (Millar, 2004, p. 8) (see Section 2.6.2).

6.5.2 ANALYTICAL STATEMENT 5: CURRICULUM BROADENING, EMPOWERING TRAINEE TEACHERS WITH PEDAGOGICAL SKILLS MANIFESTS RELEVANCE OF INCORPORATING INDIGENOUS KNOWLEDGE

The revelations from the critical partners' observation came to coincide with what I had in mind (see Table 4.6) as I sat pondering to find which of the three presentations best illustrated the incorporation of indigenous knowledge used as prior everyday knowledge with western science. A post discussion held with the critical partner pointed out that all the three lessons presented had issues which were common which made them exemplar lesson plans illuminating how trainee teachers incorporated prior knowledge with western science.

All the trainee teachers' lessons had relevant indigenous knowledge used as prior everyday knowledge to relate to science concepts discussed. Measurement of same length in the community was done by use of two pegs joined together by a rope and adjusted whenever new measurement was desired. An earthenware pot was used to understand how evaporation is perceived in the community and a model of a see-saw at the points where the beams rub each other was used to illuminate the concept of frictional force. Science curriculum done in schools becomes relevant to participants by relating what they experience outside the classroom to western science and their cases did comply with this (see Section 2.4) (Rennie, 2011, p. 29).

The critical partner also pointed out that diagnostic, open-ended and closed-ended questions were common in the three presentations. Follow-up questions used throughout made it possible to keep the class engaged and to scaffold those participants who lacked the IK to act as a base for WS. However, in these presentations all trainee teachers seemed to be in the same wavelength since they were all from the same cultural background (see Section 2.5 and 2.5.1). Indigenous knowledge varies as one moves from one community to another community. This is in line with Kibirige and Van Rooyen's (2006) statement that "indigenous knowledge is a legacy of knowledge and skills unique to a particular indigenous culture and involving wisdom that has been developed and passed on over generations" (p. 236).

Their exposition to different materials from the environment which they mentioned made the improvising of materials for practical activities possible. Even though the laboratory was ill-equipped, they still managed to carry out some practical activities. These removed the idea that practical activities can be done only in a well-equipped classroom (see Section 2.6.1) and this made the incorporation of prior everyday knowledge and experiences relevant.

This was evidenced in their presentations as they went on to use all different types of materials in their environment to make their practical activities a success. For example, group one used cell phones to measure time when stop watches were brought later. A urine spoiled blanket was used to illustrate sublimation and an earthenware pot was used to illustrate evaporation. Naphthalene which was used later was only for consolidation since the use of the urine spoiled blanket achieved the intended goals. A model of a see-saw universal in Eurocentric and Afrocentric culture facilitated the use of local materials for the practical activity to illustrate the concept of balanced, imbalanced and frictional force. The discussion of balanced and imbalanced forces could not have been achieved if such cultural model was not brought.

Although the use of indigenous knowledge as prior everyday knowledge was a success in the three presentations, there were some areas where they could not say which materials are used since the knowledge was buried with the generation which used it. For example, group three mentioned the use of friction in the community to start fire when two dry sticks are rubbed against each other. No one had a clue of which tree or shrub can achieve this. Misconceptions were avoided as they guided against bringing factual errors and removed IK related to fallacies from their discussions (Kibirige & Van Rooyen, 2006).

Furthermore, apparatus brought to support teaching and learning were limited to those ideas which we had discussed during lesson preparation. However, it was seen that they were not adequate. This is attested by one presenter shouting out, "*rulers for measuring please*". Frantic effort was made to bring them since trainee teachers needed them to clarify some ideas which emerged but were not expected during lesson planning.

6.5.3 ANALYTICAL STATEMENT6: PRIOR EVERYDAY KNOWLEDGE IS SPECIFIC AS IT LOOKS INTO A SPECIFIC SOCIO-CULTURAL VIEW

While using audio-visual techniques during the completion of worksheets, the themes that emerged showed that the trainee teachers endeavoured to put into practice the PEEOE approach (see Table 4.7.1 and Section 2.6.2). In essence, the PEEOE approach made the trainee teachers acquire the required skills in science as suggested by Maselwa Ngcoza (2003). At times, however, some predictions and explanations were not in unison with the western science. For example, in question six of the worksheet where fifty percent were in agreement while the remainder were in disagreement. The spin-off though was the argument which took place, what Lemke (2001) refers to 'learner talk'.

On the other hand, observations revealed that science concepts presented by the trainee teachers aroused their peers' curiosity as they brought their experiences into the science classroom. The participants were eager to know whether, for example, there were frictional forces in a see-saw or if urine really sublimed or not. According to Chalk (2007), curiosity made the trainee teachers manipulative as they handled the apparatus in the practical activity very well, perceptive(had all their sense organs on alert to capture if what was presented was in unison with what western science says) and epistemic as they developed specific cognitive skills (see Section 2.6.2).

The audio-visual techniques used during micro-teaching also indicated that practical work is a method which could be used to incorporate prior everyday knowledge of participants with western science (see Table 4.7.2). In all groups, it was seen that once prior everyday knowledge of trainee teachers was sourced out, it made them engaged in the practical activity with a minimal use of the chalk board in all the three groups.

However, the non-use of the chalkboard by trainee teachers may also be seen as a challenge. I will consider it as a step forward in the teaching and learning of science. When we do not use LTSMs such as a chalkboard, the pedagogical strategy in use is not supportive of the chalkboard as suggested by Czerniewicz, Murray and Probyn (2000). Ideas presented were easier to understand because of the incorporation of IK which was discussed using science jargon prevalent in the communities of the participants. Then, the non-use of a chalkboard by trainee teachers was a barometer which measured the success of the incorporation of indigenous knowledge.

Teachers use a chalkboard so that abstract concepts become clear in the minds of learners. Prior knowledge did not only contextualize what was taught but it also brought a cultural translation of learner centredness to meet the conditions under which it is implemented (Thompson, 2012) (see Section 1.2.1). There was thus no need to use the chalkboard for more explanations (see Section 2.3.1).

From the focus group interviews and also from the worksheets, the responses to the questions were in most cases positive (see Table 4.8). Even though in the worksheets there were instances in which we had a case in which eight participants were in agreement while the other eight were in disagreement. Such a case is found in question six in the worksheet (see Bar Chart 4.1), and this did not create premises for challenges, instead, constructive discussions emerged out of this. This did not occur during the focus group interviews (see Table 5.4). Possibly, the interaction which they experienced in the worksheets and also during micro-teaching positively developed the trainee teachers to see the importance of incorporating IK with WS (see Sections 2.5.7 and 2.5.8).

Follow up questions were posed to see if they encountered challenges in incorporating IK with WS. While cross-checking their views to see the possible challenges which could come with this approach, it was revealed that challenges were encountered when the teacher conducted a lesson in science for a group which is culturally diverse. Perhaps, this could have positive spin-offs such as arguments and discussions.

There is need for him/her to take note that all the prior everyday knowledge associated with each member of the group is discussed to ascertain that inclusive education and social justice prevail (see Section 2.5.1 and 2.5.7). Furthermore, probing revealed that such challenges were prevalent in places where the population comes from different ethnic background. Also, town dwellers believed they left the indigenous knowledge with elderly population in rural settings (see Section 2.5.12).

Another challenge the trainee teachers encountered was if indigenous knowledge is taken as prior everyday knowledge, then teachers need to work only in areas where they are born where such prior everyday knowledge is known, used and applied (see Sections 2.5.4; 2.5.5 and 2.5.6). The implication is that teachers would become very static instead of them being mobile and cannot be deployed in areas where they are experts. Alternatively, teachers could still be deployed in those areas where they are not indigenous with the understanding that they probe from the community members and learners to acquaint themselves with the necessary prior everyday knowledge of that particular cultural group and then align it to western science as they teach. However, this will require them to be very good in WS so that they can relate it to what they hear and see in the community.

Despite the challenges mentioned, the trainee teachers agreed that western science is made accessible to those marginalized people if their prior knowledge is taken note of and allows them to contribute in the economic development of Namibia (see Section 2.5.7). This solves the challenge which the government has as it is battling to bring these people to the same level as others through use of educational programs. So, with all what has been found in this study, I summarize the discussions of this chapter using the table below.

