Pre-service Teachers' Experiences of Learning to Teach Culturally Inclusive Science

By

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ABSTRACT

Pre-service teachers training at tertiary institutions are expected to adapt to and implement curriculum changes in several subjects, including Natural Sciences, which are designed by the Department of Basic Education. According to the new Curriculum and Assessment Policy Statement (CAPS) for Natural Sciences (2011), teachers are expected to embrace indigenous knowledge systems (IKS) in order to deliver culturally inclusive science lessons. Specific aim three in the Natural Sciences curriculum (CAPS, 2011) postulates the inclusion of indigenous knowledge systems and states that learners should understand the different cultural contexts in which indigenous knowledge systems were developed. However, a review of literature indicates that this is not being practiced in many schools because teachers do not have adequate knowledge, background and teacher education to integrate culture rooted in indigenous knowledge systems in their science lessons. At the tertiary institution where my study was located, pre-service teachers were being taught to infuse cultural knowledge rooted in IKS in science lessons.

This qualitative case study sought to explore 20 purposefully selected pre-service teachers' experiences and views of learning to teach culturally inclusive science in a pedagogic content knowledge module at a tertiary institution in KwaZulu-Natal. In this study, culturally inclusive science included school science which engages with alternate knowledge systems, which are rooted in indigenous knowledge systems. This research used an interpretive paradigm with multiple data generating methods which comprised of reflective journals, video recorded observations, document analysis, focus groups, and individual interviews in order to understand pre-service teachers' experiences and views of learning to teach a culturally inclusive science which is embedded in indigenous knowledge systems.

Drawing on the constructs of socio-cultural theory and the Zone of Proximal Development, pre-service teachers' learning experiences were analysed. Content analysis was used to analyse the data obtained. Categories were developed with meaningful words, phrases and sentences. Thereafter, patterns, trends and links were established, and finally conclusions were developed. The findings included pre-service teachers' views and experiences of the integration of culture whilst learning to teach science. Pre- service teachers express two broad views regarding the integration of culture. The first view was the lack of integration of cultural knowledge, rooted in IKS, in Natural Sciences content modules. The second view related to the potential benefits of the integration of cultural knowledge in science lessons.

The experiences of pre-service teachers' learning to teach culturally inclusive science revealed both challenges and opportunities. The pre-service teachers involved in this research expressed a lack of cultural knowledge rooted in IKS, insufficient teacher education, a lack of resources, time constraints, and inadequate details provided by the CAPS document as challenges. In spite of these challenges, the pre-service teachers who participated in this study expressed that working in groups and the use of external human resources were opportunities for them to learn to teach culturally inclusive science.

Recommendations which evolved from insights from this study were directed to teacher education institutions, curriculum designers and university educators.

DECLARATION

I, Raeesa Ismail declare that:

(i) The research reported in this thesis, except where otherwise indicated is my original work;

(ii) This thesis has not been submitted for any degree or examination at any other university;

(iii) This thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons;

(iv) This thesis does not contain other persons' writing, unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then:

a) their words have been re-written but the general information attributed to them has been acknowledged;

b) where their exact words have been used, their writing has been placed within quotation marks, and referenced.

(v) The work described in this thesis was carried out in the School of Education, University of KwaZulu-Natal, from 2012 to 2013 under the supervision of Dr. R. Mudaly (Supervisor); and

(vi) The Ethical clearance No. HSS/0671/012M was granted prior to undertaking the fieldwork.

Signed: _____ Date: _____

As the candidate's Supervisor I, Dr Ronicka Mudaly, agree to the submission of this thesis.

Signed: _____ Date: _____

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DEDICATION

This thesis is dedicated to my grandmother, Amina Bibi Raheem who passed away during the completion of this study.

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

IK – Indigenous knowledge

IKS – Indigenous knowledge systems

AIKS – African Indigenous knowledge systems

NCS – National Curriculum Statement

RNCS – Revised National Curriculum Statement

CAPS – Curriculum and Assessment Policy Statement

CNE – Christian National Education

NS – Natural Sciences

PCK – Pedagogic content knowledge

ZPD – Zone of Proximal Development

TIMSS – Third International Mathematics and Science Study

TAP – Toulmin's Argumentation Pattern

CAT – Contiguity Argumentation Theory

UKZN – University of KwaZulu-Natal

CHAPTER 1

Orientation of the study

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Chapter 1

Orientation of the Study

1.1. Introduction and background

"Indigenous or traditional technologies and practices in South Africa were not just ways of working; they were ways of knowing and thinking… Much of this valuable wisdom has been lost in South Africa over the last 300 years, and effort is needed now to rediscover it and examine its value for the present day… Given this history, it is fitting that traditional and indigenous knowledge systems should be included among the ideas the learner examines…. Different worldviews are usually present in the classroom… people tend to use different ways of thinking for different situations. One can assume that learners in the Natural Sciences Learning Area think in more than one worldview. Several times a week they cross from the culture of their home, over the border into the culture of science and back again" (Department of Education (DoE), 2002, pp. 10-12).

Historically, the knowledge possessed by indigenous people has been devalued (Corsiglia & Snively, 2001; Ogunniyi, 2004). The advent of colonial education began the demise of the vast epistemologies of indigenous people. The curriculum was a vehicle used by the colonial powers to subjugate indigenous people (Cobern & Loving, 2001; Kanu, 2006). In the postcolonial era, a critique and a re-thinking of curriculum content has been heralded (Kanu, 2006), and with this has come the development of a space for indigenous knowledge (IK) in school curricula.

According to Manzini (2000, p.20), "indigenous knowledge is a kind of localised knowledge passed down from generation to generation and that historically has been considered to originate from a particular place". Various researchers in science education have accentuated that "indigenous practices in Africa were not just ways of working; they were ways of knowing and thinking" (Onwu & Mosimege, 2004, p.1). A continental study conducted by Owuor (2007) explored the reclamation of cultural identity by the people of Kenya, in which they decided that the only way of ensuring the existence of their cultural identity was to transform their education system and include indigenous knowledge so that the future leaders of the country would be educated about the value of indigenous knowledge.

Likewise, an innovative post-apartheid school curriculum in South Africa has been developed with a requirement that "students should be taught school science within the context of their societal and cultural knowledge" (DoE, 2002, p.10). It is intended that this will provide students with the essential grounding for effective learning and promote awareness of different viewpoints in this multicultural society. Malcolm (2002, p.71) adds that schooling should incorporate "cultural heritage and cultural transmission, and that learners' knowledge and experiences are deeply significant in the lives of South Africans, and should be reflected in the outcomes and content of science education". The attainment of the objectives stipulated in the school curriculum and the promotion of a culturally inclusive science education depends on "teacher's ability to equip their learners with the necessary intellectual skills and this in turn depends on the quality of their training at the higher education level" (Ogunniyi, 2004, p.289). Natural Sciences teachers are constrained by having limited pedagogic knowledge, support and teacher education for the successful implementation of the new curriculum (Govender, 2009). Furthermore, researchers add that the National Curriculum Statement (NCS) is a challenge for science teachers because they do not know the necessities of various indigenous knowledge systems (IKS) within a South African context, and may not be trained or inclined to teach such knowledge (Corsiglia & Snively, 2001; Hewson, Javu & Holtman, 2009; Odora Hoppers, 2002; Ogunniyi, 2004).

Currently, higher education institutions are considering the potential value of a culturally inclusive science education which is rooted in IKS, and are re- designing courses/modules to include IKS. " In some universities in South Africa there is a heightened focus on IKS issues resulting in the establishment of IKS faculties" (Naidoo, 2010, p.14). A Bachelor of IKS degree was introduced in 2009 by four historically disadvantaged universities, namely the universities of Venda, Limpopo, North West and Zululand (Naidoo, 2010). This suggests that there is a call for culturally-infused science education at tertiary institutions. According to Tisani (2004), higher education practitioners in particular have an added responsibility to produce new knowledge. At the University of KwaZulu-Natal, pre-service teachers are given an "indigenous voice" whereby culture and indigenous knowledge is included in the teaching of a particular science concept, astronomy (Govender, 2009, p.117). According to Adler and Reed (2002), the curriculum is not fully being met in achieving objectives such as the inclusion of IKS. Govender (2009, p.118) argues that science teacher educators in tertiary institutions are aware of these issues (raised by Adler and Reed, 2002) and are "seeking

informed ways to bring IKS, as valuable local knowledge, into the mainstream science curriculum".

This chapter serves to frame the study and provide insight into the chapters that follow. This study focused on pre-service teachers' experiences of learning to teach culturally inclusive science. This study used a case study approach to explore pre-service teachers' experiences and views of learning to teach culturally inclusive science. This chapter is organised according to three foci. First, the chapter presents the purpose and the rationale for this study. Second, the research aims and methodology, which focus on the research questions, are presented. Third, a brief summary of the main points to be covered within each chapter is presented in the form of a chapter overview.

1.2. Purpose and focus of this study

The purpose of this study was to explore pre-service teachers' experiences of learning to teach culturally inclusive science in a pedagogic content knowledge (PCK) module at a tertiary institution in KwaZulu-Natal. This PCK module aimed to prepare pre-service teachers to be able to teach Natural Sciences to learners in the intermediate and senior phases. The content of this module encompasses learning theories, practical work, investigations, demonstrations, improvisations and the infusion of IKS in science lessons. In this study, culturally inclusive science included school science which engages with alternate knowledge systems which are rooted in indigenous knowledge systems. This study focused on pre-service teachers' experiences of learning to teach culturally inclusive science. In this study, pre-service teachers' experiences included their thoughts, feelings, opportunities and challenges. This study also focused on pre-service teachers' views on the integration of culture in science education when they learnt to teach science. The findings of this research will inform teachers, higher education lecturers, as well as curriculum designers of the experiences of pre-service teachers who attempt to understand and practice a culturally inclusive science education which incorporates indigenous knowledge systems. There is limited literature in the area of pre-service teachers' experiences of learning, especially in ways that are culturally inclusive. This study aimed to provide new insight and contribute to the body of knowledge regarding culturally inclusive science education. [1]

[1] Natural Sciences - Intermediate Phase - Grades 4-6
Natural Sciences - Senior Phase - Grades 7-9

1.3. Rationale for the study

South Africa's education policy formally began within a Christian National Education (CNE) regime, which dates back to its inception in 1890. This policy (CNE) dominated the Apartheid era, which spanned the period 1948-1994, where the teaching of content was a major focus. Curriculum content was in line with immediate economic needs and therefore, culturally-infused education was not seen as an important aspect in education generally, and within science education in particular. However, when the new democratic government came into power in 1994, the curriculum was designed, among other things, to heal the social, political and economic divisions of the past (Botha, 2010). This resulted in the adoption of Curriculum 2005 which "openly and unequivocally" embraced an Outcomes Based Education System (Aldous & Rogan, 2009, p.62). In its initial version, Curriculum 2005 was expressed as a document called The National Curriculum Statement (NCS). However, in an attempt to simplify Curriculum 2005, a Revised National Curriculum Statement (RNCS) was published in 2002 (DoE, RNCS, grades R-9, 2002, p.1). The RNCS is based on the philosophy of "science for all which embraces a humanistic perspective of science through the inclusion of societal and environmental issues as is articulated in one of the learning outcomes (LO3) of the sciences curriculum statements, which specifically allows for and accommodates indigenous knowledge systems (IKS)" (Naidoo, 2010, p.23). The RNCS was then refined to generate the Curriculum and Assessment Policy Statements (CAPS) which also values and requires the inclusion of cultural knowledge, such as indigenous knowledge (IK) (DoE, CAPS, grades 7-9, 2011). The CAPS document for Natural Sciences aims to ensure that "learners acquire and apply knowledge and skills in ways that are meaningful to their own lives. In this regard, the curriculum promotes the idea of grounding knowledge in local contexts" (DoE, CAPS, grades 7-9, 2011, p.3). "Valuing indigenous knowledge systems" (DoE, CAPS, grades 7-9, 2011, p.3) is one of the primary principles enshrined in the CAPS document. Teachers are also expected "to show the link between indigenous knowledge systems and Natural Sciences, and be cognisant of the diversity of cultures in this respect" (DoE, CAPS, grades 7-9, 2011, p.13). Many South African teachers are not in favour of the change in curriculum because this new curriculum expects more of teachers (Hewson *et al*., 2009). Teachers are also left in a position of uncertainty with regard to the inclusion of IKS in the curriculum (Dumile, 2011). Hewson *et al*. (2009) assert that teachers indicate that there is minimal support in terms of the actual content, pedagogic content

knowledge and teaching strategies of IKS integration in the science curriculum. Furthermore, science teachers depend on university-related courses for learning about IKS.

The rationale for this study was firstly located in the requirement of the Curriculum and Assessment Policy Statement (CAPS) of Natural Sciences, which expects teachers to embrace indigenous knowledge systems in order to deliver culturally inclusive lessons through "Specific Aim 3: Understanding the use of Science" (DoE, CAPS, grades 7-9, 2011, p.10). Specific aim 3 specifies the inclusion of IKS and states that learners should understand the different cultural contexts in which indigenous knowledge systems were developed. Furthermore, learners should understand "the use of Natural Sciences and indigenous knowledge in society and the environment" (DoE, CAPS, grades 7-9, 2011, p.10). "This aim of Natural Sciences is to enable learners to understand that school science can be relevant to their everyday lives" (DoE, CAPS, grades 7-9, 2011, p.10). Secondly, and from my personal experience which is supplemented by conversations with subject advisors, I am aware that the teaching of IKS is not being practiced in many schools because teachers do not have adequate knowledge, background and teacher education to integrate IKS into their science lessons. Ogunniyi (2007) states that science teachers do not hold valid understandings of IKS or possess adequate knowledge or instructional skills to implement a science IKS-curriculum. Thirdly, learners perform poorly in science due to the conceptual gaps in their knowledge because teachers are unable to link prior learning to school science (Chetty, 1999; Ingle & Turner, 1981; Jegede, 1999; Manzini, 2000; Odora Hoppers, 2000). At the tertiary institution where my study is located, pre-service teachers are currently being taught to integrate IKS in their lessons, thereby promoting a culturally inclusive science education.

1.4. Significance of the study

The gap in content and pedagogical content knowledge, as these relate to the teaching of culturally inclusive curricula in science, is crucial and will be addressed in this study. The significance of this study is that it will contribute to a deeper understanding of a culturally inclusive science education that is embedded in indigenous knowledge systems. This study will enable a more meaningful implementation of IKS by Natural Sciences teachers. The findings of this study will have a positive impact on existing teachers' practices and thereby contribute to a better quality of teaching and learning in the Natural Sciences learning area. Furthermore, findings from this study are expected to inform teachers, higher education

lecturers and curriculum designers of the experiences and views of being taught to implement the new curriculum to include IKS in Natural Sciences lessons.

1.5. Research aims

The fundamental aims of conducting this study were:

- To explore how pre-service teachers view the integration of culture when they learn to teach science.
- To explore pre-service teachers' experiences of learning to teach culturally inclusive science.

In this study, science refers to the subject Natural Sciences which is taught to learners from grades four to nine.

1.6. Research questions

The following questions underpin this study:-

1) How do pre-service teachers view the integration of culture when they learn to teach science?
2) What are pre-service teachers' experiences of learning to teach culturally inclusive science?