6.2 Summary

TABLE 6.2 RELATIONSHIP BETWEEN DATA SOURCE, ANALYTICAL STATEMENT AND RESEARCH QUESTIONS

Analytical statement	**Research question**	**Data sources and analysis**	**Theoretical framework**
Enablers and constraints influence teaching of science.	What factors enable or constrain the teaching of physical science in the curriculum?	Document analysis: NNCBE; NNCBE/LC – NNCBE/PE, Research papers DPEKE/LC -	Socio-cultural, constructivism

		DPEKE/IK Physical science textbooks PST/LC – PST/PW	
Relevant examples of prior everyday knowledge to illuminate physical science concepts promote learner-centredness	How can an exemplar worksheet on pressure facilitate trainee teachers' understanding of incorporation of prior everyday knowledge in physical science concepts?	Worksheet: WS/Q1-WS/Q7	Constructivism , socio – cultural
Trainee teachers have an abundant storage of prior everyday knowledge related to western science which they can incorporate in science teaching and learning.	How do trainee teachers identify and design physical science topics with relevant examples of prior everyday knowledge?	Brainstorming : **WS/C - WS/PW** AVT/P – AVT/E. ,micro-teaching; M/PEKEIK – M/PMP	Socio – cultural, constructivism
	What ways do trainee teachers use to identify examples of prior everyday knowledge which learners have?	Microteaching : M/PEKEIK – M/PMP Audio-visual techniques : AVT/P – AVT/E	Socio – cultural, constructivism
Curriculum broadening, empowering trainee teachers with pedagogical skills manifest. Relevance of incorporating indigenous knowledge.	What is the relevance of the prior everyday knowledge and experiences associated with physical science concepts that trainee teachers come with to science classroom?	Critical partners observation : CPO/PEKEIK– CPO/PWM Audio-visual techniques : AVT/P – AVT/E	Socio – cultural, constructivism
Prior everyday knowledge is specific as it looks into a specific socio-cultural	Which ways do trainee teachers use to identify good examples of everyday knowledge of their particular learners, recognizing that in some cases they as teachers may have a different profile	Focused group interviews : FGI/R1 – R2 Audio-visual	Socio – cultural, constructivism

view.	of experiences to those of their local learners	techniques : AVT/P – AVT/E	

6.6 CONCLUDING REMARKS

This chapter related the analysed data to the questions in the research and cross referenced it with the literature in Chapter Two and others. From analysing and interpreting the data, it was clear that trainee teachers used prior everyday knowledge and experiences related to the phenomena they presented and also used the socio-cultural views in teaching and learning science.

The next chapter provides a summary of the findings, recommendations and reflections of this study. These will be drawn from what has been discussed in the above chapter while also using the synthesized information in Table 6.2. I also suggest some other possible areas of research related to this study.

CHAPTER SEVEN

SUMMARY OF FINDINGS, RECOMMENDATIONS, REFLECTIONS AND CONCLUSION

Emphasis on 'being' rather than on 'how to do', will draw in students and practitioners, making what once seemed remote and difficult become accessible and achievable (Darlington & Scott, 2002, p. 115).

7.1 INTRODUCTION

The chapter presents the summary of the findings, recommendations, reflections and conclusion of the study whose focus was on understanding trainee teacher's engagement with prior everyday knowledge when teaching physical science concepts. This study was triggered when I found that trainee teachers grappled to incorporate learners' prior everyday knowledge and experiences with western science while on school based studies (SBS). Their failure was attributed to, among other things, the fact that there is no literature on how to incorporate prior everyday knowledge and experiences in physical science lessons.

However, there is abundant literature on the "'being' rather than on 'how to do',"of prior everyday knowledge and experiences (Darlington & Scott, 2002, p. 115). Yet, this study, drew "in students and practitioners, making what once seemed remote and difficult become accessible and achievable" as this will be seen in the findings, recommendations, reflections and finally the conclusion to be discussed in this chapter (Darlington & Scott, 2002, p. 115).

7.2 SUMMARY OF THE FINDINGS

The study looked into how trainee teachers incorporated prior everyday knowledge and experiences which could potentially constitute a combination of their indigenous knowledge as well as western science. Document analysis was used to look intofactors that enable or constrain the teaching of physical science in the curriculum. It emerged from these documents that it is possible to incorporate IK with WS.

An exemplar worksheet on pressure was used to see if it facilitated trainee teachers' understanding of incorporation of prior everyday knowledge in physical science concepts.

The aim was to find out how to assist in improving trainee teachers' understanding of IK and WS in relation science concepts and how to combine the two types of knowledge effectively.

To find how trainee teachers identified and designed physical science topics with relevant examples of prior everyday knowledge and experiences, brainstorming, micro-teaching, audio-visual techniques and critical partner's observation were also used to see the relevance of prior everyday knowledge. Essentially, microteaching, audio-visual techniques and critical partner's observation were also used to see the relevance of the prior everyday knowledge and experiences associated with physical science concepts that the trainee teachers presented in the science lesson. Observations coupled with focus group interviews were used to establish ways that trainee teachers used to identify good examples of prior everyday knowledge of their particular learners. One of the primary questions of this study was to investigate challenges trainee teachers encounter in designing and delivering physical science concepts incorporated with prior everyday knowledge?

To find out if trainee teachers recognized that in some cases they as teachers may have a different profile of experiences to their local learners. Documentation and understanding the issues and challenges in designing and delivering such lessons, which could include a specific examination of how trainee teachers engaged with and responded to this approach was obtained using focus group interviews. The use of such a handful instruments triangulated the data generated and then validated it (see Section 3.8).

The participants in this participatory action research study were purposefully sampled. At the same time, ethical issues were addressed by informing them of this study, its importance in equipping them with the necessary pedagogical content and technical knowledge as they made their teaching and learning culturally responsive. Pseudonyms were used in instances where it was applicable and permission to conduct the study was sought from the relevant authorities. All the participants consented to lend their attention on account of the reasons below.

The four trainee teachers pursuing a BETD program are normally required to do an action research study during their finally year of study. Thus, this served as a good opportunity for them to see how action research is done. Secondly, during post discussions done after they had presented a lesson, they were required to reflect and indicate how they had engaged with learners' prior everyday knowledge and experiences in the presence of the teacher educator, some moderators from The National Institute of Educational Development (NIED) and the main campus of the University of Namibia and grading was done. They agreed in order to get solution to problems of not being able to relate how prior knowledge could be incorporated into the teaching of physical science concepts rather than to get a low grade.

The remaining twelve participants agreed since during micro-teaching they are required to include the socio-cultural perspective of teaching and learning science in their presentations. They are required to plan a lesson in which there is a background, foundation, connection and accommodate contingency issues. All the four must have elements of prior everyday knowledge and experiences of learners. Also, in both, illustrations, demonstrations, examples and explanations with learners' prior everyday knowledge must be present. So, this also served as ripe premises for them to see how this could be achieved. Through the use of the above, the findings of the study are summarized in the sections below.

7.2.1 ENABLERS AND CONSTRAINTS OF ENGAGING PRIOR EVERYDAY KNOWLEDGE AND EXPERIENCES

The theme above comes from the first research question. It illuminated prior everyday knowledge and experiences as one of the components of the zone of free movement as advocated by Vasliner (1997); Goos (2008) and Galligan, (2008). In the trainee teachers' community environment, prior everyday knowledge is made accessible to them by other community members. They use it to understand the environment. Yet when they are constructing science knowledge using WS they are sometimes denied the inclusion of their prior every day knowledge. That is in their zone of promoted action sometimes because of prior everyday knowledge and experiences not recognized as a knowledge source, science teachers do not take it aboard in science teaching and learning. Their world view is IK is not a source of science knowledge.

However, IK or prior everyday knowledge and experiences recognition creates premises for border crossing as advocated by (Aikenhead, 1996; Ogunniyi, n.d.) which is a prerequisite of teaching and learning physical science concepts in context (see Section 2.6.2). Its incorporation enables the bringing in of practical activities related to concepts taught (see Section 2.6.2) as proposed by Ramorogo and Ogunniyi (2010, p. 26) in their study. Research question one came up with the following findings on what enables and constrains the engaging of prior everyday knowledge and experiences.

ENABLERS ARE:

- The encouragement from the NNCBE (2010) to use all knowledge sources which are at the learners' disposal;
- Use of culturally responsive practices in the teaching and learning of physical science phenomena;
- Use of curricula materials which address readability, sentence construction that is not complex and technical language density in each textbook takes into account the maturity of the users ; and
- The use of trainee teachers' prior everyday knowledge and experiences to place them in their ZPD and at the same time cultivating their ZPA.

CONSTRAINTS ARE:

- Lack of curricula materials which show how prior everyday knowledge and experiences can be reconciled with WS;
- Physical science textbooks in use have very few examples, illustrations and demonstrations linked to trainee teachers' or learners' prior everyday knowledge and experience ; and
- The non-use of a practical curriculum by science teachers and educators since they lack empowerment.

7.2.2 WHAT IS NEEDED TO INCORPORATE PRIOR EVERYDAY KNOWLEDGE WITH WESTERN SCIENCE?

The second research question allowed me to develop the above theme. It highlights what is needed to incorporate prior everyday knowledge with western science. Carter (2007) suggests that science is a micro-culture found that exist in each and every culture. In their communities, trainee teachers use social science jargon to explain natural physical science phenomena (see Section 2.3.1 and Appendix 4.2.2) and (Carter, 2007). This micro-culture found in the learners' community act as good perspective to use to improve the teaching and learning of physical science concepts. Stears, Malcolm and Kowlas (2003) state that learners' prior everyday knowledge and experiences must be a point of reference in thinking about the nature of science and as a context for applying scientific ideas and skills. Question two of the research study question is inclusive of other questions in the study as it brings answers to some of the questions. Most of the techniques used in the study contributed to the findings for this question and these are listed below.

- Social science jargon prevalent in trainee teachers' communities should be brought into the classroom to use as prior knowledge during science teaching and learning.
- Cultural artifacts in use in their communities could be used as materials to conduct practical activities and also as examples to illustrate, demonstrate and explain how physical science phenomena are seen in their communities.
- Bringing trainee teachers' experiences of how they perceive physical science concepts and use them as a starting point during teaching and learning of science.

7.2.3 RELEVANCE OF PRIOR EVERYDAY KNOWLEDGE WHEN INCORPORATED WITH WESTERN SCIENCE

Most of the techniques used in the study provided answers to questions three. The findings for the relevance of incorporating prior everyday knowledge with western science are listed below.

- The use of prior everyday knowledge allowed the use of an approach, a pedagogical style which is culturally responsive in the teaching and learning of science concepts.
- It contextualizes science teaching and learning since contextualizing entails what people are doing and where and when they are doing it.
- It allows the cultural translation of learner-centred approach to take place.
- It developed in the trainee teachers the habits of mind which are a prerequisite to know science.
- Broadening of curricula as it will allow the official and practical curricula to operate together and also address conceptual progression and cohesion.

7.2.4 HOW CAN PRIOR EVERY DAY KNOWLEDGE BE INCORPORATED WITH WESTERN SCIENCE?

Observations together with focused group interviews were used to get some insights on the ways that trainee teachers used to identify good examples of prior everyday knowledge of their particular learners. The findings for this question four are below.

- Those explanations of physical phenomena in the community which do not show disparities with western science are good examples of prior everyday knowledge which can be used to incorporate prior everyday knowledge with western science;
- The use of the social science jargon used by trainee teachers in the community should be explained first before western science explanations are brought; and
- Prior everyday knowledge must be clarified to get rid of misconceptions if any and must be used as a base to build tensions in teaching and learning of science.

7.2.5 PRIOR EVERYDAY KNOWLEDGE IS CONTEXT DEPENDENT

Finally, findings from the focus group interviews which were aimed at answering the fifth research question revealed that prior everyday knowledge of trainee teachers can sometimes be different from that of their learners since it is specific to particular communities (Kibirige& Van Rooyen, 2006). For this not to constrain incorporation of prior everyday knowledge, practitioners can first probe from the community or from the participants. As they do so they would align their activities to be inclusive of IK teaching and learning.

Based on my findings of my study the following recommendations are made.

7.3 RECOMMENDATIONS

Recommendations made are those on factors which constrain or enable the teaching and learning of science. That is pros and cons of using an exemplar worksheet on pressure, relevance of prior everyday knowledge and experiences, ways to incorporate prior everyday knowledge and experiences and challenges in designing and delivering such lessons. The recommendations for all the items are discussed in the sections below.

7.3.1 Factors that enable or constrain

As seen, the official curriculum encourages teaching practitioners to embrace the use of prior everyday knowledge and experiences which is an enabling factor. Yet, there are no supporting materials on how this should be done and this comes as a constraint. Regardless of this constraint, one then needs to bring a practical curriculum in which the knowledge sources work together (see Section 2.5.10). Thus, there is a need to empower trainee teachers with relevant pedagogical approaches. However, practitioners also need to extend themselves by bringing a practical curriculum which is socio-culturally responsive. In it they will include their views on how the participants in their community learn science. The official curriculum will have the responsibility of standardizing their activities and guiding them on what to teach in western science. Localizing of the physical science concepts will occur as trainee teachers incorporate ideas from the community of learners and explain the same concepts based on the way they have learnt them and how they talk about them.

The adoption of a practical curriculum as we incorporate prior everyday knowledge and experiences requires that teachers be empowered on its use since they are required to construct exemplar worksheets or develop relevant LTSMs as proposed by Czerniewicz, et al. (2000). However, its construction comes with its pros and cons which are discussed in the section which follows.

7.3.2 Pros and cons of an exemplar worksheet on pressure

Science teaching and learning engaging prior everyday knowledge and experiences in culturally diverse schools can be problematic in culturally non-homogenous science classrooms. It entails each learner discussing his/her prior everyday knowledge and experiences with the teacher and this could be time-consuming. It is recommended that as we prepare exemplar worksheets to facilitate incorporation of prior everyday knowledge and experiences, we need to make sure that all participants' prior everyday knowledge are collected, selected, discussed and negotiated with the participants. This enables each participant's way of explanation of natural phenomena under study to be understood by him/her and provoke knowledge construction. Since it is time consuming, I recommend that the use of cooperative learning can alleviate this. Stears and Malcolm (2005) suggest that learners should be designers of LTSMs.

Learners from the same cultural background should discuss the phenomena according to how their community perceives it and then they should be given an opportunity to discuss their views. As they engage in the first phase of cooperative learning they scaffold each other using the language they use in their community to discuss the natural phenomena under discussion. In the second discussion group, each participant will then explain how that particular phenomenon is viewed in his/her community to a group which is non-homogeneous in terms of their understanding of the concept under discussion. Finally, the teacher provides explanations and relates learners' understanding to how western science names each concept under discussion. In doing so he/she can facilitate the acquisition of science concepts and is able to clarify which areas of IK are true and which are fallacy (Kibirige & Van Rooyen, 2006).

7.3.3 RELEVANCE OF PRIOR EVERYDAY KNOWLEDGE AND EXPERIENCES

The use of prior everyday knowledge in the worksheet on pressure made the trainee teachers find what Bernoulli (see Section 2.6.3) constructed years ago through the use of mathematical tools. However, in the case of the trainee teachers, establishing the relationship between pressure and the square of the velocity of fluid in flow was easy as they related to how this natural phenomenon is explained in their communities.

However, the concepts related to Bernoulli's theorem are considered not accessible. These same concepts are found in curricula of learners who are labeled as the cream of the crop, yet all can learn that provided it is done using the appropriate pedagogical style. Basing on the fact that learners know and apply IK it becomes relevant to them when IK is incorporated with WS. They apply Bernoulli's theorem to cross big rivers, namely; the Zambezi and Kunene and also to warn others that they can be sucked by the air from a heavy truck passing by if they are near it (see Appendix 4).

All this happens in their communities and can act as premises for them to see what they are discussing about. Instead, science teachers would prefer to take science learners to an industrial site or use a model of a gadget in western science to explain what entails that theory under discussion. Sometimes, teachers use examples of; an aeroplane, a helicopter or a throttle in an engine to explain Bernoulli's theorem. Do our learners have experiences of these?

Give examples in the community related to the phenomena under discussion, explain, illustrate, demonstrate how a roof of a hut is struck off by wind or how a bird flies then bring the related western science. These are examples they see and use in their communities hence they can easily be related to western science and understood so they are relevant (see Appendix 4). By so doing, the two worldviews supplement each other since in IK there is WS and there is WS in IK (Kibirige & Van Rooyen, 2006).

7.3.4 CHALLENGES IN DESIGNING AND DELIVERING SUCH LESSONS

On account of prior everyday knowledge being specific it makes each community has its own prior everyday knowledge. Its implication is that the trainee teachers need to look into this issue each time they bring their prior everyday knowledge into the classroom (Kibirige & Van Rooyen, 2006) (see Section 2.5). IK is locally based since it has its roots in a given community. Also, it is tacit as it can be understood without being addressed directly.

It is recognized that sometimes the cultural activities that are brought into the classroom are sensitive. Certain issues in certain communities cannot be discussed publicly such as in the case of urine spoiled blanket and the case of the chamber pot brought in the thesis. When bringing such ideas into the classroom one must be careful and capable of breaking the cultural barriers to which it is associated with. Thus, it is necessary to be well prepared in order to bring these into the classroom and openly discuss them.

7.4 REFLECTIONS

From the study I managed to come with some reflections. These are discussed below. Those of the trainee teachers are discussed first and followed by mine.

7.4.1 REFLECTIONS OF TRAINEE TEACHERS

At our Teacher's College, action research is done by the trainee teachers in their last year. Those who participated indicated that this study assisted them to find how they could also come up with solutions pertaining their practice and share with others. A follow up of the trainee teachers' action research studies showed that the quality of the action research documents of participants were better than those who did it the previous years.