1.7. Research design

A case study approach was used to explore 20 pre-service teachers' experiences of learning to teach a culturally inclusive science education through a PCK module at a teacher education institution in KwaZulu-Natal. The case in this study was a PCK module within a teacher education programme at a teacher education institution. An interpretive paradigm was used to frame this research in order to explore and understand pre-service teachers' experiences and views of learning to teach culturally inclusive science. Furthermore, this study made use of a qualitative methodological approach because qualitative research aims to understand and describe human behaviour from the insider's perspective (Babbie & Mouton, 2001). This study employed five methods of generating data, namely: reflective journals, observations, document analysis (pre-service teachers' lesson plans), focus group interviews and individual interviews. The aim of using multiple methods for data generation was to answer the research

questions from different perspectives, thereby triangulating data and thus enhancing the validity and reliability of the findings.

1.8. Findings

The findings of this study emerged from the data that were generated through multiple methods. Themes emerged from the data in response to the two research questions that guided this study. The findings included pre-service teachers' views and experiences of the integration of culture whilst learning to teach science. Pre- service teachers express two views regarding the integration of culture. Their views revealed a lack of integration in Natural Sciences content modules, and the potential benefits of this integration. The experiences of pre-service teachers learning to teach culturally inclusive science illuminated both challenges and opportunities.

1.9. Overview of the chapters

Chapter one provided a general introduction and background to the study. The study was introduced through a discussion of the requirements of the new school curriculum, which values and requires the inclusion of cultural knowledge such as IK, together with the challenges experienced by many teachers. The purpose of the study and rationale for pursuing this study are presented. The key research questions informing this study are also highlighted. A brief outline of the research methodology employed in this study brings this chapter to a conclusion.

Chapter two focuses on the review of relevant international and local literature related to the chosen research area. The review of literature commences firstly by defining and discussing a culturally inclusive/relevant science education. Secondly, indigenous knowledge as a component of the school curriculum, and indigenous knowledge and science education are explored. Thirdly, the theories around IKS are discussed. Finally, the current state and relevance of indigenous knowledge systems in higher education institutions, together with teacher education, is reviewed. The socio-cultural theory and the Zone of Proximal Development (ZPD) which are central theoretical constructs of this study bring this chapter to a conclusion.

Chapter three focuses on the major methodological approach adopted in the study. The paradigm, design and sample are discussed. The data generation tools, which were video

recorded observations, reflective journals, document analysis, focus group interviews and individual interviews schedules, are justified. Validity, reliability and ethical considerations are then highlighted. Finally, the limitations of the study are presented.

Chapter four presents the analysis of findings of this study. Content analysis was used to analyse the data obtained. The data is firstly presented; thereafter the themes that emerged inductively from the data are discussed.

Chapter five presents the conclusions of the research. Thereafter, some recommendations are presented.

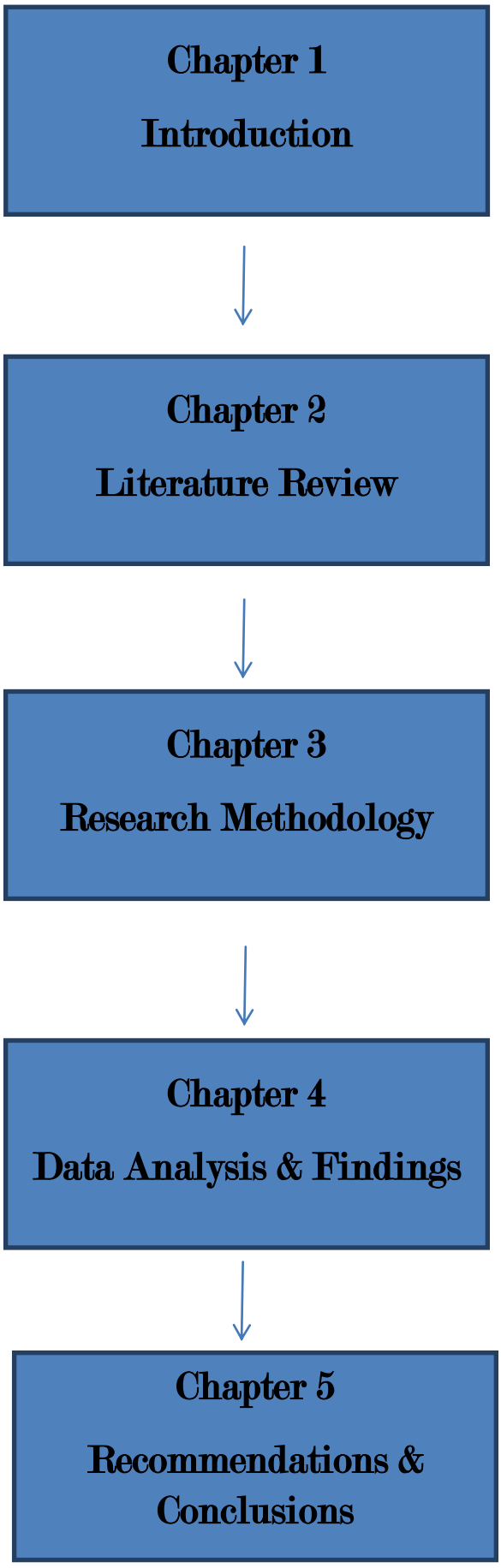

Figure 1- Sequence of Chapters

1.10. Conclusion

In this chapter I presented the introduction and background of the study. The purpose and rationale for the study were highlighted. The methodology employed for this study and the key research questions were discussed. Finally, the structure of the dissertation was outlined discussing what each chapter entailed. The next chapter will survey scholarly articles, books and other literary sources which are related to the research focus of this study.

CHAPTER 2

Literature Review

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Chapter 2

Literature Review

2.1. Introduction

The literature review explores local and international literature as it relates to culture (which is influenced by IKS) and science education. This chapter discusses related literature around a culturally inclusive science embedded in indigenous knowledge systems. This chapter is organised according to five main foci. First, indigenous knowledge and a culturally inclusive/relevant science education is defined and discussed. Second, indigenous knowledge as a component of the school curriculum is discussed. Third, indigenous knowledge and science education are explored together with the different methods used to introduce IKS in a science classroom. Fourth, the theories around IKS in science education are discussed. Finally, the current state of IKS in higher education institutions, together with teacher education, is reviewed.

2.2. Defining Indigenous Knowledge

Various authors define indigenous knowledge (IK) as:

"Local knowledge unique to a given culture or society. It is the systematic body of knowledge acquired by local people through the accumulation of experiences, informal experiments, and intimate understanding of the environment in a given culture" (Warren & Rajasekaran, 1993, p.8).

Odora Hoppers (2005, p.2) describes IK as "knowledge that is held and used by people who identify themselves as indigenous of a place on a combination of cultural distinctiveness and prior territorial occupancy relative to a more recently arrived population with its own distinct and subsequently dominant culture".

George (1999, p.80) defines IK "as knowledge that has evolved in a particular societal context and which is used by lay people in that context in the conduct of their lives. IK seeks to find solutions to problems in day-to-day lives by drawing on existing wisdom and resources. It is knowledge that is passed on from one generation to another through an oral mode".

Flavier, de Jesus and Navarro (1995, p.479) state that "indigenous knowledge is basically local knowledge that is unique to a given culture. It is the information base for a society which facilitates communication and decision-making. Indigenous knowledge systems are dynamic, and are continually influenced by internal creativity and experimentation as well as by contact with external systems."

The World Bank (2003) highlights the traditional origins and the cultural aspect of IK, as well as the dependence on other knowledge systems. They define IK as:

"Local knowledge that arises from tradition and is embedded in culture. Indigenous knowledge is not independent, and is always linked in some ways to other parts of the global knowledge system" (World Bank, 2003, p.x).

"IK systems are adaptive skills of local people, usually derived from many years of experience, that have often been communicated through "oral traditions" and learned through family members and generations" (Warren & Rajasekaran, 1993, p.8).

The following elements from the above definitions encompass the essence of my study:

- Local, informal knowledge
- Dynamic and ever-changing
- Everyday knowledge and experiences
- Transferred in oral form

IK is local, informal knowledge that is passed down through generations. It is dynamic in nature and is embedded in the experiences of a particular culture.

2.3. Poor performance and underachievement in science education

Dzama and Osborne (1999) state that there exists a universal conflict between science and everyday culture. This conflict is an important factor which contributes to how well African learners perform in science. Ingle and Turner (1981) reiterate that there is a mismatch between African culture and the science that is being taught in the classroom. They go on to state that this mismatch is one of the reasons why African learners perform poorly in science.

According to Dzama, Holtman, Kolsto and Mikalsen (2008), learners' culture, their teachers' and their worldview play a role in their success or failure in science education. The element of the learning style and learners' attributions of success and failure in learning science is

associated with this worldview. They further state that there is an abundance of literature on the underachievement of African learners in science education, but these reports and discussions are mainly focused on generally the same concepts, namely: the shortage of materials and human resources, learners' negative attitude to learning science and a lack of commitment from learners.

The International Association for the Evaluation of Educational Achievement conducted an international study of mathematics and science called TIMSS. Howie (1999, p.6) asserts that "TIMSS was the largest and most ambitious international study of mathematics and science achievement at school level ever undertaken".

Howie (1999), who reports on the TIMMS R (1999), states that the performance of South African learners in science was far lower when compared to all participating countries. She adds that the performance of South Africa's highest achiever was equivalent to the lower quarter of the achievers from international countries. South Africa also scored the lowest in science from all African countries participating in TIMSS (Howie, 1999).

"The poor performance was attributed largely to inappropriate curricula and teaching in schools, under qualified teachers, a lack of parental involvement and the socio-economic status of learners"(Naidoo, 2010 p.4). This resonates with Ogunniyi's view (2011, p.98) that "learners of well-trained teachers tend to outperform those of poorly trained teachers in most tasks." Naidoo (2010) further states that the ravages of apartheid in South Africa cannot be blamed for the poor performance of these learners. Kawagley and Barnhardt (2000) concur with this view and add that these poor performances in science are a common trend in many African countries, even those that have not been subject to the apartheid regime. They further state that these poor achievements in mathematics and science are significant among the indigenous learners of these African countries.

McKinley (2005) offers a reason for the underachievement/poor performance of these countries in science. She states that the underachievement/poor performance is due to a lack of connection between the home of the learner and the classroom in which the learner is located. Connecting the learners' cultural background to science education has crucial importance as it makes science relevant to learners (McKinley, 2005). This resonates with Jegede's view (1995) that there exists a gap between the reality of the learner and the science being taught at school. He further adds that this gap prevents significant learning from taking place in the science classroom. Jegede (1999) states that there is no correlation between

indigenous learners' prior knowledge and the school science they are exposed to. This view is shared by Quiroz (1999) who states that there is a lack of relevance attached to the science being taught at school. This irrelevance and lack of mediation contribute to the high drop-out rate of African learners in science and mathematics in secondary and tertiary institutions (Naidoo, 2010). Quigley (2009, p.77) postulates that "achievement and equity can only occur if there is careful consideration of students' language, cultural knowledge and experiences as well as analysis of the current role of science education".

Naidoo (2010) argues that learners do not enter science classrooms empty of science; therefore there is a great need to ensure relevance of learners' cultural backgrounds and experiences in science classrooms. Furthermore, Naidoo (2010, p.6) adds that "a science curriculum that includes aspects of relevant indigenous knowledge that recognises learners' preconceptions and worldviews, affords a platform for discussion of different ways of knowing and encourages critical thinking; this is bound to attract and sustain more students in science classrooms".

2.4. Culturally inclusive (relevant) science education

This thesis does not focus on everyday knowledge in general, rather on everyday knowledge that is rooted in indigenous knowledge Systems (IKS). The literature that follows shows how cognitive conflict arises when school science does not include everyday knowledge that is embedded in IKS.

Science education policy advocates linking learners' science learning to their everyday knowledge so that their experiences, interests and prior knowledge can be built upon (Stears, Malcolm, & Kowlas, 2003). Ledbetter (1993) argues that the previous experiences of learners in science have a great impact on their conception of science. If the learner has had positive experiences, then they are more likely to want to learn more about science. Ogunniyi (2011, p.106) adds that "before studying school science most African learners particularly in rural areas have accumulated a wealth of holistic knowledge about the environment which school science with its compartmentalized disciplines, have tended to displace rather than accommodate". The effect of this, as stated by Ogunniyi (2011) is that these learners become alienated from school science.

According to Gamble (2002), there are two forms of knowledge, one in the oral form and the other in the written form. The oral knowledge represents everyday knowledge and the written

knowledge represents the formal knowledge attained at school. Stears *et al*. (2003) argue that these two types of knowledge or domains can be in conflict with each other. These two domains can either remain separate or they can merge by a relationship being developed between them. Villegas and Lucas (2002) add that teachers would need to develop teaching approaches that critically allow the merge of formal science and everyday science as it is the learners' prior knowledge that shapes their science conception. Stears *et al*. (2003) state that the curriculum for learners can be devised such that the learning cycle firstly looks at learners' everyday knowledge and uses it as a foundation to build more formalised structures of scientific knowledge. As stated by Stears (2008, p.132), the stakeholders involved in the designing of science curriculum need and should take into account that learners have "alternative beliefs with regard to science concepts and curricula". There should be an attempt to link the informal learning that learners possess to the structured learning presented at school. Ogunniyi (2011, p.101) argues that "for school science to be relevant it has to reflect some aspects of IK which shape the lives of learners from indigenous communities". In doing this, the informal knowledge that learners already possess can act as a foundation for the formal knowledge gained at school (Stears, 2008). But, if the two domains remain separate, a problem arises when learners lack the ability to move from one domain to the other. It can also be regarded as moving from one context to the other, from everyday knowledge to formal knowledge (Stears *et al*., 2003).

Specific Aim 3 of the CAPS document specifies that "science learnt at school should produce learners who understand that school science can be relevant to everyday life" (DoE, CAPS, grade 7-9, 2011, p.21). It is then the task of teachers to find the link between the science that is taught and the backgrounds of learners. What this indicates is that a culturally responsive teacher is a necessity in the science classroom (Villegas & Lucas, 2002). A teacher must possess the ability to recognise learners' background and have prior knowledge of learners in the science classroom. Semali and Kincheloe (1999, p.49) support this view, stating that, "an understanding of both indigenous knowledge's and indigenous educational practices is necessary for the insightful educator to integrate such curricular understandings into his or her teachings". A teacher must promote the idea of someone that articulates a vision of teaching and learning in a diverse society and makes use of that vision to systematically guide the infusion of multicultural issues in the curriculum. According to Villegas and Lucas (2002), a culturally responsive educator is socio-culturally conscious, has encouraging views of learners from different backgrounds and promotes the construction of knowledge.