Based on the findings of this research trainee teachers remark that they had seen how they could bring science from the community into the classroom. Initially, incorporation of IK with WS was difficult. After each lesson presented by any of the trainee teachers, I discussed with him and asked him how he incorporated IK into the classroom. They could not do this. After the study they said if science at home is brought into the classroom, it would allow them not only to follow what the official curriculum suggests but to also to incorporate different pedagogical styles to enhance understanding of science in the classroom.

However, they indicated that for one to gain skills in incorporating IK in the community with western science, one need to be knowledgeable in western science. This would avoid bringing IK with factual errors or fallacies (Kibirige & Van Rooyen, 2006).

7.4.2 MY CRITICAL REFLECTIONS

As an insider researcher in this study, I have seen that science in the community can be brought into the classroom through the use of different activities which are done in the community. However, this needs to be done taking into account the different cultural groups which are in the class. This approach could make all learners understand the concepts taught as their explanations are considered.

I used to think that the incorporation of prior everyday knowledge with western science aligns science teaching and learning to mythological ideas. This stemmed from one occasion when I was warned not to bring explanations from the community into the classroom. I could not argue as at that stage I was still a novice teacher. So, this study has armed me with abundant ideas and tools which will equip me to argue for the use of this pedagogical approach. Though I have been empowered through this study, it still has some limitations and my recommendations for these are discussed below.

This research looked only into explanations of natural physical science phenomena related to pressure whose explanations from the community of the participants are similar as the explanations from western science even though the community members might not be aware of this commonality. Now, only those related to pressure were researched but natural physical science phenomena are not only restricted to pressure. There is a wide spectrum of natural physical phenomena which need to be researched. This presents another area for future research.

Secondly, those natural physical phenomena whose explanations in the community are not the same as explanations from western science were not looked into. So, this is another area where if given an opportunity I could focus my attention on as this comes as a limitation to this study.

The current study only looked into incorporating IK with WS when the two worldviews have the same view- that is the cognitive stage of equipollence was in use (Ogunniyi, n.d.) (see Section 2.6.2). Yet, in other occasions, a worldview from one of the knowledge systems in use can exert more pressure- that is the dominant cognitive stage will be in use. It can happen that the dominant cognitive stage can be suppressed, assimilated or one emerges out. This results in the use of the suppressed, assimilate or emergent cognitive stages. So, the other four cognitive stages were not researched. It is worthwhile to focus research in investigating the four cognitive stages since these are a common place in physical science concepts. Thus, if I were to do this study again I would read more on the Contiguity Argumentative Theory (CAT) as this theory seems to be relevant to the study of this nature.

Also, one can conclude that research in the use of indigenous knowledge in teaching and learning of science concentrates on policy formulation and encouragement to use it (O'Donoghue, Neluvhalani, 2002; Mokuku, 2004; Shava, 2005) (see Section 2.2). Most of this knowledge is not documented to make it accessible to teaching practitioners. Even the worksheet used in this research only looked into a thin spectrum of examples of pressure yet there is a broad range of them. So, one could focus a research on documenting indigenous knowledge related to physical and chemical natural phenomena and relate it to western science. This would not only be used by science teachers as a resource book for teaching physical science but also by learners.

Finally, as suggested by Kelly, Chen and Crawford (1998); Woods (2006); Carter (2007) and Leach and Scott (2003) that contextualizing entails bringing the cultural aspects into the classroom, this will mean that learner centred approach can be contextualized using IK to suit the conditions under which teachers in Namibia are implementing it (see Sections 1.2.1, 2.3.1 and 7.3.3). So, it is worthwhile to focus a research on how to contextualize learner centred approach through use of IK to suit the Namibian context. Thompson (2012) too argues that learner centred approaches need to be subjected to 'cultural translation' to suit the environment it is applied to.

7.5 CONCLUSION

The skill to guide the classroom discourse as views are observed, explored and then explained is fundamental to the science teacher's pedagogical styles and very much critical in influencing teaching and learning. From this study, there is evidence that instructional approaches that are designed on the basis of insights about students' prior everyday knowledge seemed more effective than the conventional teaching approaches. Prior everyday knowledge consideration allows some inverted pedagogical practices which foster knowledge deconstruction and reconstruction in science studies to be used. Inverted pedagogical styles are those which favour knowledge construction (see Section 2.3.2)

Science studies are essentially concerned with knowing nature through a multicultural approach in which all communities' ways of knowing are taken on board. Culturally constituted conceptual or epistemological frameworks facilitate discursive practices since they bring with them the science jargon prevalent in students' communities which they know and then the teacher could scaffold them from there.

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APPENDIX 1.1

M. Mukwambo

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20 th June 2012

Approved.

The Deputy Dean

University of Namibia

Katima Mulilo Campus

Private Bag 1096

Ngweze

Katima Mulilo

Dear Sir

Ref: Seeking permission to conduct a research

Please kindly allow me to conduct a research at your campus. This will benefit the trainee teachers to incorporate indigenous knowledge into their teaching practices.

I am kindly requesting to make use of sixteen trainee teachers in my science research thesis. Twelve are pursuing BEd and four are pursuing BETD.

Yours faithfully

Muzwangowenyu Mukwambo

APPENDIX 1.2: EXTRACT FROM THE NAMIBIAN NATIONAL CURRICULUM FOR BASIC EDUCATION

6. TEACHING, LEARNING AND ASSESSMENT

This chapter sets out some basic didactic considerations in learner-centred education in the Namibian context.

In a knowledge-based society, existing knowledge and skills are being constantly evaluated and new knowledge and skills acquired, with a view to transforming knowledge in order to innovate to improve the quality of life. A knowledge-based society needs independent thinking and creativity as well as highly-developed communication, social and teamwork skills. The development of the core skills depends on the approach used to teaching and learning. The optimal approach to develop the core skills is learner-centred education.

6.1 TEACHING

The challenge in preparing learners for a knowledge-based society is to provide well-managed flexibility in the approach to teaching and learning, and provide learning experiences which motivate the learner to learn more. Some of the implications of this are the following:

6.1.1 A wide repertoire of teaching roles

Learners learn best when they are actively involved in the learning process through a high degree of participation, contribution and production. At the same time, each learner is an individual with their own needs, pace of learning, experiences and abilities. The teacher must be able to identify the needs of the learners, the nature of the learning to be done, and the means to shape learning experiences accordingly. Teaching strategies must therefore be varied but flexible within well-structured sequences of lessons: learner-centred education does not mean that the teacher no longer has responsibility for seeing that learning takes place. It means that the teacher has to take on a wider repertoire of classroom roles. These include being a manager and organiser of learning, a counsellor, and a coach, as well as being an instructor. Consequently, a variety of techniques will be used, such as direct questioning, eliciting, explaining, demonstrating, challenging the learners' ideas, checking for understanding, helping and supporting, providing for active practice, and problem solving.

The teacher has to exercise professional discretion in deciding when it is best to convey content directly; when it is best to let learners discover or explore information for themselves; when they need directed learning; when they need learning support (remedial or enrichment); when there is a particular progression of skills or information that needs to be followed in sequence; or when the learners can be allowed to find their own way through a topic or area of content.

6.1.2 Variation in working methods

The teacher's roles are complemented by the way work is organised in the classroom. Work in groups, in pairs, individually or as a whole class must be organised as appropriate to the task in hand and the needs of the learners. Wherever possible, co-operative and collaborative learning should be encouraged and in such cases, tasks must be designed so that pair or group work is needed to complete it, otherwise the learners will not see any relevance in carrying out tasks together. As the learners develop personal, social and communication skills they can gradually be given increasing responsibility to participate in planning and evaluating their work, under the teacher's guidance.

Textbooks and other learning resources can be used in a variety of ways. Instead of just reading a section as homework or in class, the learners may be guided to search for snippets of information, or to share ideas in pairs or groups of what they have read and how it is relevant to the topic. Natural Science teaching, for example, provides many opportunities for learners to use the immediate environment, everyday situations, everyday items and waste materials to investigate phenomena using a scientific approach. The use of information and communication technologies, especially the internet, can be integrated into teaching and learning in various ways.

6.1.3 Flexible organisation of knowledge and learning

Although the intended learning is described in the form of subject area syllabuses, flexible ways of organising learning should be adopted. Some topics and activities do not lend themselves to a pre-set sequence and may be characterised as incidental and taken up as and when relevant, e.g. current affairs. A great deal of the teaching and learning in the Pre-

Primary and Lower Primary Phases may be organised by thematic webs, where different subjects are integrated in one theme. In Grades 1-4 there will still be some subject-specific knowledge and skills that can only be taught by concentrating on them separately, and as steps towards wider competencies.