According to Ogborn, Kress, Martins and McGillicuddy (1996), in order for scientific phenomena to be explained, there needs to be dynamic interaction between the teacher and the learners. They add that this dynamic interaction is done so that the prior knowledge that these learners possess can be recognised in the science classroom. The idea of contextualisation can be used to do this as it improves access to knowledge as well as bringing about knowledge equity that was dismissed as unimportant previously (Campbell & Lubben, 2000). Employing contextualisation will allow the teacher to bridge the gap between the everyday knowledge that the learners possess and the formal knowledge of the classroom. Semali and Kincheloe (1999, p.49) affirm the need for a connection to be made between the prior knowledge of learners and the knowledge taught at school by stating: "in addition they must be able to help their students grasp the connections between the indigenous understandings and the students' lived experiences and school activities". Indigenous knowledge can be seen on the same level as western science if the teacher relates to the context of each learner and allows each an opportunity to be at the forefront of the science lesson. Campbell and Lubben (2000), similar to Stears *et al*. (2003), allude to the existence of the two domains namely, everyday science and school science. With the use of contextualisation, these two domains can be merged so that learners have a sense of connection to what they are learning and are not unconsciously importing alternative concepts and ways of thinking, which are effective in everyday life but not in science. The teaching and learning of science is meant to be enjoyed and context-led approaches to both teaching and learning of science curriculum tends to improve learner enjoyment (Campbell & Lubben, 2000). They further suggest that in order for teachers to be able to do this, they will require education and skills as well as confidence to be able to offer direction in the science classroom. This is supported by Ogunniyi (2011) who states that teachers need to be trained to implement relevant science in the classroom. He adds that the education of teachers in this regard will avoid the alienation of learners in school science.

According to Stears *et al*. (2003), learners' everyday knowledge (that is rooted in IKS) can be used as part of teaching. They add that this everyday knowledge can form part of the curriculum and be the departure point for learning science. This everyday knowledge possessed by learners can be used as a reference point and as a context for applying ideas and skills. Kawagley, Norris-Tull, and Norris-Tull, (1998) state that the very definition of science limits the scientific literacy and development of learners from non-western cultures. The way in which science is taught must include the conceptualisation of the principles and beliefs of

all learners in the science classroom. Stears (2008) found that many children from African cultures are taught from a western science perspective, it may be difficult for these children to demonstrate understandings of concepts learnt at schools as western science often conflicts with their beliefs generated by science learned out of school. As learners possess their own worldview born out of everyday experience, it is difficult for them to change their beliefs of scientific knowledge. Campbell and Lubben (2000) conducted research in Swaziland and found that context-led approaches exhibited positive attitudes in learners through lessons that allowed learners to work on personally useful applications of science, by gaining ownership of lesson activities in contributing to the knowledge and the discussion of contentious issues. Findings from a study based in Swaziland also included discussion that allowed speculation around everyday activities, which sparked conceptual development (Campbell & Lubben, 2000). This speculation was beneficial to teachers in that it allowed misconceptions to be identified as well as the subsequent addressing of these misconceptions (Campbell & Lubben, 2000).

Snively and Corsiglia (2001) allude to the point that because many children enter the science classroom with ideas based on their prior experiences; teachers need to begin exploration into culturally infused instruction. Probing needs to be done by teachers in order for the prior beliefs of indigenous knowledge that those children possess to be incorporated into the science lessons. A discussion involving these different perspectives of culturally-infused knowledge has the further advantage of encouraging mutual respect among learners in the classroom. Teachers are also able to allow different opinions and indigenous knowledge to be a part of the science classroom. Science teachers require not only a curriculum that recognises indigenous knowledge, but also the education that will enable them to teach this indigenous knowledge. McKinley (2005) supports the education of teachers and states that many teachers have been exposed to education that does not allow them to recognise that the underachievement of learners is related to the lack of cultural integration in the learning of non-western learners.

Non-western learners sitting in a science classroom learning western science, questions the relevance of the curriculum. The teacher in the science classroom has no room to consider the everyday knowledge (that is rooted in IKS) of the learners, but has to merely impose western philosophy onto that learner. Kawagley *et al*. (1998, p.134) argue that western science as ‘true science’ is often presented in the form of textbooks and laboratory science. They add that this is a very narrow view of science and it devalues the legitimacy of cultures that derive

their knowledge from observations and insight. In a science classroom science is portrayed as a discrete body of knowledge (Kawagley *et al*., 1998). The portrayal of school science as a discrete body of knowledge makes school science a foreign concept to learners of a specific culture where their understanding of science is located within that culture (Kawagley *et al.*, 1998). Nnandozie (2009, p.23) agrees with this view stating that "textbooks and other resources should be designed in such a way that they incorporate the activities and practices of the indigenous people". Science should be viewed as a foreign culture that needs to be translated into the informal language of the learner (Stears, 2008). By doing this, the learner is not being pushed towards science; but with the science teacher as the vehicle, science is brought closer to the learner. Concepts rooted in IKS are the foundation that science teachers can use to build concepts of science.

Cobern and Loving (2001, p.50) pose a question: "Is science universal?" In answering this question they state that in science education the very definition of science is a gatekeeping devise used to regulate what can and cannot be included in the science curriculum. In the United States, there exists a question of whether to include creation science in the science curriculum. Cobern and Loving (2001) state that if science is to be seen as universal, then it will eliminate scientific pretenders such as creation science. Kawagley *et al*. (1998) explain that having such a tapered view of science confines the legality of knowledge derived through generations of natural observations and it diminishes traditional knowledge. Cobern and Loving (2001) add that there are often contending versions of natural phenomena principally in schools situated in multicultural communities.

Cobern and Loving (2001) expound that there has been an engagement between science and western culture and that this has fragmented the influence of traditional values and forms of representation. Colonial education was designed to use science to modernise and supersede indigenous culture (Cobern & Loving, 2001). They further state that the West dominated the rest of the world using western science and western technology, and also education to impose change onto certain communities. Kanu (2006) states that the western power of colonialism is found at the core of education systems worldwide. The curriculum of western colonising powers aimed to educate obedient citizens, impose chosen knowledge on people, subjugate indigenous knowledge, negate identities and impose a new form of order (Kanu, 2006). He adds that these education systems derive their power and control from western knowledge and impose rules and regulations onto the recipients of this education. This in turn affected and changed the culture of the people on whom it was imposed (Kanu, 2006). Ogunniyi

(2011) adds that indigenous knowledge had been relegated to the background by western education through the advent of colonisation. He further states that education was one of the major tools used by these colonial powers to colonise the indigenous people of these countries. These schools had prescribed curricula that "imposed on the indigenous learners, science taught as a culture-free subject" (Ogunniyi, 2011, p.100).

According to Agrawal (1995), in today's world indigenous knowledge is pivotal in all discussions surrounding sustainable resource use and balanced development. He asserts that on the basis of development, indigenous knowledge is seen to be essential and the systematic collection of indigenous knowledge will further indicate its relevance to development. Agrawal (1995) states that there are presumed differences between indigenous knowledge and western science theorised by other authors.

These presumed differences, according to Agrawal (1995), are not pertinent in today's world. He asserts that attempts of previous authors to distinguish between indigenous knowledge and western science cannot be sustained. He adds that there is a presumption that indigenous knowledge is concerned with the immediate and daily needs of people, while western science seeks to construct a general explanation that does not relate to people's daily lives. Agrawal (1995) explains that this deduction does not hold water because there is scarcely any aspect of the lives of people in the west that do not connect with science. He further states that the presumption indicating differences by previous writers also shows substantial similarities, for example, agronomy and indigenous techniques for domestication of crops, and agroforestry and the multiple tree-cropping systems of small holders in parts of the world (Agrawal, 1995). Agrawal (1995) states that it is impossible to insist upon the candidness of science and the closed nature of traditional knowledge systems as a distinct difference. He further postulates that to successfully build new epistemic foundations, accounts of innovation and experimentation must be used to bridge the gap between indigenous knowledge and western science.

Agrawal (1995) writes on the assumptions of previous researchers about the conservation of indigenous knowledge stating that authors have promoted ex situ conservation. According to Agrawal (1995), there are flaws in this type of conservation when it is applied to indigenous knowledge. He further states that indigenous knowledge is intrinsically scattered and local in character, so it would seem contradictory to attempt to isolate, archive and transfer such knowledge. He continues revealing that, due to the vibrant nature of indigenous knowledge

and its mutable character, together with the fluctuating needs of people, ex situ conservation is ill-suited to the conservancy of indigenous knowledge (Agrawal, 1995).

In his rebuttal to this type of conservation for indigenous knowledge, Agrawal (1995) promotes in situ preservation as a way of conserving indigenous knowledge. He further states that in situ preservation would involve the reorientation and the reversal of state and government policies to certificate the people of the indigenous culture to determine their own future. According to Agrawal (1995) the success of in situ preservation lies in the control of lands and resources being handed back to the indigenous populations and local communities. In this study, the conceptualisation of in situ preservation is extended into teacher education. I argue that by locating the education of teachers at tertiary institutions, in situ preparation of teachers to teach culturally inclusive science can be accomplished. Ex situ education would imply the education of practicing teachers at school level and is less suitable because of the challenges faced by practicing science teachers in South Africa.

According to Aikenhead and Ogawa (2007), the labels of science and Indigenous knowledge guise the similarities that exist amid these two categories. These similarities include empiricism, rationality, and dynamic evolution (Aikenhead & Ogawa, 2007). They further state that these two terms require more authentic categories such as the triad *indigenous ways of living, neo-indigenous ways of knowing nature* and *Eurocentric science* (Aikenhead & Ogawa, 2007, p. 540). Neo-indigenous refers to clusters of Asian cultures and knowledge systems (Aikenhead & Ogawa, 2007). They define neo-indigenous science from cultures that are non-Eurocentric with a lengthy standing history of living in a particular geographical constituency. According to Bauer (1992) in Aikenhead and Ogawa (2007) Eurocentric science involves the working together, within a community, of scientists where Eurocentric Science is communal. Aikenhead and Ogawa (2007) state that Eurocentric sciences theorises that nature is knowable. They argue that this type of science postulates that knowledge typically encompasses generalised descriptions and mechanistic explanations and that the mystery of nature is a key intellectual goal that Eurocentric science assumes to eradicate. According to Aikenhead and Ogawa (2007, p.540), this triad categorisation is in opposition to previous literature which encompasses comparisons between science and indigenous knowledge, and this triad categorisation of indigenous knowledge and science reflects more intricate and genuine concepts than those borne by the idiomatic “dyad” indigenous knowledge and science.

Aikenhead and Ogawa (2007) postulate that exploration into the differences and similarities among these categories offers valuable insight for science teachers in that they can use it to build bridges between Eurocentric knowledge systems and other bodies of knowledge. Aikenhead and Ogawa (2007) articulate that over the past few decades there has been increased interest from science educators about indigenous and neo-indigenous ways of knowing nature. They assert that increased interest is driven by a longing for impartial social justice and the achievement of marginalised learners in mathematics and science. Aikenhead and Ogawa (2007) assert that there are other reasons for interest being sparked. Firstly, some academics feel that there is a need to enlarge the domain of science to encompass features of indigenous knowledge. The purpose of this encompassment would be to improve the involvement of science in the planet's sustainable future. Secondly, there is a movement to enhance the cultural survival of indigenous people from all over the world. And thirdly, a growing number of science teachers want to understand the role of culture in the science performance of learners' from indigenous cultural backgrounds (Aikenhead & Ogawa, 2007).

2.5. IKS and education

According to Owuor (2007, p.23), indigenous knowledge involves the ancient practices of African people together with "the process of learning and sharing social life, histories, and cultures, economic and political practices unique to each cultural group". She adds that "African indigenous knowledge is reflective of the uniqueness of ways that specific social societies make meaning of the world and how such forms of knowledge can be used to address problems in local and specific contexts" (Owuor, 2007, p.23). Looking at education from an African perspective, much of the problems experienced in Sub-Saharan Africa can be referred to using indigenous knowledge (Owuor, 2007). One such problem is development and addressing the knowledge deficiencies for development, which can be achieved by integrating indigenous knowledge into the formal education system. The role of education is therefore highlighted as the harmonising instrument for different forms of knowledge e.g. social knowledge, economic knowledge and political sustainability, all into one social fabric (Owuor, 2007).

2.5.1. IK and the curriculum

Malia and Loubser (2003) argue that with the state of affairs in the world and with the environmental hazards and frailties that exist, now more so than before, there should be a

move towards the development of other systems of knowledge in order to help find solutions. Every avenue should be explored such that the most suitable and environmentally friendly solution is found. One such avenue is the emergence or inclusion of IKS in formal schooling. Ogunniyi (2011) postulates that as alternative solutions are sought for the devastating effects of scientific and industrial activities on the environment, more attention is being focused on indigenous knowledge. Empowerment of other systems of knowledge is part of education. As stated by van Wyk (2002), the inclusion of IKS and its relevance are more pronounced than ever. Malia and Loubser (2003) assert that IKS is assumed to be a part of the Arts and Culture learning area. They add that this assumption is incorrect as it marginalises the effect of IKS and limits the true essence of IKS as a body of knowledge. Rather, IKS can be integrated into educational policies as valuable systems of knowledge (Malia & Loubser, 2003). They postulate that a sense of clarity can be attached to IKS with its inclusion in other learning areas of the South African school curriculum. This confers with van Wyk (2002), who states that IKS is entrenched in many traditions and beliefs of people in South Africa and Africa at large, therefore the traditional knowledge processes in Africa should be based on African culture and on South African culture in particular. Van Wyk continues stating that it should be profoundly biased to a multicultural dimension.

Barnhardt and Kawagley (2005) allude that learners from indigenous cultures around the world demonstrate a distinct lack of interest and enthusiasm for attending or experiencing school in its conventional form. The curricula of mainstream schools emit an approach based on a worldview and exhibit a lack of appreciation for indigenous knowledge and culture (Kawagley, Norris-Tull & Norris-Tull, 1998). Indigenous people have their own way of thinking and relating to the world. Their traditions are entrenched in observing natural processes, adapting for survival, living off the land and making use of the natural elements around them (Barnhardt & Kawagley, 2005). In recent times, indigenous and non-indigenous people have begun to recognise the connectedness that can exist between the two domains of knowledge. Quigley (2009) postulates that there is a movement towards a curriculum that promotes a science that is relevant to all learners. Effective teaching and learning could be an outcome of the conjunction of IKS and formal education. However, this contextualisation must be discernible in that the teacher must be able to augment the experience of science for the learners, both western and non-western, in the classroom (Barnhardt & Kawagley, 2005). To this effect, within some South African classrooms, IKS is included in different concepts of science in the following ways:

- Fermentation – African beer-making
- Food storage – grain pits
- Fertilizers – preparation and use of cow and poultry manure.
- Sustainable use of plants – medicinal plants (Blackjack, turmeric).