As learners progress through the other phases, subject boundaries become more apparent. However, if subject boundaries are kept strong, it may result in compartmentalised learning experiences where knowledge, skills, attitudes and values learned in one subject are not related to those learned in other subjects. It may also give rise to partial or incomplete understanding of important principles and issues in reality. Thematic and cross-curricular approaches can strengthen the learner's knowledge and awareness of issues, and the complexity and interrelatedness of the problems surrounding them.

There is ample opportunity for the synchronisation of topics in the cross-curricular themes, and to vary subject-bound work with thematic cross-curricular project work throughout basic education, including course work at Senior Secondary level where this is used as part of the assessment. As learners take on increasing responsibility for their learning, they may participate in planning their work ahead for a topic or project, and evaluate the process together with the teacher on its completion. Flexibility is needed to use the local environment and community as an extension of the classroom, both as a field to be researched and as resources to obtain information and knowledge, to stimulate investigation, enquiry and creativity.

6.1.4 A stimulating learning environment

The learner-centred classroom is a text-rich and a visually and tactile-rich learning environment. Textbooks continue to be a main source of knowledge and guidance on how to work, and learners are taught how to use the textbooks in different ways: to search for information, to compare different sources, to go in depth, and to critically review what is presented. Knowledge and knowledge production are shared through displays of learners' work, charts, posters, and easily accessible information sources. Effective learning and teaching are closely linked to the use of teaching and learning materials (e.g. books, posters, charts or recycled waste materials, etc.) and ICTs (e.g. computers, audio and visual media) in the classroom. The teacher must select and develop the most appropriate materials and media to support learning, and for the learners to use a range of materials and media in their work. Wider knowledge sources must be readily available in the school library and through software and the internet.

It may be necessary and sometimes preferable for teachers to improvise teaching and learning materials from easily available and inexpensive objects in the immediate environment, such as sticks, string, bottle tops, cardboard, etc., provided that they are safe and hygienic. Particularly at the Lower Primary level, materials can often be prepared together with the learners, following discussion of the learners' experiences, stories or ideas. At all levels, reading materials can be developed from the learners' own creative writing or from selected newspapers, magazines and other printed resources.

APPENDIX 2 1 : *EXTRACT FROM A RESEARCH PAPER DISCUSSING SCIENCE AS*

of alienation show in the decreasing numbers opting to take science beyond the compulsory years (also Jenkins 2005; Jenkins & Pell 2006; Lyons, 2006).

The purpose of this paper is to review the significant sociocultural literatures on science studies, cultural diversity, and sustainability science to help develop another vision for science education more suitable to the challenges of contemporaneity. While influences of science studies and cultural diversity are not uncommon within the science education literature, the difference here is their juxtaposition to, and the inclusion of, the newer field of sustainability science. Likewise, aiming to develop innovative or alternative visions for science education is also relatively commonplace, and the literature contains many suggestions for its own reformulation (see Aikenhead, 2006; Appelbaum, 2001; Hodson, 1999; McGinn & Roth, 1999; Millar & Osborne, 1998; Reid & Traweek, 2000; Weaver, 2001; Weinstein, 1998; as well as the Twenty-First Century Science Project from the Nuffield Foundation, 2005, and University of York). My intention here then, in the interests of diversity and plurality, is to add to these accounts to help foster more discussion about what science education could be in the 21st century.

I begin by examining the recent sociocultural literatures on science studies, cultural diversity, and sustainability science in the usual manner of a literature review, and go onto consider ways science education has grappled with their implications for its own practice to date. I then utilize the notion of *recognition* as a type of conceptual net that holds and connects together these ideas to better enable their comprehension as major influences on thinking differently about science education in the 21st century. Finally, I describe attempts to enact this vision within a science unit in a preservice teacher education course, which aims to engage, inform, and empower beginning teachers in ways that tackle the challenges of contemporaneity.

SOCIOCULTURALLY LOCATED PERSPECTIVES ON SCIENCE

The Contribution of Science Studies and Diversity

Although science has provided powerful and reliable knowledge enabling much human flourishing, De Landa (1996) suggests that the intellectual critiques in undermining sciences assertions to be objective and universal have been the most significant epistemological event in recent years (also Gieryn, 1999). The resultant so-called "Science Wars" (Ross, 1996) has proponents like Wolpert (1997), Gross and Levitt (1994), and Sokal and Bricmont (1998) aligned against those whose more critical perspectives have emerged from the fields of postcolonialism, poststructuralism, cultural studies, sociology, anthropology, and feminism. Known variously as the cultural studies of science (Weinstein, 1998), the sociology of scientific knowledge (Rose, 1997), and elsewhere as science studies (Jasanoff, Markle, Peterson, & Pinch, 1995), these areas more thoroughly examine the nature, history, production, and sociocultural location of European and ethnosciences and other indigenous/local knowledges. Essentially, science studies argue that we can know nature only through culturally constituted conceptual or epistemological frameworks, enabled and limited by local cultural features such as discursive practices, institutional structures, interests, values, cultural norms, and so on (Turnbull, 2000). Its purpose is to know as much "about the people and positions from which knowledge is constructed and for which it is targeted, as it is to the status of knowledge made" (Haraway, 1996, p. 4).

Harding (1998) organizes science studies into the two schools of post-Kuhnian and postcolonial. Post-Kuhnian science studies focus on the construction of Western scientific knowledge within the Western-style scientific institutions, permeated as they are by social and personal beliefs (Turnbull, 2000). A large literature has emerged (see Collins & Pinch, 1993; Jasanoff et al., 1995; Knorr-Cetina, 1995) that describes microsociological laboratory studies, investigating the interrelationships between scientific method and knowledge to understand how scientific statements emerge from practice. They show science behind the scenes as characterized by the same messy and conflicting individual values and reputation, tacit knowledge, social negotiation, and cultural constructions as any other knowledge field (also Turnbull, 2000).

By contrast, postcolonial science studies move beyond Kuhn's focus on Western science, to indigenous and localized perspectives emerging from a renewed acknowledgment of cultural diversity within the globalizing world. Also known as oppositional science studies (Haraway, 1996), they draw from anti-Eurocentric histories such as "science and imperialism studies" that have revealed links between the development of science and European colonialism (Osborne, 1999; Paty, 1999). Postcolonial science studies argue that the normative conceptualization of "science" contrasts it to earlier European (premodern) and non-European (including indigenous) knowledge systems and practices. For Harding (1998), the identification of "science" with the epistemologies, practices, and applications of the West recasts Western science itself as an ethnoscience and reveals its subjugation and assimilation of different non-Western scientific and cultural traditions. These practices fit within Bauman's (1995) view of modernity that sees Western science as privileged truth whose might resides in its power to define and make the definition stick. Moreover, postcolonial science studies argue that Western science and cultural indigenous knowledge traditions should be treated on an epistemological par as each developed in response to their culture's need to understand, predict, and influence its environment. Along with others including Paty (1999), Harding (1998) argues for a more diverse and inclusive view of science that sees it as any systematic attempt to produce knowledge about the natural world including local knowledge systems, ethnosciences, and science as local cultural practice.

Together, these strands of science studies erode the mythological status of universal science within the rationalizing framework of modernity and refract it through the prism of culture. Even science's claim to epistemological superiority (see Siegel, 2002) becomes bound and mediated through cultural codes, and social and economic power interests that need to be teased out and exposed. Indeed commentators, according to Aronowitz, Martinsons, and Menser (1996, p. 8) "have often claimed that science is the dominant institutional and ideological player in the global cultural scene, the one that most dramatically affects or . . . permeates our corporeal, subjective and social being." Similarly, for de Alba, Edgar, Lankshear, and Peters (2000), science as culture means engagement with sociocultural constructs to better elaborate the ways by which science is shaped and shapes our contemporary world (also Fuller, 2000).

The Contribution of Sustainability Science

The recent emergence of sustainability science, while not yet a recognized field or discipline, responds to the growing acceptance of the ecologically fragile state of our world with its irreversible loss of biodiversity, altered atmospheric and geological conditions, and its vast human load beginning to exceed carrying capacity. It has developed from a variety of the fields including environmental science, science and technology for sustainability, Third World development studies, economics, social and political sciences, globalization, cultural studies, and anthropology. Sustainability science draws heavily upon, and is supported by, a large number of international reports and meetings including the 1992 United Nations Conference on Environment and Development, *Agenda 21*; the U.S. National

APPENDIX 2.2 : EXTRACT FROM A RESEARCH PAPER DISCUSSING USE OF MODELS

A VIEW OF SCIENCE LEARNING DRAWING ON BOTH SOCIOCULTURAL AND INDIVIDUAL VIEWS

In this section we present our own perspective on science learning, drawing upon aspects of sociocultural theory and making links to the individual views outlined earlier.