According to Ogunniyi (2004), the Revised National Curriculum Statement for Natural Sciences in South Africa sees the use of scientific and indigenous knowledge as important to the development of the learner. Two main characteristics need to be developed in this regard, namely: (i) solve practical problems both inside and outside the science classroom and (ii) demonstrate an understanding of the relationship between science and technology, society and the environment (DoE, 2002). The ability of the teacher is what consequently determines whether or not these two characteristics/traits are attained by learners. The teacher needs to be able to develop these traits and they need to be equipped with the relevant intellectual skills. Ogunniyi (2004) mentions that western science is seen as the only validation for the existence of the world. Ogunniyi (2004) postulates that with the introduction of western science into the education system, the cultural values and practices of African people have begun to erode away. He continues to assert that western science however, is incomplete if it does not include non-western science. Ogunniyi (2004) states that science has a basic mechanistic worldview and that indigenous knowledge systems (IKS) exhibit an anthropomorphic worldview. In the view of Ogunniyi (2004), with the modernisation of society and the world at large, western science has been seen to replace non-western science and consequently, this has led to the gradual disappearance of IKS. Bishop (1990) states that the reviving of IKS has to come about through the emergence of ethno-science. Ethno-science is science that is embedded in various indigenous knowledge systems. Ethno-science as a whole poses a challenge to the science curriculum as it has a negative connotation as an inferior science. Many scholars have focused only on the measure of IKS in western science but never on the important scientific aspects or traditional cosmologies of IKS. Ogunniyi (2004) alludes to the challenge that stems from the fact that the rediscovery of IKS is still in its rudimentary stage and full insight is not being gained as there is little or no direct experience of IKS. Adding to this challenge is the fact that a word can have different meanings in different cultures. Textbooks used in schools also pay little attention to IKS and do not take into account the context of the learner (Ogunniyi, 2004). Dumile (2011) is in agreement with Ogunniyi (2004) and states that certain textbooks make mention of the integration of IKS, but do not provide guidance as to which components of IKS should be

integrated, and how this integration should transpire. Govender (2012) provides a reason for this in that the complexity of IKS can be challenging to comprehend when looking at it from an educational perspective.

Ogunniyi (2012) states that despite the multi-facet science curriculum there are significant challenges that many science teachers are facing. Included among these challenges are "lack of teacher education programmes explicitly geared at equipping science teachers to teach in the present multi-cultural South African classrooms; lack of instructional models that teachers can use to implement the new curriculum; the constraints concerning the feasibility of enacting a curriculum requiring a drastically different instructional approach in an examination-driven education system" (Ogunniyi, 2012, p.2). Ogunniyi (2011) argues that teacher trainers at higher education institutions urge prospective teachers to leave out indigenous knowledge and focus on western science. He adds that "most of our trained science teachers lack a clear-cut guidance about how to implement a science-IKS curriculum" (Ogunniyi, 2011, p.109).

According to Snively and Corsiglia (2001), indigenous science is a culture dependant collective rationale perception of reality and it can also be referred to as ethno-science. Snively and Corsiglia (2001, p.10) add that "indigenous science interprets how the local world works through a particular cultural perspective". Scientists who argue for modern western science dismiss multicultural science as unconventional or unorthodox. People from western countries seem to accept indigenous art, music, literature, drama and politics, but fail to appreciate indigenous science (Snively & Corsiglia, 2001). Indigenous science is sometimes referred to as the "neglected science" but this neglected science can offer new understandings to the science classroom with regard to biology, chemistry and physics (Snively & Corsiglia, 2001, p.7).

Botha (2010) states that Curriculum 2005 is dominated by western science and the knowledge and worldviews of indigenous people of South Africa continue to play a marginalised role in the country's education. She adds that Curriculum 2005 negates important aspects of learning processes of South Africa's traditionally-based communities. Abdi (2003) indicates that the education curriculum in South Africa is supposed to address the oppression of the apartheid era by presenting an anti-colonial and anti-apartheid education. This reformed education curriculum can support the attempt to create a space in the new democratic South Africa for the previously disenfranchised African population

(Abdi, 2003). He further adds that the education system of South Africa must be consciously designed so that people at the base of the education pyramid can be uplifted. Since South Africa is dominated by Black African people, the way they are educated must reflect their traditions and cultures (Botha, 2010). Botha adds that the traditional beliefs of *sangomas* (traditional healers) and ancestors are a strong part of a majority of South Africans. Botha (2010) alludes to the trend of globalisation that makes western science and knowledge more applicable as part of an education system. But according to Botha (2010), a more collaborative approach is needed for education in South Africa where the two, indigenous knowledge and western science, merge to create a more effective education system. Von Lieres (2005) calls for the school to be the arena for negotiating new ways of understanding the particular nature of our nation. Botha (2010) cites Edwards (2005) who argues for a space to be created in the school curriculum for indigenous knowledge. Currently within the new school curriculum (CAPS) in South Africa, space is created for the inclusion of IKS. Hewson *et al*. (2009), however, mentions that teachers are not adequately prepared to engage with such knowledge. In addition to this, Nhalevilo and Ogunniyi (2012) argue that many teachers have not gone through teacher education that has taught them what exactly to teach as IK, how they should teach it, and how IK should be integrated in the science classroom. Dumile (2011) supports the need for teacher education by mentioning that without the necessary support and education, teachers are left to ponder their own ways of integrating IKS into the science curriculum. The idea of an inclusive curriculum promotes the notion that western science and IKS are both valid (Nhalevilo & Ogunniyi, 2012). They add that both should be given space in order for integration to occur.

According to George (1999), indigenous knowledge is an everyday rationalisation that rewards individuals who live within a particular vicinity. He asserts that indigenous knowledge is often known as being part of lay beliefs or common sense beliefs that differs from western science. Serrano (1996) cited in George (1999) contends that this type of knowledge must also exist in the western science classroom.

George (1999) states that the process of making use of indigenous knowledge in the classroom is not a simple initiation. He argues that the main impediment that needs to be overcome is that indigenous knowledge is not embalmed the way other school materials are. It is therefore necessary for the teacher to firstly access indigenous knowledge, ensure understanding of the content, be able to relate it to the material being taught in class, and then

devise effective teaching approaches that will permit the communication of this knowledge to the learners (George, 1999).

George (1999) argues that indigenous knowledge possesses great potential to be used in the teaching of several subjects in the school curriculum. He substantiates this by stating that science teachers who propose making use of indigenous knowledge must comprehend clearly the relationship between the traditional practices and beliefs of the community in which they teach school science. With this increased understanding, science teachers would be better positioned to be effective in the science classroom (George, 1999). Another valuable benefit of science teachers understanding the traditional practices and beliefs of the community in which they are teaching is that learners make extensive use of their everyday lives and cultural experiences embedded in IKS in their arguments. This equips learners with the information found in indigenous knowledge and will greatly increase the knowledge gained in the science classroom (George, 1999).

Ogunniyi and Ogawa (2008) argue that western science has not only marginalised indigenous knowledge, but it has also put forth the notion of being the only valid way of interpreting human experience with nature. Looking at the Japanese school system, there is the inclusion of a subject called Rika which is part of the school science curriculum (Ogunniyi & Ogawa, 2008). This subject consists of two parts, namely, science education and "Shizen" (nature) education. The science education focuses on learners interacting with nature, developing a love for nature and learning to be in communion with nature (Ogunniyi & Ogawa, 2008).

Relating this now to the South African perspective, Ogunniyi and Ogawa (2008) state that the teaching of school science in South Africa is not dissimilar to Japanese Rika or science education. Teachers in South Africa have, for the most part, subscribed to both western science and indigenous knowledge when asked to explain various natural phenomena (Ogunniyi & Ogawa, 2008). Ogunniyi and Ogawa (2008) add that there are numerous studies involving African teachers giving equal importance to both IKS and western science. One such example is Curriculum 2005, but other examples exist in other African countries (Ogunniyi & Ogawa, 2008).

Informal learning settings are popular in both Japan and South Africa because a sense of community and close communication between generations is more prevalent than before (Ogunniyi & Ogawa, 2008). The notion that there is no longer the stronghold of examinations placed on the science curriculum has allowed for a more flexible approach to IKS in South

Africa (Ogunniyi & Ogawa, 2008). Ogunniyi and Ogawa (2008) add that this affects the environment and the environment becomes conducive to enacting the process of transformation and the sharing of cultural values as well as a shifting of the focus from learning a host of scientific facts for an examination, to learning that promotes the amalgamation of school learning with what is needed for a productive member of society. The development of productive members of society is crucial to the economic sustainable future of South Africa.

2.5.2. IK and school teachers

According to van Wyk (2002) given the transformative approach of South Africa, the way teachers view learners' construction of knowledge is more diverse than ever before. Teachers are expected to now have a greater understanding of and insight into how learners group knowledge and construct knowledge. Learning is viewed as a construction where children try to make sense of their world through active exploration of their environment and social exchanges with the people around them (van Wyk, 2002). Teachers of science must value learners' social and cultural context. Teachers who are able to contextualise learners' backgrounds can eliminate the discomfort attached to learning science and can also assist learners in connecting their indigenous knowledge to the formal knowledge taught at school (van Wyk, 2002). He adds that this contextualisation is closely linked to sensitivity. Odora-Hoppers (2000) indicates that sensitivity amongst teachers is crucial to indigenous knowledge being successfully integrated and implemented in schools. This sensitivity of teachers also works to empower both the teacher as well as the learners. If the teacher is sensitive to the culture and the prior knowledge of the learner, then an environment that is more conducive to learning is created. A teacher who is cognisant of the socio-cultural context of the learner will enable learners to accept the content being transmitted more easily (van Wyk, 2002). More than this, teachers could use this to realise their ability to teach. By drawing from learners' indigenous knowledge, neutrality amongst all learners in the classroom can be reached and the creation of social knowledge that compliments personal knowledge can be brought forth.

According to Le Grange (2007), what a child learns through religion may be different to what they learn in school science. Non-western learners are continuously engaged in interaction between two worldviews and this potentially results in cognitive conflict. It is imperative that teachers are aware of this conflict before they enter the science classroom. The inclusion of IKS in the South African school curriculum policy is a positive step, but the effectiveness of

the learning will depend on teachers' understanding of this interaction and IKS as a distinct body of knowledge (Hewson *et al*., 2009). Quigley (2009) asserts that science teachers need to tap into important resources that are located in IK to enhance the learning of science in the classroom.

In the science classroom, non-western learners learn science in a different way to western learners. Le Grange (2007) highlights research done on ways in which indigenous knowledge might be integrated and explored, and the factors regarding non-western learners in the science classroom. These include: "the social background of the learners has a greater effect on the learning of subject content; the indigenous worldview inhibits the adoption of western science; non-western learners are involuntary in their observations in the science classroom; and the non-western learner might explain natural phenomena in ways that seem irrational if looked from a western science perspective" (Le Grange, 2007, p.582). These factors lead to a lack of integration of IKS within the science classroom. But importantly, the existence of IKS in the science curriculum does not necessarily mean that teachers will be teaching it. If teachers are teaching IKS in the science curriculum, it does not imply that it is being done in a manner that promotes domain congruency.

2.6. The relevance of IK in formal education: From an international and continental perspective

An international study done by Michie and Linkson (2005) reveals how curriculum developers in Australia refined the science curriculum such that it became accessible to all members of society. This promoted the notion of "Science for all" (Michie & Linkson, 2005, p.1). They add that the aim of this refinement was for the inclusion of cultural backgrounds of all learners in the planning and teaching of science. Michie and Linkson (2005, p.2) allude to the point "that conflict arises when two worldviews are compared unsympathetically rather than considered as complimentary, and to avoid conflict of both worldviews (IK and western science) are equally valid and are based within each culture".

Owuor (2007) examined the Kenyan education system and the relevance of indigenous knowledge in formal education. The concept of integrating indigenous knowledge into the formal education system is not new to Kenya because for some time now Kenyans have been attempting to reclaim their cultural identities that are rooted in indigenous knowledge systems (Owuor, 2007). This integration is being used as a way of decolonising the country and

removing the western dominance in the education system of Kenya. According to Owuor (2007), the Kenyan people believe that the western dominated school curricula undermine African values and cultural practices and impose western culture and tradition. Reclaiming their African identity attaches self-worth that is grounded in their own authentic cultural systems of knowledge construction and this must be developed in young Kenyans (Owuor, 2007).

Dziva, Mpofu and Kusure (2011), who studied the Zimbabwean context, found a vast gap between the culture of formal education and the learners of the country. The school science of the country is a reflection of their British colonial history and has many traits found in the colonial style education system (Dziva *et al*., 2011). They assert that the education policies of Zimbabwe reflect very little cultural heritage, which has led to an increasing need for teaching to incorporate learners' cultural knowledge that is embedded in their indigenous knowledge. But there is little being done to integrate indigenous knowledge into school curricula, thus there is an emphasis on the need for teaching and learning in Zimbabwe to incorporate the traditional cultural knowledge that it possesses (Dziva *et al*., 2011).

Liphoto, Kolsto, Oluka and Ogunniyi (2008), mention that the main reason for localising the science curriculum in Lesotho was to make it responsive to the needs and values of the Basotho people as a nation. They contend that the children in Lesotho enter the science classroom having already gained some knowledge. The knowledge that these learners possess cannot be ignored and the backgrounds, conceptions, culture and their explanations cannot be overlooked. It is crucial to the education of these learners that the teachers of these learners should be aware of the influence of culture on learners' conceptions of diverse natural phenomena (Liphoto *et al*., 2008). Liphoto *et al*. (2008) assert that Africans should remain African by investing in their traditional cultures, while still absorbing modern influences.

Tisani (2004) argues that the natural environment and resources are nearing depletion and this is due to the radical advancements of western science which is threatening the pollution levels of the world, as well as the ever-widening hole in the ozone layer. The integration of African IK and western science should be in a continuum, and alternative ways of teaching and learning for both academics as well as non-academics, should be a priority constituting an intertwined knowledge system including African IK (Tisani, 2004).

Relating this to the South African context is simple because, like Zimbabwe and Kenya, South Africans have emerged from a history of colonisation with the added scars of

apartheid. As stated by van Wyk (2002), we live in a multicultural and multilingual country; we also need to have the zeal to want to establish our pride among young people, pride that is rooted in the traditions and values of the country's people. Our education system must not only be reflective of our history, but also be informed by our democracy. Learners at school must believe that they are learning a curriculum that is developed by South Africans who want to educate their youth to become informed and communicative young people who possess a rich cultural knowledge of their land.

2.7. A method to introduce indigenous knowledge into science classrooms

Ogunniyi (2007) proposes that argumentation, which is a statement or a group of statements put forward by an individual or a group of individuals to justify or contest a claim in order to attain the commendation of an audience, can be used to reach consensus on controversial issues such as the integration of IKS and science. Argumentations have been used as a rhetorical and instructional tool for a significantly long time (Ogunniyi, 2007). Skirbekk and Gilje (2001) add that during the process of argumentation there exist certain inevitable conditions that allow an argument to occur. They underscore the following conditions;

- participants must be able to follow the argument and be submissive to a superior argument;
- the mutual recognition of one another as both reasonable and fallible participants where equity is a normative component;
- the element of universalization as a valid argument needs to be valid for everyone.

Ogunniyi (2007) argues that if teachers were given a dialogical or intellectual space to express their views and put forward their arguments for or against Curriculum 2005, there would be greater acceptance of it and the integration of IKS. Historically, from a science perspective, the progression of science was due to the advent of argumentation, dialogue and revolutionary ideas (Ogunniyi, 2007). In the science classroom, interactive arguments and dialogues tend to encourage teachers and learners to voice their views on certain scientific concepts (Ogunniyi, 2007). Argumentation can be used in the science classroom by both the teacher and the learner to clear their doubts, increase their current knowledge, acquire new understandings and reasoning, change perceptions, attitudes, and help them make informed decisions regarding the use of IKS (Ogunniyi, 2007). Ogunniyi and Ogawa (2008) add that from the results of numerous studies it is clear that the most effective approach to make

teachers emphasise IKS in the science classroom is through their engagement in long-term processes involving dialogue, argumentation and role modelling.

Hewson and Ogunniyi (2011) assert that the new school curriculum in South Africa (NCS) is innovative in that it requires that learners should be taught school science within the context of their societal and cultural knowledge. They add that as stipulated by the Department of Education, 30% of a learner's school curriculum must comprise of content and contexts of local significance. The implementation of this will, in theory, provide learners with the essential grounding for effective learning and the promotion of learners who are aware that different viewpoints exist in this multicultural society (Hewson and Ogunniyi, 2011).

Over the last decade, interest has been ignited over the effectiveness of the use of argumentation to enhance teachers' and learners' understanding of the nature of science (Ogunniyi & Hewson, 2008). Toulmin's Argumentation Pattern (TAP) has been a frequently used argumentation model by science institutions to heighten the understanding of the nature of science for both teachers and learners (Ogunniyi & Hewson, 2008). According to Hewson and Ogunniyi (2011, p.682), TAP is helpful to learners and allows them "to make claims concerning the phenomenon being studied, to provide data, to provide supportive statements in the form of warrants, to reveal their backings, and to offer rebuttals or counter claims." According to Ogunniyi (2007), TAP comprises a claim, data, warrants, backings and rebuttals. He further explains that TAP has been criticised for its inconsistency by including backing, rebuttal and warrants but no data. Ogunniyi and Hewson (2008) state that TAP is more relevant to a deductive-inductive classroom discourse and is not pertinent to the integration of IKS into the science classroom. It is for this reason that the Contiguity Argumentation Theory (CAT) is recommended, as it deals with both logical, valid arguments as well as non-logical discourse encompassed by IKS. Ogunniyi and Hewson (2008) mention that the CAT model is embedded in the Contiguity Theory. The Contiguity Theory is a learning theory that asserts that two systems of knowledge can work together to create a more enhanced system of knowledge (Ogunniyi & Hewson, 2008). According to Hewson and Ogunniyi (2011), the CAT model integrates culture into science and this model proposes five vibrant adaptive cognitive outcomes that occur when learners endeavour to resolve conflict between two different bodies of knowledge, e.g. IKS and science. These outcomes include:

- dominance, where one idea possesses more cognitive power than another;

- suppression, a previously dominant idea becomes suppressed in favour of a more dominant idea;
- assimilation, a new idea unified with prior ideas;
- emergence, the approval or generation of new ideas without the existence of preceding knowledge;
- equipollence, where two competing ideas have equal cognitive power and co-exist without rational connection (Hewson & Ogunniyi, 2011).

The TAP model and the CAT model both encourage learners and teachers to be involved in the discussion of ideas in a way that they are able to verbalise their viewpoints and decide which ideas have the greater power. Both the TAP and CAT models involve interactivity and discursiveness. Teaching with argumentation differs from the traditional instructional approaches of many South African schools, because fundamentally it does not allow the transmission of scientific facts (Hewson & Ogunniyi, 2011).

Ogunniyi and Hewson (2008) postulate that there have been attempts to improve teachers' understanding of the nature of science but with little success because of the lack of teaching approaches afforded to teachers such that they can translate the knowledge they have gained into classroom practice. They further state that much research has been done to illustrate the most effective way to get teachers to understand the nature of science, which is to have them engaged in long-term mentoring, dialogues and explicitly reflective instructional approaches.

2.8. IKS and higher education

The university had identified the need for a policy on African Indigenous Knowledge Systems. As such, the policy on AIKS was developed. The university has adopted this policy and states that the purpose of this policy "is to advance the sustainable development, promotion and protection of AIKS in research, teaching, learning and community engagement consistent with the university's vision of becoming the premier university of African scholarship" (AIKS policy, p.1). Furthermore, Naidoo (2010) asserts that a Bachelor of IKS degree was introduced in 2009 by four historically disadvantaged universities, namely the universities of Venda, Limpopo, North West and Zululand.

Odora Hoppers (2001) contends that scientific practices in South Africa have the same intentions or directives as colonialism and apartheid. She states that African children enter school and perform badly in mathematics and science because components of these subjects

are taught mechanically without any attempt to link it to the prior knowledge of the learner. Like colonialism and apartheid, which aimed to direct people into a certain way of living and thinking, so too are scientific practices pushing learners in schools and tertiary institutions towards western science (Odora Hoppers, 2001). She adds that tertiary institutions set standards that they require students to reach in order to be deemed successful. But what these institutions choose to include or exclude from their content could make a significant difference to the cognition of the students that are at that institution (Odora Hoppers, 2001). Odora Hoppers (2001) argues that western science knowledge is still valuable and is a body of knowledge to be acquired. She contends that indigenous knowledge systems represent both a national heritage and national resource to be protected, promoted and conserved. This has implications for tertiary education.

Ogunniyi and Ogawa (2008) emphasise that alternative ways of restoring our natural environment are in demand. Indigenous knowledge systems are the vehicle to set this restoration in motion, but there needs to be a substantial revision of the content and modes of delivery of content to pre-service teachers at tertiary institutions (Ogunniyi & Ogawa, 2008). If this revision of content and mode of delivery were done for pre-service teachers in higher education, teachers would become knowledgeable about the nature of science and indigenous knowledge systems (Ogunniyi & Ogawa, 2008). They postulate that this would create in teachers an awareness of how indigenous people deal with environmental problems and these teachers would also inculcate in their learners the relevant knowledge, skills and values to manage their immediate environment.

If improvement of teachers' knowledge of science is to be successful, then help needs to be given to them regarding the translation of this knowledge into classroom practice, according to Nichol and Robinson (2000). They add that teachers need to ensure that programmes are developed so that the specific needs of learners are met. Ogunniyi and Ogawa (2008) indicate that informing teachers about science and IKS cannot guarantee that these teachers will be able to integrate the two systems of knowledge in their instructional practices within the science classroom. They go on to mention that according to a number of studies, the most effective way to get teachers to underscore science and IKS in their science classrooms is for these educators to be engaged in a long-term mentoring process. This mentoring process can be "in the form of dialogue, argumentation, role-modelling and explicitly reflective instructional approaches within a conceptual change framework" (Ogunniyi & Ogawa, 2008, p.183). What is important and noticeable is that there is a call on the education institutions of

these science teachers to include courses and research initiatives to help make a new science curriculum (integrating IKS) work (Ogunniyi & Ogawa, 2008).

Higgs and van Niekerk (2002, p.38) contend that "South Africa needs to develop an indigenous knowledge system which will support local economic development and enhance its rich culture, technological, artistic, linguistic and traditional healing heritage". They further postulate for an IKS programme that will promote a synergy between modern knowledge creators and institutions of IKS, so that dialogue can be facilitated between IKS and western based systems of knowledge. This IKS programme or strategy promises to contribute significantly to the creation of wealth in local communities by utilising indigenous technologies (Higgs & van Niekerk, 2002).

Relating this to institutions of higher education, Higgs and van Niekerk (2002) state that the curriculum at these institutions is dominated by western knowledge systems. They add that one of the challenges faced by higher education is how to go about creating a relevant interpretation of Eurocentric curricula when working with African ethno-centric people (Higgs & van Niekerk, 2002).

Higgs and van Niekerk (2002) suggest that an IKS programme can inform the educational discourse of higher education institutions because prominence can be given to IKS and attention can be given to the underlying philosophical issue of creating space for the African voice. They emphasise that the African context needs and deserves special attention in the curricula of higher education, especially those institutions involved in the education of teachers. Matos (2000) states that the context of the African people is held in high regard in the IKS programme. It is for this reason that the IKS programme needs to be a substantial and visible part of the formal curricula of higher education. He adds that the higher education system as a body must be aware of the community in which it is located. Understanding the locality in which it is found serves to highlight one of the goals of an education system, which is to create a better life for the people of the community in which it serves (Matos, 2000). Higgs and van Niekerk (2002) state that educators in higher education need to have an attitude that should transmit to a diverse student population the idea of legitimacy in their own voice. Furthermore, they postulate that students must be encouraged to find the link between content being taught to them and their own life experiences. The challenge for educators in higher education institutions is to be able to facilitate the connection between what they teach and the life experiences of students.

Tisani (2004) asserts that in the transformation of higher education in South Africa, one mechanism that can propel this transformation forward is curriculum development. He goes on to state that at the centre of a vibrant, growing and adapting education system is curriculum development. The curriculum sometimes undergoes radical changes, and Tisani (2004) is of the view that it is the responsibility of the teacher educator to interpret the changes and integrate them in a meaningful way. Higher education institutions have an added responsibility as producers of new knowledge (Tisani, 2004).

Tisani (2004) states that there is a lack of integration of African IKS into the mainstream of teaching and learning in South African higher education curricula. Furthermore, he postulates that current thinking is to "expose tertiary students to real life situations to consolidate their learning, just as education programmes run mainly in technikons in South Africa expose their students to industry" (Tisani, 2004, p,180). He adds that tertiary institutions in South Africa adopt the approach of reducing IK to an object of research. But there has been development and a generalisation of the value of knowledge possessed by other knowledge systems such as IKS (Tisani, 2004).

Ogunniyi (2004) postulates that conventionally trained science teachers in higher education institutions are hardly more than transmitters of the scientific knowledge they have been schooled in. He continues by adding that this is because these science teachers are schooled in scientific modes of inquiry that assume that nature is real, observable and testable, space is real and has definite dimensions, time is real and has a continuous irreversible series of duration. This claim is opposed to the assumptions underlying indigenous knowledge systems which state that nature is real and partly observable and testable, space is real and has definite dimensions but ultimately incommensurable and time is real, continuous and cyclical (Ogunniyi, 2004). Ogunniyi's views have implications for higher education institutions which offer teacher education.

2.9. IKS and transformation

According to Tisani (2004), transformation of the South African education system entails making it relevant to the people and the needs of the South African society. The society of South Africa is besieged with the problems such as HIV & AIDS, unemployment, poor service delivery, poverty and crime. The South African education system must have at the forefront of its agenda the strategies to educate the youth of South Africa so that these issues,

as well as others, can be alleviated and the challenges stemming from them overcome. He continues stating the importance of the neglected African IKS being part of this transformation, adding that without it, the transformation process would be a re-enactment of the old colonial and apartheid systems. Le Grange (2004) alludes to the point that if IKS is to contribute to transformation, education has a pivotal role to play. He states that educational transformation faces a dual challenge, it has to transform for its own sake but also crucially for the sake of the transformation of other spheres of social life.

Dei (2002) contends that the challenge for the western academy is to validate the legitimacy of IKS as a tool in the process of delivering education and the recognition that different knowledge exists is key to the integration of IKS into western academies. He continues to state that by integrating or including IKS in education, indigenous and minority scholars would also need to join teaching facilities. Dei (2002) mentions that integrating IKS is only the beginning of the challenge and acknowledging the complementation of different knowledge systems is vital. Another challenge highlighted by Green (2007) is that IKS policy calls for the re-evaluation of poetics and politics of epistemology and because of the way it was evaluated initially by science and in law, a place in the university for IKS is hard to find.

Within the South African context, Greenlands University (this is a pseudonym used to anonymise the university) has the vision of becoming the premier university of African scholarship. It is with this in mind that the university's Institutional Policy on African Indigenous Knowledge Systems (AIKS) was designed. The introduction of this policy states that for centuries African communities have developed their own systems of knowing and knowledge production through social practice. These social practices were a part of every aspect of their lives. This policy further states that AIKS was extremely marginalised and seen as primitive and unscientific during colonial eras. According to the university policy on AIKS, Africa is one of the few continents that still permit foreign developmental paradigms to be central in their developmental progressions. The policy further states that the full potential of the continent's indigenous knowledge has not been exploited to benefit the African people.

Le Grange (2004) argues that South Africa has to use the good of western science as well as the perspectives of IKS for development to occur. He cautions that the continuing neglect of IKS will worsen the destruction of natural environments and the denigration of the cultures of African people. According to Gratton (2003) as cited in Le Grange (2004), the integration of

indigenous knowledge with western science in higher education helps negate the blind spots and fissures currently existing in science education.

Horsthemke (2008, p.338) observes that the idea of indigenous knowledge "is a very recent phenomenon in higher education". He states that the ideas of reclamation and transformation are linked closely to the inclusion of indigenous scientific knowledge in the tertiary educational curricula. Horsthemke (2008) postulates that the challenge facing curriculum developers at university level is what to include and what to exclude regarding indigenous knowledge systems. He goes on to state that the inclusion of myths, beliefs, fabrications and superstitions should not be included as it can be seen as an infringement on the epistemic right of students.

2.10. Theories of IKS in science education

2.10.1. Cultural border crossing

Incorporating IK in science teaching involves the concept of cultural border crossing. According to Aikenhead and Jegede (1999, p.269), cultural border crossing is "the transition between a student's life-world and school science". Related to cultural border crossing is collateral learning. Jegede and Aikenhead (1999, p.52) state that "collateral learning generally involves two or more conflicting schemata held simultaneously in long-term memory". Jegede and Aikenhead (1999) further assert that teachers who want to teach science that is relevant to all learners face the challenge of cultural clashes between western science and the culture of the learner. In order for 21st century science teachers to overcome this immense challenge, they require teaching methods and curricula that are culturally sensitive (Jegede & Aikenhead, 1999). The teacher needs to guide the learner between the culture of science and the culture of the learner, and the success of the learner in science is dependent on how well the teacher is able to negotiate cultural borders with the learner (Jegede & Aikenhead, 1999).

Aikenhead and Jegede (1999) mention research conducted in Nepal and Canada where teachers devised specific methods and strategies that were applicable to their teaching context in order to facilitate border crossing for their learners. In our South African context, the same approach is required. Teachers need to be conscious that the culture of the learner is significant and that border crossing needs to occur between the learner's culture and the culture of science. Pre-service teachers need to be taught how to negotiate cultural borders

and be exposed to teaching methods that will assist them in their teaching. Cultural border crossing is important in the inclusion of IKS in science teaching.

2.10.2. Collateral learning

Jegede and Aikenhead (1999, p.52) define collateral learning as "two or more conflicting schemata (ideas) being held simultaneously in long term memory." As mentioned earlier, learners in the science classroom are faced with a conflict between the IK they possess and the school science being taught to them. Collateral learning can be used by teachers to aid their understanding of how learners think when found in the science classroom. Jegede and Aikenhead (1999) postulate that conflict resolution and meaningful learning of science conflicts are the results of collateral learning.

Aikenhead and Jegede (1999) identify four types of collateral learning:

- Parallel collateral learning refers to ideas that are conflicting and do not interact in any way. Both ideas are held in the mind of the learner and can be accessed interchangeably depending on the context in which the learner is found.
- Secured collateral learning is where two conflicting bodies of knowledge are held by the learner, but the learner has found a way to achieve commonality between the two. This can be done by the learner recognising that one body of knowledge can be used to reinforce the other body of knowledge (Aikenhead & Jegede, 1999).
- Dependant collateral learning occurs when one body of knowledge challenges another body of knowledge. In doing so the challenge from one to the other allows the learner to formulate new ideas. This could occur by the modification of an IK concept through the challenge made by an opposing science concept (Jegede & Aikenhead, 1999).
- Simultaneous collateral learning refers to the learning of a concept from one knowledge domain facilitating the learning of a similar concept from another knowledge domain (Aikenhead & Jegede, 1999). A concept in IK can help facilitate the learning of a similar science concept located in school science.