We start with the fundamental assumption of Vygotsky's view of development and learning, that higher mental functioning in the individual derives from social life (Vygotsky 1978, p. 128). In the first instance, language and other semiotic mechanisms provide the means for scientific ideas to be talked through between people on the social (or intermental) plane. The process of *internalisation* (Vygotsky 1987) is where individuals appropriate and become able to use for themselves (on the intramental plane) conceptual tools first encountered on the social plane. The products of internalisation will be different for different individuals. Following the process of internalisation, language provides the tools for individual thinking. Central to this view is the continuity between language and thought. It is not the case that language offers some 'neutral' means for communicating personally and internally generated thoughts; language provides the very tools through which those thoughts are first rehearsed on the intermental plane and then processed and used on the intramental plane.

Wertsch (1991, p. 46) has made the point that the Vygotskian view is limited in that there is no recognition of the different forms of intermental functioning which occur on the social plane. He has turned to the work of M.M. Bakhtin for the additional tools needed to develop the Vygotskian account.

In his approach to discourse analysis, Bakhtin draws attention to the fact that different modes of discourse are used in different parts of society and he refers to these as *social languages*. For Bakhtin a social language is 'a discourse peculiar to a specific stratum of society (professional, age group etc.) within a given system at a given time' (Holquist & Emerson 1981, p. 430). Thus, a social language would include a dialect used in a particular geographical area, or a particular form of professional jargon, or indeed the way of talking about the natural world which is termed *science*. In Bakhtin's view, a speaker necessarily invokes a social language in producing an utterance, and this social language shapes what the speaker's individual voice can say. All of these social languages 'are specific points of view on the world, forms for conceptualising the world in words, specific world views, each characterised by its own objects, meanings and values. As such they all may be juxtaposed to one another, mutually supplement one another and co-exist in the consciousness of real people . . .' (Bakhtin 1981, p. 292).

Thus the *scientific* social language, the scientific way of talking and thinking, is that which has been developed within the scientific community. It is based on the use of specific concepts such as energy, mass and entropy, it involves the development of models which provide a simplified account of phenomena in the natural world, and it is characterised by certain key epistemological features such as the

APPENDIX 2.3 : EXTRACT FROM A RESEARCH PAPER DISCUSSINGSCIENCE JARGON

development of theories which can be generally applied to different phenomena and situations. However, it is not the case that 'anything goes' in the generation of scientific knowledge, as this knowledge should, in principle, be consistent with empirical evidence about the material world. Scientists are not in a position to create their social language in isolation from empirical data.

Wertsch (1991, pp. 93–118) makes use of the Bakhtinian concepts of social languages and speech genres (typical forms of utterances tied to particular social situations) and the Wittgensteinian (1972) notion of 'language games' in developing the 'Principle of Heterogeneity'. In this, Wertsch suggests that means of communication (the 'mediational Means') be viewed not as some kind of single undifferentiated whole but rather in terms of the diverse items that make up a *tool kit*:

> When the notion of heterogeneity is coupled with a Bakhtinian approach to meaning, I argue that speech genres are good candidates for the tools in the heterogeneous mediational tool kit (…) (C)hildren do not stop using perspectives grounded in everyday concepts and questions after they master these [scientific] forms of discourse. Different speech genres are suited to different activity settings or spheres of life. (Wertsch 1991, p. 118)

According to this view, the different social languages and speech genres which are rehearsed on the intermental plane of the classroom, offer the means for developing a range of distinctive modes of personal thought: a whole kit of psychological tools. In these terms, learning science involves internalising the social language and genres of science and becoming able to use them appropriately in various situations.

In the classroom, science is often presented, either explicitly or implicitly, as the only acceptable way of talking about the natural world. However, there are other acceptable modes of expression. In day-to-day living we are immersed in everyday ways of talking and thinking about the world. These everyday ways of talking are usually spontaneous (Vygotsky 1987), in the sense that they are developed without conscious reflection and thought. These are simply the ways in which we talk and think about 'normal events'. Joan Solomon (1983) refers to these ways of talking and thinking as 'lifeworld knowledge' and makes the point that this knowledge could not be eradicated even if science educators set this as their goal. Thus, for example, in everyday contexts it is quite appropriate to say 'I've used up all my energy' after a long walk. It is appropriate because people can fully understand what is meant. In everyday situations it would not be appropriate to worry about the scientific principle of conservation of energy and to suggest that, in fact, 'energy can't be used up'. In these terms learning science involves coming to understand and be able to use a new set of tools for talking and thinking about the world, which can be drawn upon when circumstances and context are appropriate. Furthermore, we would suggest that a mature understanding of science can be demonstrated in terms of the ability to move between ways of talking and thinking about phenomena

APPENDIX 2.4 : EXTRACT FROM A RESEARCH PAPER DISCUSSING CONTEXTUALIZING

aims to understand how what is taken for science is accomplished through the everyday actions of students, teachers, texts, and technologies. Whether or not what counts as school science to the classroom actors would qualify as "science" under normative grounds we leave as an open question. Our methodological orientation is to use a sociocultural perspective to investigate issues of concern for the educational community. We are generally sympathetic to educational theories informed by science studies. For example, Duschl (1990) provides a model for science teaching that draws from multidisciplinary perspectives on science and offers ways to integrate the history and philosophy of science into science education. Roth (1995) similarly offers models of science teaching informed by sociology of science. The investigation of what counts as science as interactionally accomplished by actors in local settings does not suggest that we view all pedagogy as good science teaching, nor that such descriptive studies should necessarily set normative curricula ideals.

Before turning to our historical analysis of research on the nature of science, we reconsider two constructs (i.e., situated definitions and context) emanating from the sociocultural perspective described above and the discursive nature of sociocultural practices in science and schools. These constructs will be tools we use to explore methodological issues in the remaining sections of the paper.

From the sociocultural perspective described previously, meanings among members of a group are situationally defined. As we are concerned with what counts as science across settings, "science" serves as an example of how situated definitions derive from and lead to other methodological considerations. Rather than referring to the literature in the philosophy of science, a situated view suggests that what counts as science is accomplished interactionally among members through discourse processes within a particular community (e.g., sociologists of science, textbook authors, high school physics students). This view, based on anthropological perspectives, suggests that "folk" definitions (Spradley, 1980) or "indigenous meanings" (Emerson, Fretz, & Shaw, 1995) be sought when studying science, both in and out of school. As these situated definitions are constructed in particular social situations, the issue of social context becomes theoretically important for research framed by this approach.

A sociocultural perspective suggests that "context" be understood as socially constructed through interactions among participants in a social situation. As described by Carlsen (1991), no simple definition of context exists; indeed, hundreds of uses of the term in research on literacy have been published in two leading journals over a five year period (Rex, Green, & Dixon, in press). Drawing from research on sociolinguistics, we take an interactional view of context, claiming that in order to understand the enacted practices of school science, we need to interpret context in particular ways described: "Contexts are constituted by what people are doing and where and when they are doing it. . . . Social contexts consist of mutually shared and ratified definitions of situation and in the social actions persons take on the basis of these definitions" (Erickson & Shultz, 1981, p. 148). From this point of view, context depends on the discourse processes (Gumperz, 1992), including contextualisation cues, that are produced in unfolding conversations, and presumably with reader-text interactions as well. Context is thus a socially constructed phenomenon (for multidisciplinary views of context, see Duranti and Goodwin, 1992) and consists of more than some real-world phenomenon and/or setting and situation, as these are fixed external to the social processes creating the context at the interactional level. Ochs (1979) states, from a sociolinguistic point of view, context "includes, minimally, language users' beliefs and assumptions about temporal, spatial, and social settings; prior, ongoing and future actions (verbal, non-verbal), and state of knowledge and attentiveness of those participating in the social interaction in hand" (p. 5). Thus the "context" of a sequence of interpersonal interactions changes over time as the actors signal and interpret contextualisation cues identifying the varying importance of the social actions being accomplished.

APPENDIX 3.1 : AN EXTRACT FROM A PHYSICAL SCIENCE TEXTBOOK USED BY LEARNERS

Which animal produces the largest force (weight)? The elephant.

Which animal has the largest area under its feet? Also the elephant. The area under the elephant's feet is large. There is less pressure under an elephant's foot than under a springbok's.

Have you ever noticed the tracks left in the sand by elephant and springbok? Which is the deeper track? The springbok's is usually deeper because the pressure under its foot is greater.

Did you know?