Collateral learning is closely linked to cultural border crossing. This concurs with Aikenhead and Jegede's (1999, p.277) assertion that "effective collateral learning in science classrooms will rely on successful cultural border crossings into school science." They further postulate that cultural border crossing and collateral learning are primarily interrelated.

Another concept closely associated with collateral learning is that of the science teacher being a cultural broker. Jegede and Aikenhead (1999) assert that science teachers should be engaged with collateral learning and be actively guiding learners in meaningful learning of science concepts. "A science teacher who is a culture broker will guide learners between their culture and the culture of science, and help them resolve conflicts" (Jegede & Aikenhead, 1999, p. 55). This can be implemented in the science classroom to facilitate learning, taking learners from their familiar knowledge (IK) to the unfamiliar knowledge (school science).

2.11. IKS and teacher education

Darling-Hammond (2000, p.166) mentions that "over the past decade, public dissatisfaction with school has included dissatisfaction with teacher education". The dissatisfaction with teacher education is also highlighted by Berry, Daughtrey and Wieder (2010) who state that many traditional university courses train pre-service teachers in universal practices rather than specific courses relevant to the community and culture that they will be teaching in. They call for teacher education to be done with the community, and the culture of the surroundings in which pre-service teachers will be teaching to be taken into account. Teachers who are able to recognise and take into account the community and culture of the surroundings in which they teach are more effective in their teaching. This resonates with Darling-Hammond's assertion (2000, p.167) that "researchers have found that teachers who have greater knowledge of teaching and learning are more highly rated and are more effective with students".

2.11.1. Microteaching

In this study, the experience of learning to teach culturally inclusive science took place through a PCK module located in a microteaching setting. Bucat (2004, p.217) states that "there is a vast difference between knowing about a topic, and knowing about the particular teaching and learning demands of that particular topic". This reveals the value of a PCK module which focuses on the specific teaching and learning of a particular topic in science. This correlates with Lee and Luft (2008, p.1334) who assert that "many researchers in the area of teacher education have recognised PCK as a critical component of the professional status of teachers". Lee and Luft (2008) are of the view that PCK is vital to the teacher education of a prospective teacher.

According to Remesh (2013, p.158), the art of teaching does not only involve the transference of knowledge but rather, "it is a complex process that facilitates and influences the process of learning". He further asserts that microteaching can be used to help pre-service teachers develop the relevant skills needed to teach. By definition, microteaching is a "teacher education technique for learning teaching skills. It employs real teaching situations for developing skills and helps to get deeper knowledge regarding the art of teaching" (Remesh, 2013, p. 158). Altuk, Kaya and Bahceci (2012, p.2964) define microteaching as "a technique which is used to train student teachers in a minimized and restricted or artificial teaching environment".

Remesh (2013) emphasises that a benefit of microteaching for pre-service teachers is that it helps build stronger teaching skills and eliminates common errors. Altuk *et al*. (2012) underscore the benefits of microteaching which include:

- Pre-service teachers having the opportunity to observe their lecturer as well as fellow pre-service educators teaching. This allows them to analyse and reflect on their teaching,
- Pre-service teachers becoming more aware of their shortcomings in teaching and this helps them develop pedagogic content knowledge,
- Pre-service teachers' awareness of the potential use of technology in education increases.

Ananthakrishnan (1993, p.142) observes the following benefits of microteaching:

- "It focuses on sharpening and developing specific teaching skills and eliminating errors
- It enables understanding of behaviours important in classroom teaching
- It increases confidence of the learner teacher
- It is a vehicle of continuous training
- It enables projection of model instructional skills
- It provides expert supervision and a constructive feedback
- It provides repeated feedback without adverse consequences".

Remesh (2013) asserts that these benefits are achieved through a process involving planning, teaching, observing, re-planning, re-teaching, and re-observing and that this can be done by using a single concept and working with small groups of students.

In this study it was revealed that teacher education involving microteaching was extremely beneficial to pre-service teachers in that it provided an opportunity to enhance their learning. The use of microteaching proved beneficial in pre-service teachers' education of how to incorporate cultural knowledge embedded in IKS in their Natural Sciences teaching, and to improve on their shortcomings. This correlates with Ananthakrishnan's assertion (1993, p.142) that microteaching "eliminates some of the complexities of learning to teach in the classroom situation". He adds that microteaching allows the observer (lecturer) to closely observe each individual pre-service teacher's faults whilst teaching, and provide constructive feedback to the individual.

2.11.2 Culturally responsive education

According to Smith (2005), the belief of teachers regarding teaching and learning is shaped largely by their experiences. Bryan and Atwater (2002, p.823) state that "beliefs are part of a group of constructs that describe the structure and content of a person's thinking that are presumed to drive his/her actions". Pre-service teachers enter teacher education facilities with beliefs about teaching and learning (Smith, 2005). This corresponds with the view of Bryan and Atwater (2002, p.823) that "pre-service teachers enter their undergraduate programs with little or no intercultural experiences and with beliefs and assumptions that serve to undermine an equitable education for students of culturally diverse backgrounds". This indicates that pre-service teachers come into Natural Sciences teacher education modules with their own beliefs and then need to be trained so that they can teach learners from diverse cultures. It is at this junction that teacher education institutions need to provide these pre-service teachers with teaching methods needed to educate learners from diverse cultures with knowledge of Natural Science. This resonates with Bryan and Atwater's (2002, p.825) assertion that "given the increasing growth rate of the population of students of colour, we (teacher educators) need to seize the opportunities to use knowledge of teacher beliefs to tailor instructions to address conceptions of those who are expected to meet the needs of a variety of learners".

The view that teacher educators have of teacher education is crucial to the development and education of pre-service teachers, and also to the success these pre-service teachers have in the classroom. This resonates with Smith's (2005, p.28) assertion that "teacher educators must also acknowledge and honour the complexity of teaching and learning to teach – understanding and building upon the strengths... of teacher candidates as they prepare to teach children". The assertion by Smith (2005) correlates with that of Bryan and Atwater

(2002, p.833) that "both teacher educators and students of teaching need to view teaching as a personal process of inquiry and view tensions or cultural bumps as a necessary catalyst for developing professional knowledge and skills about science learning and teaching". Another aspect of teacher education that is vital is the content being taught. The content taught to pre-service teachers must encompass the full spectrum of what they are likely to encounter in a school situation. This concurs with the argument of Bryan and Atwater (2002, p.833) that "a cohesive science teacher education infuses issues of race and culture in education, social science and science courses".

2.12. Silence/gap in literature that was reviewed

The above literature that was reviewed included the views and experiences of various researchers, policy makers, curriculum designers and practising teachers of a culturally inclusive science education embedded in indigenous knowledge systems. There is paucity in the literature related to capturing the views and experiences of pre-service teachers about a culturally inclusive science education. The literature that was reviewed does not centre on pre-service teachers; this indicates that pre-service teachers appear to be marginalized in the area of culturally inclusive science education. It is therefore important to explore the views and experiences of pre-service teachers.

2.13. Theoretical framework

Socio-culturalism is a learning theory postulated by Vygotsky. The socio-cultural theory of Vygotsky (1978) states that learning is a social process and that human intelligence originates in society or culture. In the socio-cultural theory, learning occurs through interaction, negotiation and collaboration. But what is peculiar to this theory is the notion that instruction is informed by the discourse, norms and practices associated with communities. The aim of instruction is to encourage students to engage in activities, discussions, and use tools that are consistent and form part of the community to which they are being introduced (Vygotsky, 1978). According to Lantolf (2000), the socio-cultural theory of Vygotsky postulates that humans do not impact their physical world directly, but rather act on it with the aid of tools. He further states that these tools are created by a person's cultural and historical conditions. Lantolf (2000) explains that humans use these tools as aids in problem solving and that these tools, in turn, influence the individuals who use them. This occurs in such a way that it gives

rise to previously unknown activities and previously unknown ways of conceptualizing world phenomena.

Implicit in the socio-cultural theory is the consideration that natural and social worlds have co-evolved in cultures, and that science, in order to be useful, needs to be taught within social and historical contexts (Mudaly, 2011, p.30). A socio-cultural perspective of science education conceptualizes learning as not only understanding and memorizing of scientific facts and processes, but also understanding cultural realities in learners' lives that make the learning of science revolve around learners' interests. Reis & Galvao (2009, p.1) researched teachers' practices and asserted that "several teachers in science have called for the inclusion of the controversial socio-cultural-scientific issues discussion in science curricula because of its potential for creating a more real, humane image of scientific activity". Vygotsky (1978) alludes to the point that although the biological factors are fundamentally necessary for elementary processes to merge, for the development of rudimentary natural processes, socio-cultural factors are requisite. He regards the uniqueness of the social context and socio-cultural background as the principal and determining factor in the development of higher forms of human mental activity.

According to Vygotsky (1978), collaboration between students in joint activities constructs new strategies and knowledge of the world and culture for students to acquire. Vygotsky is of the belief that every child brings something from their culture, history and institution when they interact with another child or person. Collaboration between the student and the teacher is encouraged. The teacher is seen as the vehicle or scaffolding that evolves a student's understanding of knowledge or the development of complex skills. Vygotsky (1978) also states that the environment around the student must be socially rich so that an exploration of knowledge can occur. He also viewed learning as an individual cognitive development. This is subject to a "dialectical interplay between nature, history, biology and society" (Govender, 2009, p.122). With relevance to this study, culturally inclusive science education, particularly as it relates to indigenous knowledge systems, is embedded in a socio-cultural learning theory.

Wertsch (1985) states that the theorising about the Zone of Proximal Development (ZPD) by Vygotsky was an effort to deal with two practical problems found in educational psychology. These problems were the evaluation of instructional practices and the assessment of children's intellectual abilities. Vygotsky's Zone of Proximal Development is defined as "the

distance between a child's actual development level as determined by independent problem solving, and the higher level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Wertsch, 1985, p. 60).

Donald, Lazarus and Lolwana (2002) state that the ZPD may be defined as that space that lies just beyond a child's present understanding. It is that critical space where a child cannot quite understand something alone, but has the potential to do so through proximal interaction with another person who has the capacity. A teacher is able to provide the learner with "scaffolding" to support the students evolving understanding of knowledge domains or development of complex skills. Collaborative learning, discourse, modelling and scaffolding are strategies for supporting the intellectual knowledge and skills of learners and facilitating learning.

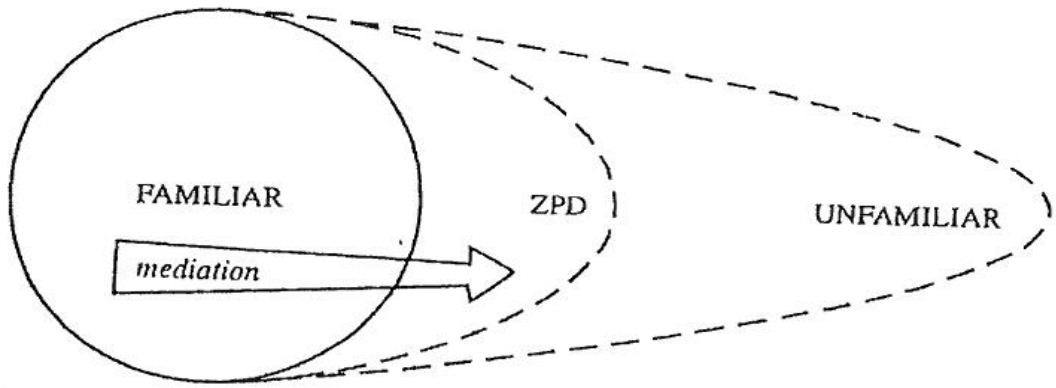


Figure 2 - Zone of proximal development (ZPD)

Donald *et al*. (2002), p.71

Donald *et al*. (2002) state that the ZPD is the critical space in a persons' current understanding where, through face-to-face mediation a new level of understanding can be fashioned. They further mention that the ZPD can be explained in terms of a teacher standing before a class. The teacher must take cognisance of the fact that he/she cannot introduce concepts to the class that are too far beyond their grasp, risking the loss of their attention. Neither can the teacher present concepts that are too familiar to the class, for the attention of the class may dwindle. But, the teacher must engage the class in the critical space of potential development where the concepts are somewhat familiar to the class, but the class still wants

to enquire more about it. The ZPD is this critical space where potential development of knowledge can occur (Donald *et al*., 2002).

Vygotsky (1978) mentions that learners should be provided with socially rich environments in which to explore knowledge domains with their teachers. The concept of argumentation can be used by the teacher, in conjunction with the ZPD, to explore knowledge domains with learners. This would involve the teacher acknowledging and supporting the familiar, indigenous knowledge of the learner. Thereafter, by introducing a new concept of western science to learners and by using argumentation, the teacher can justify the new concept to learners in order to acquire their commendation, and then move with learners to the unfamiliar, new knowledge.

Kinginger (2002) supports the use of Vygotsky's ZPD in educational situations. She argues that "the ZPD is a tool capturing the emergence of cognitive development within social interaction, when learners are provided with assistance from more-competent others (teachers or peers) as they engage in learning activity" (Kinginger, 2000, p.240). Her argument for the advocacy of the ZPD is that it encourages learning.

My study examines how pre-service teachers learn to teach culturally inclusive science, specifically as it relates to IKS. I use the socio-cultural learning theory with the Zone of Proximal Development as a theoretical framework to understand how pre-service teachers learn to teach culturally inclusive science.

2.14. Link between theoretical framework and study

Currently in tertiary education science classrooms, the science that is being taught to pre-service teachers is embedded in a western framework. Western science excludes learners' cultural backgrounds although the cultural background of learners should not be excluded in the science classroom. Vygotsky's ZPD (1978) calls for learning of new concepts to begin with the acknowledgement of the prior knowledge of learners, and in this study, the focus will be on prior knowledge which is rooted in IK. This theory is applicable to my study as it calls for the inclusion of culture when learning to teach science.

2.15. Conclusion

The literature reveals that South African learners are performing poorly in science. This is in comparison to the rest of Africa and other countries around the world. This poor performance

was represented in an international study called TIMMS conducted by the International Association for Evaluation Achievement. This poor performance was attributed to the irrelevance of the school science curriculum, as well as under qualified teachers, a lack of involvement from parents, and the socio-economic status of learners, as well as language issues since the evaluation was done in the English medium (second language learners were disadvantaged and also may have performed poorly due to this). In order for the performance to improve, the literature shows that the science being taught must be culturally relevant to learners. This can be done through the integration of IKS in science teaching. IKS takes into account the cultural experiences and backgrounds (rooted in IKS) of learners. By integrating IKS in science teaching, teachers will be recognising the IK that learners bring into the science classroom.

The integration of IK into the science curriculum is linked to the development of school science curriculum. Literature reveals that there needs to be transformation in the development of the curriculum for school science. Studies in Kenya and Zimbabwe reveal that educational systems have been transformed so that the cultural knowledge of the people of the country is reflected in the education curriculum. IKS must be integrated into the science being taught at school, so that the prior knowledge and cultural knowledge of the learners are taken into account in the science classroom. The acknowledgement of the cultural knowledge possessed by learners promotes effective teaching and learning. The literature further expresses that if the cultural knowledge (rooted in IK) of the learner is to be recognised in the science classroom, then culturally responsive teachers are a necessity. Teachers of science must be able to see the value of the cultural knowledge of learners and use this knowledge in their science teaching. Sensitivity is required by teachers of science so that the IK of learners is not ignored. The literature shows that if learners are ignored in the science classroom, their learning and understanding is impacted negatively. But if learners are included in the science lessons and their cultural knowledge is recognised, literature reveals that their learning and understanding is enhanced.

A teacher being culturally responsive is connected to the teacher education they receive. The literature shows that the curriculum of teacher education institutions is dominated by western knowledge systems. Literature calls for content at these institutions to be revised so that IKS can be integrated into it. If pre-service teachers receive teacher education that integrates IKS, then they will transfer that knowledge into the science classroom. However, literature indicates that there is a lack of integration of IKS into mainstream teaching and learning in

South African higher education curricula. Teacher education is not equipping pre-service teachers to teach culturally inclusive science (that is rooted in IKS). A review of the literature reveals that there is a paucity of documented research relating to the views and experiences of pre-service teachers who integrate cultural knowledge in their learning experiences. This reveals that pre-service teachers appear to be marginalised in the area of culturally inclusive science education.

The review of literature and theories assisted in the research design, analysis, findings and recommendations in this study. The next chapter will focus on a discussion of the research design and methodology which was employed for the study.

CHAPTER 3

Research Methodology

Chapter 3

Research Methodology

3.1. Introduction

Methodology refers to a philosophy or the general principles which will guide the research (Dawson, 2007). In this chapter I describe and explain the research methodology selected for this study which adopts a qualitative approach and is located within an interpretive paradigm. The reasons for selecting a case study design, as well as the data collection methods are discussed. Justification for the use of the research instruments has been presented with a view ensuring validity and reliability of the data generated. The chapter concludes by addressing ethical issues and limitations of this study.

3.2. Context of the study

This study was conducted at Greenlands University (this is a pseudonym used to anonymise the institution) in the school of education, which trains teachers. The teacher education school is multi-racial and it prepares students to become teachers by offering a four year Bachelor's degree in Education. The vision of the university underscores leadership in African scholarship (Greenlands University vision and mission, 2013). The university embraces socially and contextually relevant curricula that reflect the university's location in South Africa. The module which was central to this study was a pedagogic content knowledge (PCK) module, a compulsory module for pre-service teachers who were being educated to teach Natural Sciences at Year 3 or 4 level. The purpose of the study was to explore pre-service teachers' experiences of learning to teach culturally inclusive science. The participants in the study were students who were registered for the PCK module during the first semester of 2013. Pre-service teachers receive teacher education from two types of modules: Natural Sciences content modules and Natural Sciences PCK modules. There are three Natural Sciences content modules namely: Natural Sciences 110, Natural Sciences 120 and Natural Sciences 210. These modules are done in years one and two of pre-service teachers' teacher education. The PCK modules include Natural Sciences Method One and Natural Sciences Method Two. Natural Sciences Method One, which is usually done in year two, and Natural Sciences Method Two, which is done in year three or four.

3.3. Paradigm

A paradigm can be described as a lens through which we view the world. Sikes (2004, p.18) defines a paradigm as a "basic set of beliefs that guides an action in the research".

The paradigm which framed this research was an interpretive paradigm. According to Cohen, Manion and Morrison (2011), an interpretive paradigm aims to understand the subjective world of human experiences. The interpretive researcher gains insight and understanding of people's behaviour. Interpretation, according to Cohen, Manion and Morrison (2000), involves giving meaning to data from the point of view of the people being studied. This is done by finding out how the people being studied see the world, how they define the situation, or what it means for them (Neuman, 2006). Cohen, Manion and Morrison (2007, p.21) add that the interpretivist paradigm focuses "on the individual in order to understand the phenomena that is being investigated from within the individual". In this study, the phenomenon that I investigated was pre-service teachers' experiences of learning to teach culturally inclusive science. The reason for selecting this paradigm was to gain insight into pre-service teachers' experiences of learning to teach culturally inclusive science. This study fits in with the interpretive paradigm because its aim was to explore pre-service teachers' experiences of a culturally inclusive science education and also to understand their views of the integration of culture which is embedded in IKS when they learn to teach science.

3.4. Approach

The methodological approach for this study was qualitative. A quantitative approach was not adopted as the meanings derived from this work were not "experimentally examined or measured in terms of quantity, amount, intensity, or frequency" (Denzin & Lincoln, 2005, p.10).

"Qualitative research explores attitudes and experiences" (Dawson, 2007, p.14). Bartlett, Burton and Peim (2002, p.45) add that qualitative research is concerned with "situations as they are constructed in the day-to-day, moment-to-moment course of events". According to Cohen, Manion and Morrison (2009), qualitative studies deliberately focus on individuals and their responses in a particular scenario. In this study, pre-service Natural Sciences teachers' experiences of learning to teach culturally inclusive science were explored. Creswell (1998) mentions that the purpose of a qualitative study is to present a detailed view of the topic. In

this work, detailed views of pre-service teachers' experiences of teaching a culturally inclusive science were explored.

" Qualitative research is research that attempts to collect rich descriptive data in respect of a particular phenomenon or context with the intention of developing an understanding of what is being observed or studied" (Nieuwenhuis, 2007a, p.50). Through the use of a qualitative approach, I was able to obtain a rich and in-depth understanding of pre-service teachers' experiences and views of learning to teach a culturally inclusive science. I wanted to explore what Erickson (1998, p.1155) refers to as "subjective understandings" of pre-service teachers, therefore the qualitative approach was suitable. Exploring qualitative research further, De Vos and Fouché (2000, p.80) highlight some of the approaches or tools that can be employed when conducting qualitative research. "Researchers using this strategy of interpretative enquiry will mainly utilise participants' observations and interviewing as methods of data collection. Data is systematically collected and analysed within a specific context". This description encapsulates approaches embarked on in this study. In this study I observed teaching, interviewed participants, analysed reflections and interpreted lesson plans (documents). Consideration of the five characteristics of qualitative research suggested by Bogdan and Biklen (1998, pp.4-7) endorse the appropriateness of a qualitative approach to this study. These include "descriptive research" in a "natural setting", which focuses on "process rather than simple outcomes", involves inductive analysis and "meaning is of essential concern".

This study is set within the context of a pre-designed PCK module for the pre-service teachers. Almost all the data were generated from activities that formed part of this module. The data were in the form of reflections, video recorded observations of lesson presentations and interviews, many of which are presented in this study, to provide a rich description of the experiences of the participants in the study. The data in this study were analysed into themes such as experiences, which include challenges and opportunities of learning to teach a culturally inclusive science. This inductive approach is suited to the qualitative research design. Finally, meaning is of essential concern, thus exploring pre-service teachers' experiences and views of the integration of culture is a key feature of this study.

3.5. Design

The design for this research was a case study. A case study can be viewed as an "in-depth study of interactions of a single instance in an enclosed system" (Opie, 2004, p.74). Opie (2004) mentions that the number of participants for a case study is meaningless. Thus Opie (2004) highlights that case studies could involve a single person, a group of people within a setting and a whole class of students at an institution. Orum, Feagin, & Sjoberg (1991, p.8) state that a case study design is an ideal methodology when a "holistic, in-depth understanding is needed". Nieuwenhuis (2007b, p.75) indicates that case study research aims at "gaining greater insight and deeper understanding of the dynamics of a specific situation". Yin (2003, pp.13-14) defines case study research as an "empirical inquiry that investigates a contemporary phenomenon within its real life context in which multiple sources of evidence are used". This resonates with Opie's (2004, p.74) view which states that the focus of a case study is on a "real situation, with real people in an environment familiar to the researcher". In a case study the researcher aims to describe "what is it like", "thoughts" and "experiences" of a particular situation (Cohen *et al*., 2009, p.182). The case in this study was a PCK module within a teacher education programme at a tertiary institution. A case study is an appropriate design for the research because it explores a particular case which is pre-service teachers' experiences of learning to teach culturally inclusive science. Hitchcock & Hughes (1995, p.317) mention that a case study has several hallmarks, which include its concern with "rich and vivid descriptions of events within the case; debating between the descriptions of events and the analysis of events; its focus on individual actors and seeking to understand their perception of events and the researchers integral involvement in the case". In my study, I focused on individuals as well as groups, and used multiple methods to generate data in order to explore how pre-service teachers learn to teach culturally inclusive science.

3.6. Sample

Qualitative sampling is the "process of selecting a small number of individuals for a study in such a way that individuals are good key informants who contribute to the researcher's understanding of a given phenomenon" (Gay, Mills & Airasian, 2009, p.113). The participants in this study were 20 pre-service Natural Sciences teachers, who were volunteers from a pre-designed PCK module. These pre-service teachers were engaged in studying the module and I had easy access to them. The reason for selecting 20 pre-service teachers is because they were presenting lessons in a microteaching setting, in groups of three or four

and this was a manageable number of participants. I engaged with six groups, each comprising of three or four pre-service teachers. Participants were selected using convenience sampling as well as purposive sampling techniques. Convenience sampling involves choosing the nearest individuals to serve as participants (Cohen, Manion, & Morrison, 2011, pp.155-156). The reason for selecting this type of sampling was because all the participants are based at the university and are easy to access. According to Cohen *et al*. (2011), a convenience sample may serve as the sampling strategy for a case study. The sampling technique was also purposive because these pre-service teachers had to be enrolled to study the PCK module, which is among the key elements of the study. These six groups of pre-service teachers were observed when they engaged in microteaching of culturally inclusive science. The participants also engaged in focus group interviews. This was succeeded by six final individual face-to-face interviews with six pre-service teachers. These pre-service teachers were selected on the basis of their willingness to articulate their experiences and views of learning to teach culturally inclusive science. Their willingness to articulate and share their experiences was revealed in the focus group interviews. These six pre-service teachers were selected using purposive sampling. In purposive sampling, researchers "hand-pick the cases to be included in the sample on the basis of their judgement of their typicality or possession of the particular characteristics being sought." (Cohen *et al*., 2009, p.156). McMillan and Schumacher (2010, p.138) mention that in purposive sampling "the researcher selects particular elements from the population that would be representative or informative about the topic of interest". One pre-service teacher per group was selected to participate in individual interviews. The reason for selecting one pre-service teacher per group was to attain diverse experiences and strategies in the hope that each group member brings their own ideas about how to teach a culturally inclusive science using IKS.

Table one provides a summary of the participants.

Table 1: Summary of participants and the topics selected to teach culturally inclusive science are represented in the table below.

GROUP	ETHNIC GROUP				GENDER		YEAR OF STUDY	TOPIC
	AFRICAN	INDIAN	COLOURED	WHITE	M	F		
1		1		2		3	4th	Indigenous medicinal plants - Rooibos
2		3	1			4	3rd	Astronomy
3	2				2		4th	Organic Fertilizers
4		4			2	2	3rd/4th	Soil and water management using indigenous knowledge (Permaculture)
5		3			1	2	3rd/4th	Indigenous medicinal plants – Black Jack
6	4				1	3	4th	Soil and water management using indigenous knowledge (Permaculture)

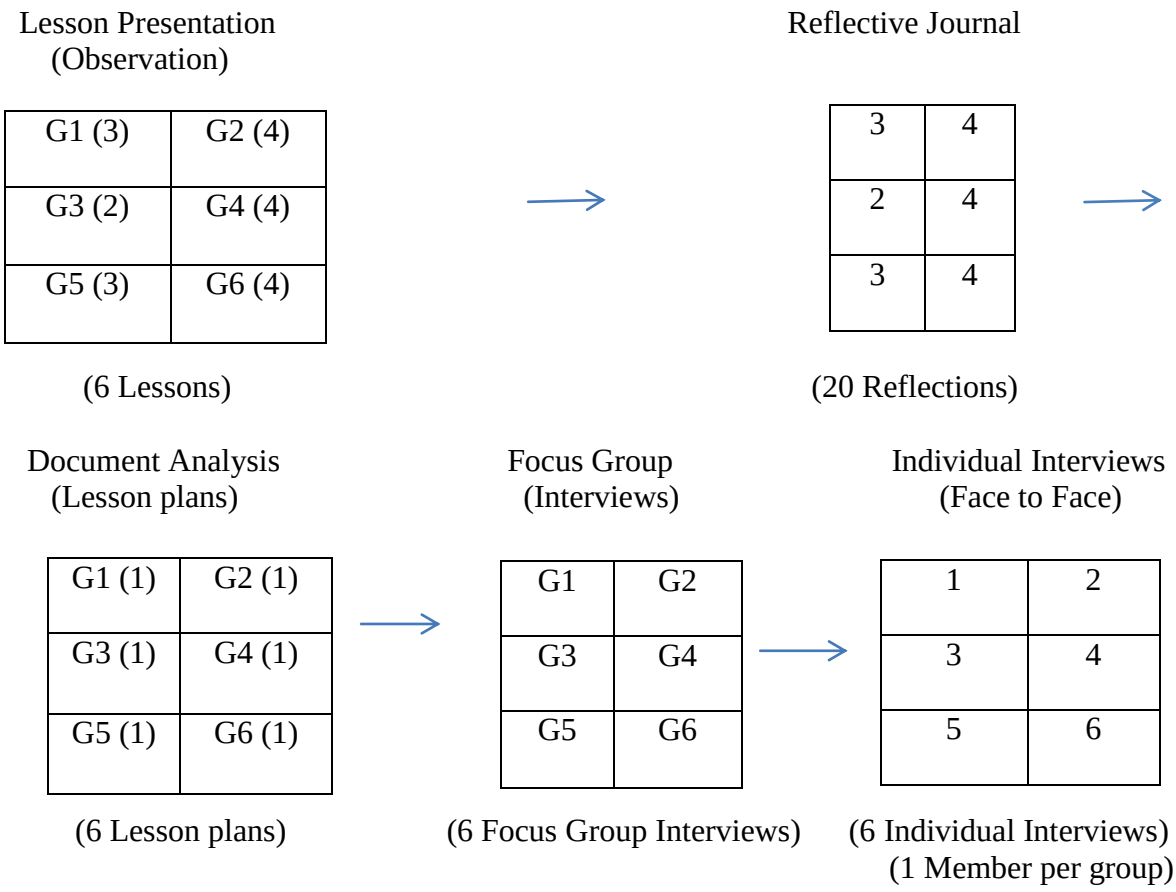
In this study, fourteen female and six male participants comprised the sample. In terms of racial demographics, there were one Coloured, two White, six African, and eleven Indian participants. They focused on Natural Sciences topics extracted from the four strands namely: "Life and Living" "Matter and Materials" "Energy and Change" "Planet Earth and Beyond" which is present in the CAPS document (DoE, CAPS, 2011, pp.13-14).

3.7. Data generation

Generating data for a qualitative inquiry involves the use of different techniques and methods, thus "qualitative research is a multi-method approach" (Denzin & Lincoln, 2000, p.5). According to Cohen *et al*. (2011), qualitative data derives from many sources such as interviews, observations, documents, diaries and video material.

3.7.1. Data generation methods and instruments

In aligning with the qualitative methodological approach described, the study employed five methods of collecting data; namely: Reflective Journals; Observations; Document Analysis (Pre-service teachers' lesson plans as well as curriculum documents); Focus group interviews and Individual interviews.