- Pianos and other heavy pieces of furniture exert great pressure on the floor and leave marks. To prevent this, small protectors with large areas are sometimes placed under their legs so that the pressure exerted on the carpet is reduced.
- Wearing high-heeled shoes can cause great damage to floors. That is why spike heels are not allowed in certain places with expensive carpets or wooden floors.
- Tracks caused by ox wagons travelling over the desert a century ago can still be seen. Why should you not drive over the desert? The tracks stay for years. Plants and little animals in the sand are killed by the pressure of the wheels. How can we stop people from driving off the roads in the desert in Namibia?

Increasing the area underneath a heavy object can reduce the pressure it exerts on the ground.

7.2 Pressure in liquids

The pressures we have been looking at so far are caused by solids. We have been thinking about pressure caused by bricks, animals and vehicles. The force exerted by these things is their weight. The force acts downwards on the earth.

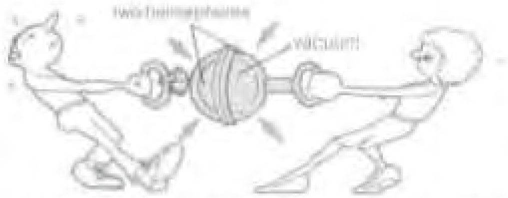
Can liquids also exert pressure? What would it be like to dive deep into some water? Look at the diver deep under the sea. Why is he in a diving suit? The suit protects him from the high pressure of the water. This pressure would crush him if he was not in the strong suit.

APPENDIX 3.2 : AN EXTRACT FROM A PHYSICAL SCIENCE TEXTBOOK USED BY TRAINEE TEACHERS

EXPERIMENT *More evidence of the atmosphere's great pressure*

You may be able to do this old experiment in the lab. The apparatus consists of two strong, hollow hemispheres of metal that fit together with an air-tight seal. There is a tube that allows you to remove the air from the inside chamber and a tap to stop the air from returning.

If you make a good vacuum inside you will find it impossible to pull the two halves apart.



(there are no screws or glue holding the two halves together)

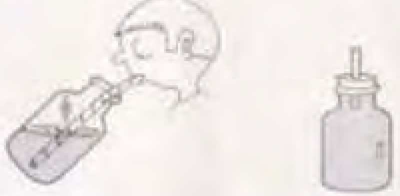
Pulling against atmospheric pressure

It cannot be the vacuum that is 'sucking' the two halves together – a vacuum means nothing is there. It must be the pressure of the atmosphere outside that presses the two halves so tightly together.

21 How does this experiment show that atmospheric pressure acts upwards and sideways as well as downwards?

22 Explain why liquid fills a syringe when the plunger is pulled out and the end is under the liquid.

23 When you suck up liquid with a straw, it is atmospheric pressure that pushes liquid up the straw. Why is it impossible to suck liquids from the bottle on the right?



APPENDIX 4 : UNIT OF WORK

Unit of work questions

Instructions

The expectation is you answer questions from 1-6, thereafter, answer 1-5 and then question 7. In question I-6, base your answers on your experiences and use knowledge gained in the practical work to answer 1-5. Proceed to do mind maps in question 7. These occurrences happen within our communities and we always have an explanation of why they happen and how. Question 7 is a practical activity question which will redirect us or confirm to whatever we have suggested. Then construct a mind map which will lead us to an idea which describes and explains all these occurrences.

1. In many parts of the country we experience severe windy conditions in certain months of the year. Even though we are encouraged to close the windows and doors of our huts or houses, our experiences tells us that the roof of a hut can still be pulled out of the walls even if the doors and windows are closed and thrown some distance away as illustrated by the diagram below. Answer the questions which follow.

(a). (i). Despite the windows and the doors left open or closed, where will we have the greatest amount of pressure, above the roof or inside the hut?

(ii). Why do you suggest that?

(b). (i). Where does the wind have greater velocity, inside the hut or on the slanting walls of the roof?

(ii). Why?

Fig. 1. Roof of a hut pulled by severe windy conditions

2. The diagram below shows some learners playing with water coming from a hose pipe.

(a). What does he need to do in order to have the water from the hose pipe have a greater range?

(b). (i). What will happen to the following as he performs that activity in 2 (a) ?

(ii) Pressure of the water and

(iii) Velocity of water?

Fig. 2. Reducing the nozzle size in a pipe to increase range *(Adapted from http://www.superstock-com/stock-photos-images/1804R-11982)*

3. The diagram below shows some birds which are flying. In some instances they achieve to set themselves into motion by flapping their wings upwards and downwards or by moving them both forward and backward. As they do so they change the air pressure around them and overcome it and fly. Answer the following;

(a). (i). Basing on your experience, where do you think there is greatest pressure when the bird is moving, above or below the wings.

(ii). Explain?

(iii). Give a reason for your suggestion

(b). (i). Whether moving its wings upwards and downwards or forward and backward, do you think a bird uses some principles in pressure?

(ii). Explain how this works.

Fig. 3. Birds use different movements of their wings to keep afloat and reach greater height.*(Adapted from http://www.deshow.net/animal/flyingbirds-669-html#pic.)*

4. The diagram below shows a pedestrian waiting some meters away from the commuter train as it passes. He will proceed to cross the railway line when he sees that it is far away from him and safe.

(a). (i). What will happen if he is very close to the fast moving train?

(ii). Why does this happen?

(b). (i) Where do you think there is greater pressure, between the pedestrian and the train or behind the pedestrian?

(ii). Why?

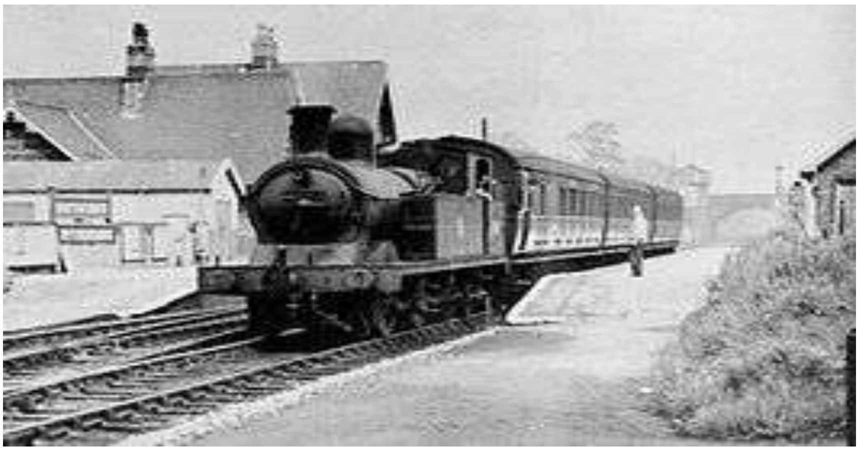


Fig. 4. A pedestrian wait a distance away for the train to pass.

5. Two sections of the Zambezi River are shown and are used by illegal border crossers as they move from Zambia to Namibia or vice versa. Section B is wider than section A which is very narrow.

(a). (i). At which point do these people use to cross the Zambezi River?

(ii). Explain your answer.

(iii). Does the velocity of moving water determine the point where people will use to cross the river?

(iv). Explain how it does?

(a) (b)

Fig.5. Two sections of a river. (a). narrow section, (b). wider section

6. Two empty and equal cans are hung at the same height using two light threads in a way that they are equal distance apart. Air is blown between the two cans. Answer the following questions.

(a). (i). Predict the direction of movement of the cans when air is blown through the two cans.

(ii). Explain your prediction.

(b). (i). Now, blow air through the cans, explore, observe and explain what will happen.

(ii). Suggest reasons why this happens?

(c). Where do you think there is (i) more pressure, (ii) less pressure, between the two cans or the external sides of the cans.

(iii). Suggest a reason why displacement occurs?

Fig. 6. Different of pressure and velocity of fluid induces movement in any given system.

7. (a). (i). Basing on what you have seen happening in question 6, do you think the same explanation can be used to explain what is happening in question 1-5?

(ii). Explain why this happens?

(b).(i). Do you think the experimental work in question 6 can be represented by the mind map below?

(ii). Suggest a reason why this happens.

(iii). Add more ideas related to what you have seen taking place?

(c). What conclusion can be drawn between the relationship between pressure and velocity of a fluid?

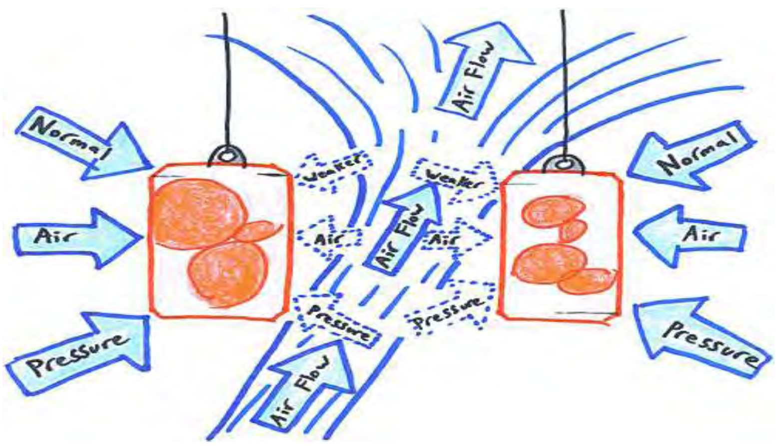
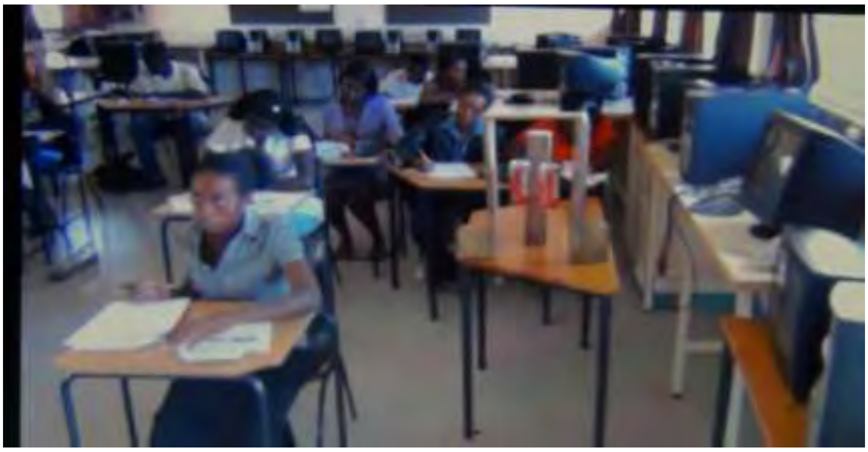


Fig.7. Mind map diagram

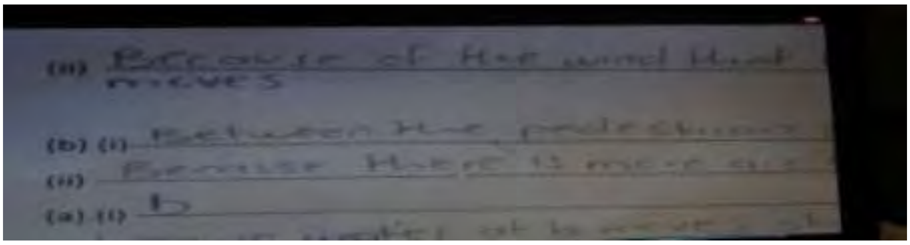
APPENDIX 5.1 : ORIENTATION WORKSHOP

Trainer teacher uses a bicycle pump to blow air between the suspended cans



Trainee teachers answering questions from the worksheet using their prior everyday knowledge and experiences thereafter relating it to western science through the practical activity and mind maps.

(a)



(b)

Data obtained from worksheet of two trainee teachers is shown in diagram (a) and (b)

APPENDIX 5.2 : BRAINSTORMING

Inside researcher brainstorming with traine teachers who are seated and critical partner behind the teachers' table listens to the discussion.

Insider research answer questions on practical activity used to incorporate trainee teachers' prior everyday knowledge and experiences with western science as they start to prepare their lesson plans.

Appendix 6.1 : Microteaching Group 1

Trainee teacher demonstrate how equal lengths are measured using a thread

Trainee teacher demonstrate how equadistant points are obtained using a thread

Trainee teacher demonstrares to peers how body parts are use for measuring length in the community

Trainee teacher incorporates different ideas of measuring discussed in the previous diagram with western science through the use of a tape measures he handed to peers and scaffolded them.

APPENDIX 6.2 : MICROTEACHING GROUP 2

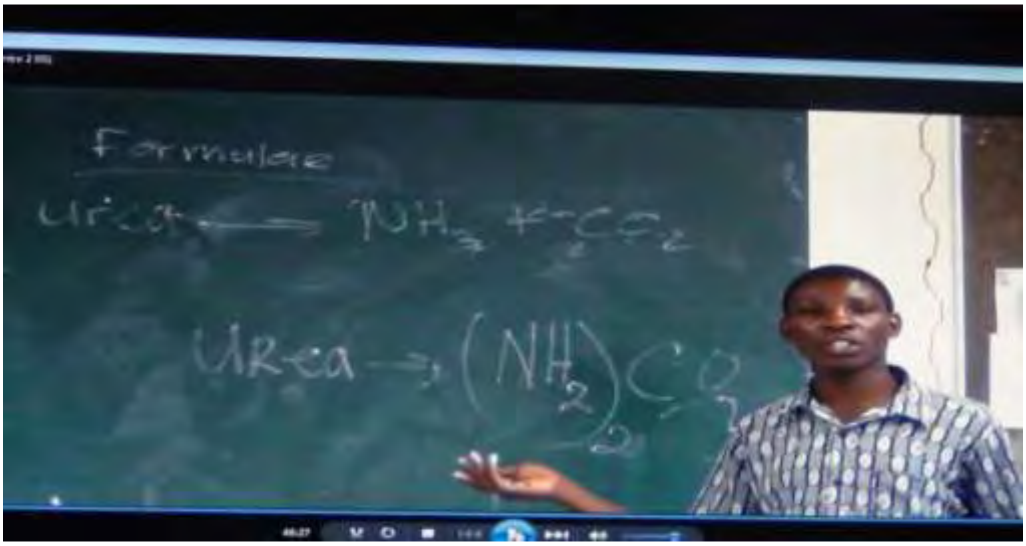
Trainee teacher displays a cultural artifact and a plastic container containing water and thermometers to bring the idea that a semi- porous earthenware materials cool liquids faster as the liquid evaporates.

The result of measuring done by trainee teacher and his peers is shown on the body

Trainee teacher incorporates ideas from his environment and of his peers to western science as he explains further why and how evaporation occurs

Trainee teacher discusses with peers how a cultural practice of hanging a urine spoiled blanket allows urea in urine to sublime

Trainee teacher consolidate the idea of sublimation of urea as he pause questions and scaffold his peers while explaining that a chamber pot stops smelling urea when urea evaporates.



Trainee teacher discuss with peers the formula of urea, thereafter the products of urea as it sublimes

APPENDIX 6.3 : MICROTEACHING GROUP 3

Trainee teacher brings a model of a see saw found in both knowledge source to explain the concept of friction and at the same time the idea of balanced and imbalanced forces to peers

Peers listen attentatively as she explains the concept of balanced and imbalanced forces

APPENDIX 7

FOCUSED GROUP INTERVIEW

The goal of this research study is to investigate trainee teachers' engagement with prior everyday knowledge, experiences and explanations of natural phenomena in teaching physics concepts

Introductory section

Since we started this exercise we have been looking into prior everyday knowledge and experiences. Our aim is to see whether it can change our teaching of physics topics in physical science and then its assimilation by the learners who will construct knowledge out of what we would have scaffolded. Now, you as an expert of prior everyday knowledge and experiences, I would like you to give your opinions in the questions which follow. Before we start, I would like to assure you that you will verify to see whether what I have written is what you have said. Also, to make sure that the fruits of our effort are known to others you need to let me allow any interested individual to look at it.

Questions

1. (a). What evidence do you have which indicates that the use of prior everyday knowledge, experiences and explanations of natural phenomena can be of importance or not in the teaching and learning of physics concepts?

(b). What challenges do you think a teacher will encounter if?

(i). he uses these ideas; and

(ii).he does not use them?

(c). How can a teacher overcome such challenges in both cases?

2. Your group came up with an exemplar lesson in which prior everyday knowledge, experiences and explanations of natural phenomena are included.

(a). State the examples of prior everyday knowledge and experience you brought and used.

(i). Do you think they were relevant?

(ii). Give a reason to your answer.

(b). Do you think your own prior everyday knowledge, experiences and explanations of natural phenomena can be different from that of your learners?

(b). (i) What will you suggest to do in a case in which your prior everyday knowledge, experiences are different from your learners'?

3. Your group selected a physics topic, you then went on to look for prior everyday knowledge, experiences and explanations of natural phenomena related to it which you have used to make sense and contextualize western science used in the source.

(a). What evidence do you have which suggest that the topic your group selected has relevant examples of these aspects?

(b). At which occasion during microteaching do you think the prior everyday knowledge, experiences and explanations of natural phenomena you selected clearly illuminate the physics concepts you intended your peers to know?

4. Can we design an exemplar physics lesson plan with prior everyday knowledge, experience and explanations of natural phenomena?

5. What challenges will a science teacher encounter if prior everyday knowledge, experiences and explanations of natural phenomena are used in designing and delivering science lesson plans?