*G represents (Group)

Figure 3 - Diagrammatic representation of data generation

"Multiple methods of data collection such as observation, interviews and document analysis complement each other and enhance trustworthiness and crystallization of the findings" (Nieuwenhuis, 2007b, pp.80-81). "Crystallization therefore provides us with a complex and deeper understanding of the phenomenon" (Nieuwenhuis, 2007b, p.81). The aim of using multiple methods of data generation was to obtain an in-depth understanding in order to answer the two critical questions from different perspectives, thus generating triangulated data.

Reflective journals

The sample which comprised 20 pre-service teachers reflected on their experiences of learning to teach culturally inclusive science by making entries in their reflective journals. According to Keke (2008), a reflective journal is a tool that allows people to give a greater and in-depth understanding of experiences. Pre-service teachers were given a designed template (see Appendix 5) which they used to introspect on their experiences, challenges and views of learning to teach culturally inclusive science.

Observations

Observation offers the researcher the opportunity to gather "live data from natural occurring situations" (Cohen *et al*., 2011, p.456). In this way, "the researcher can look directly at what is taking place in situ rather than relying on second hand accounts" (*Ibid*, p.456). Cohen *et al*. (2011) mention that observations have the potential to yield more accurate data. Pre-service teachers' presentation of a lesson (microteaching activity) was observed and video recorded. The video recordings were transcribed. The lesson was presented in groups comprising of three or four pre-service teachers, the purpose of which was to see how these pre-service teachers integrated culture, specifically culture rooted in indigenous knowledge systems, in a Natural Sciences lesson. A semi-structured observation schedule (see Appendix 6) was used during the observation of lessons. Some of the criteria which were central to the observation are encapsulated in the following questions:

- *What aspect of culture (rooted in IK) is used during the lesson presentation?*
- *How did the group incorporate culture (rooted in IK) in their lesson?*
- *Did the pre-service teachers manage to identify the culture (rooted in IK) that relates to the topic?*
- *What resources are being used?*
- *Are there any learner activities included in the lesson?*

The aim/purpose of the observation was to enable me to understand at a deeper level, how pre-service teachers teach a lesson incorporating/integrating cultural knowledge rooted in IKS. Based on the observations, focus group interview questions were refined.

According to Cohen *et al*. (2011), video material catches the non-verbal data that audio recordings cannot, which may be particularly useful in a case study. Video recordings of the lessons enabled me to understand exactly how pre-service teachers deliver a culturally

inclusive lesson incorporating IKS. Iino (1998, p.9) argues that video recorded data provides us with more relevant data which enables the researcher to "fully interpret the implications of the interaction". According to Grimshaw (1982), an advantage of using video recording is its permanence. This allows an event to be viewed and reviewed as many times as desired. This affords the researcher an opportunity to view aspects of an event from different angles. Erickson (1992) adds that revisiting/replaying a particular event also allows the researcher more time to analyse, interpret and contemplate the data before drawing final conclusions.

Document analysis

Ritchie (2003, p.35) mentions that document analysis involves the "study of documents to understand their substantive content or to illuminate deeper meanings". Creswell (2012, p.223) adds that documents provide a valuable source of data which assists the researcher to "understand central phenomena in qualitative studies". In this study, pre-service teachers' lesson plans were analysed to gain insight into how they used current policy documents to create culturally inclusive lessons. These lesson plans enabled me to see how pre-service teachers bridge the gap between western science and non-western science. Some of the aspects included in the document analysis schedule were (see Appendix 7):

- *Are the Specific Aims of the CAPS policy document clearly stated in lesson plans?*
- *Does the lesson plan incorporate culture (rooted in IK) within the science lesson? If so, what are the strategies/activities employed to incorporate culture which is embedded in IKS into the lesson?*
- *Is Specific Aim 3 of the CAPS policy document achievable in the lesson?*

Bowen (2009, p.31) highlights that document analysis has both advantages and limitations.

Document analysis has the following advantages:

- "Document analysis is less time-consuming and therefore more efficient than other research methods. It requires data selection, instead of data collection.

- Document analysis is cost-effective. The data (contained in documents) have already been gathered, what remains are for the content and quality of the documents to be evaluated.

- The researcher's presence does not alter what is being studied when analysing documents. Thus documents are said to have stability".

Document analysis has the following limitations:

"Documents usually do not provide sufficient detail to answer research questions; this is seen as a disadvantage" (Bowen, 2009, p.32)

According to Bowen (2009, p.31), insufficient detail is seen as a "potential flaw rather than a major limitation". Given its efficiency and cost-effectiveness in particular, document analysis offers advantages that clearly outweigh the limitations. In this study documents were not used in isolation to answer the research questions. Multiple methods of data generation were used, thus sufficient in-depth information was obtained to successfully answer each research question.

Focus group interviews

Kruger and Casey (2000, p.5) define a focus group interview as a "carefully planned discussion designed to obtain perceptions on a defined area of interest in a permissive, non-threatening environment". A focus group consists of a small number of individuals that are drawn together for the purpose of expressing their experiences on a specific area (Welman, Kruger and Mitchell, 2005).

The advantage of using focus group interviews is that it is highly efficient when collecting qualitative data. Focus group interviews direct the focus of discussion to the most important aspects, which makes it easy to differentiate between consistent or collective views. When interviewing participants as a group, power is transferred from the interviewer to the participants themselves. They feel free to make comments and draw confidence from the comments made by others in the group. This empowerment of participants is beneficial to those in the group who are less articulate in conveying their responses. Also, conducting focus group interviews is inexpensive and there is flexibility regarding the timing of interviews. Focus group interviews have the added advantage of making the experience of being interviewed enjoyable for participants (Robson, 2002).

Semi-structured focus group interviews were conducted with six groups of pre-service teachers studying at the tertiary institution. Each group comprised three or four pre-service teachers, and each group designed and presented the lesson which was observed. The

interviewees were all registered for the same module and were interviewed as members of the same group which designed and presented the lesson. Thus, they were familiar with one another. Familiarity and kinship in the group allowed for free-flowing discussions (Greeff, 2011). The purpose was to "address a specific topic" which was pre-service teachers' experiences of learning to teach a culturally inclusive science, "in a comfortable environment to elicit" in-depth opinions and feelings from a "group of individuals who share some common experiences, relative to the dimension under study" (Wilkinson & Birmingham, 2003, p.90). In this study, focus group interviews were used to capture pre-service teachers' experiences of learning to teach culturally inclusive science. Additionally focus group interviews were also used to understand how pre-service teachers viewed the integration of culture when they learnt to teach science. I chose to engage with focus group interviews because its interactive format is unique in providing qualitative data for educational research (Rikard, Knight & Beacham 1996). Such a technique affords researchers alternative ways of understanding pre-service teachers' experiences and views of learning to teach culturally inclusive science. A semi-structured focus group interview schedule was designed and used to generate data (see Appendix 8). Focus group interviews were in keeping with the theoretical constructs central to the study, namely, socio-cultural learning theory and the Zone of Proximal Development, "where interaction of individual cognitive knowledge contributes to the group interaction and sharing of cultural experience" (Govender, 2009, p.124).

Individual interviews

Cohen *et al*. (2007, p.349) define an interview as an "interchange of views between people on topics of mutual interest that may assist in answering the research questions". Furthermore, Cohen *et al*. (2007) state that an interview is a technique used to gather information when one wants to obtain rich in-depth views from the participants. Individual face-to-face interviews were conducted with six pre-service teachers at the end of the study. "Face-to-face interviews allow the interviewer insight into the non-verbal as well as the verbal responses of the participants. It also gives the interviewer the opportunity to motivate the participants" (McMillian & Schumacher, 2010, p.205). In addition to this, interviews allow responses to be "probed, clarified and elaborated in order to achieve specific, accurate responses" (McMillian and Schumacher, 2010, p.207). The interviews were semi-structured and audio-recorded. Neuman (2006) explains that semi-structured interviews are a guided qualitative interview that allows the interviewer to generate their own questions to develop interesting areas of

inquiry during the interview, thus opening room for further elaborations and discussions. The interviews were semi-structured to allow for deep open-ended responses. "Such an interview is flexible, allows the interviewer to go more in-depth, clear up misunderstandings and encourages cooperation" (Cohen *et al*., 2007, p.357). A semi-structured interview schedule (see Appendix 9) was used in order to obtain a deep understanding of pre-service teachers' experiences and views of learning to teach culturally inclusive science. The main aim of conducting these individual interviews was to triangulate data. Pre-service teachers were questioned on their lessons, lesson plans, reflections, experiences and views of learning to teach culturally inclusive science. Hart (2005) mentions that it provides a scope for probing issues and leading into an in-depth discussion about matters pertaining to the study at hand. Furthermore, Hennings (2004, p.6) suggests that "interviews elicit thick qualitative data, which is the kind of data that gives an account of the phenomenon".

The main intention of conducting individual interviews was to clarify and elaborate on responses mentioned in focus group interviews. In this way, I gained an in-depth understanding of pre-service teachers' experiences and views of learning to teach a culturally inclusive science. Furthermore, misunderstandings and vague responses were clarified. Firstly, pre-service teachers were asked to expand on their experiences of learning to teach a culturally inclusive science. Secondly, I asked pre-service teachers how they addressed specific challenges they had faced when designing and presenting their lesson. Finally, teacher education was expressed as deficient, so I asked pre-service teachers how would they like to be trained to teach culturally inclusive science which is embedded in indigenous knowledge systems.

3.8. Triangulation

"Triangulation is defined as the use of two or more methods of data collection in the study in the attempt to find a single answer for a single purpose" (Cohen *et al*., 2007, p.141). Lichtman (2011, p.116) mentions that triangulation involves multiple data sources such as interviews, observations and document reviews. Thus triangulation is a "method of making qualitative research more objective and less subjective" (*Ibid*, p.116). Creswell (2012, p.259) mentions that "qualitative researchers triangulate among different data sources to enhance the accuracy of a study". This implies that all the data are mapped at different angles to converge and be analysed to build a text. Patton (2002, p.247) encourages the use of triangulation by arguing that "triangulation strengthens a study by combining methods". Furthermore,

"triangulation is seen as a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study" (Creswell & Miller, 2000, p.126). There are a variety of triangulation methods. Cohen *et al*., (2007) and Willis (2007) state that methodological triangulation involves the use of different data collection methods on the same object of study. According to Cohen *et al*. (2007), there are two forms of methodological triangulation, "within methods" triangulation and "between methods" triangulation. "Within methods triangulation is when a study is replicated and reliability is being confirmed and between methods triangulation involves the use of more than one method in the study in order to gain validity" (Cohen *et al*., 2007, p.143). This case study adopted the "between methods" triangulation in its design. This method embraces the notion of convergence between independent measures of the same objective (Cohen *et al*., 2007, p.143). "Triangulation is a powerful way of demonstrating validity in qualitative research" (Cohen, Manion & Morrison, 2001, p.112). This study employed multiple data collection methods that served to triangulate the data collected and thus answer the research questions, thereby enhancing the validity and reliability of this case study.

3.9. Data generation methods fit for purpose

Table two presents a summary of the methods used to generate data, and argues for the selection of methods, based on the views of qualitative researchers. The purpose of the data generating method, as it relates to each critical question, is also included.

Table 2: Summary of the methods used to generate data and justification for the methods

Data Generating Method	Purpose	Research Question	Justification for Method
Journal Reflections	Pre-service teachers reflected on lesson plan and presentation. The purpose was for pre-service teachers to introspect on their experiences, challenges and views of learning to teach culturally inclusive science	Research questions 1 & 2	"...means of enabling student teachers to conceptualize the nature of their own professional development ..." (Moon, 2001, p.368).

Document Analysis	Pre-service teachers' lesson plans were analysed to gain insight on how they use current policy documents to design culturally inclusive lessons. Lesson plans also enabled me to see how pre-service teachers bridge the gap between western science and non -western science.	Research question 2	"...it focuses on language and linguistic features, meaning in context, is systematic and verifiable (e.g. in its use of codes and categories" (Cohen *et al*., 2007, p. 475).
Observation	Pre-service teachers' presentation of a lesson was observed and video recorded. The purpose of this lesson was to see how these pre-service teachers integrate culture specifically IKS in a Natural Sciences lesson.	Research question 2	"…offers the researcher the opportunity to gather 'live data' from naturally occurring situations" (Cohen *et al*., 2011, p.456).
Focus Group Interviews	Semi-structured focus group interviews were conducted with six groups of pre-service teachers. Focus group interviews were used to capture pre-service teachers' experiences, challenges, opportunities and views of learning to teach culturally inclusive science.	Research questions 1 & 2	"...group discussions organised to explore a specific set of views and experiences" (Kitzinger, 1994, p.103).
Individual Interviews	Individual face to face views were conducted with six pre-service teachers at the end of the study. Pre-service teachers were asked about their lesson, lesson plan and reflection.	Research questions 1& 2	"...logical gaps in data can be anticipated and closed" (Cohen *et al*., 2007, p. 353).

3.10. Pilot study

Robson (2002, p.185) defines a pilot study as "a stage version of the real research. It is a trial of the anticipated research to establish its viability and thus its feasibility can be checked". Isaac and Michael (1982, p.34) add that a pilot study often provides the researcher with

"ideas, approaches and clues not foreseen prior to the pilot study. Such ideas and clues greatly increase the chances of clear-cut findings in the main study". This view of the value of pilot studies resonates with the views of Black and Champion (1976) who state that the pilot study helps to uncover potential weaknesses and flaws in the construction and content of the measuring instrument. This is undertaken using participants who have similar characteristics to those who will be used in the main study. It also helps in determining whether the data collecting tools measure what they ought to measure. Martins, Loubser and van Wyk (1996, p.8) recommends the use of a pilot study and further reinforces the point that it is "very useful to detect a weakness in the instrumentation design and to provide a sound base for determining and refining the instruments".

A pilot study was conducted in the year 2012 with 10 pre-service teachers at the university. Almost all of the activities were from a pre-designed PCK module. I used two groups of pre-service teachers each consisting of five members. The pilot study enabled me to adjust questions present in the focus group interview and observation schedules. Furthermore, administering a pilot study enabled me to eliminate ambiguous questions and refine questions to obtain in-depth data and understanding of each participant. After conducting the pilot study in 2012, it was revealed that pre-service teachers displayed a great sense of confusion with one question in the focus group interview schedule. In my initial focus group interview schedule I included a broad question asking pre-service teachers about their experiences of learning to teach a culturally inclusive science. The question was, *tell me about your experience of learning to teach culturally inclusive science*. While administering the pilot study in 2012 pre-service teachers expressed a sense of confusion in answering this question. The question was amended into two questions to eliminate vagueness and confusion. The amended questions were: *what were some of the challenges which your group encountered when you integrated culture (rooted in IKS) in your lesson?* And *what were some of the opportunities that enabled or allowed your group to integrate culture (rooted in IKS) in your lesson?* These modified questions enabled me to obtain rich in-depth responses from participants.

3.11. Data analysis

Qualitative data analysis involves organizing, accounting for and explaining the data obtained (Cohen *et al*., 2011). Seidel (1998, p.1) mentions that "qualitative data analysis consists of three parts namely: Noticing, collecting and thinking about interesting things".

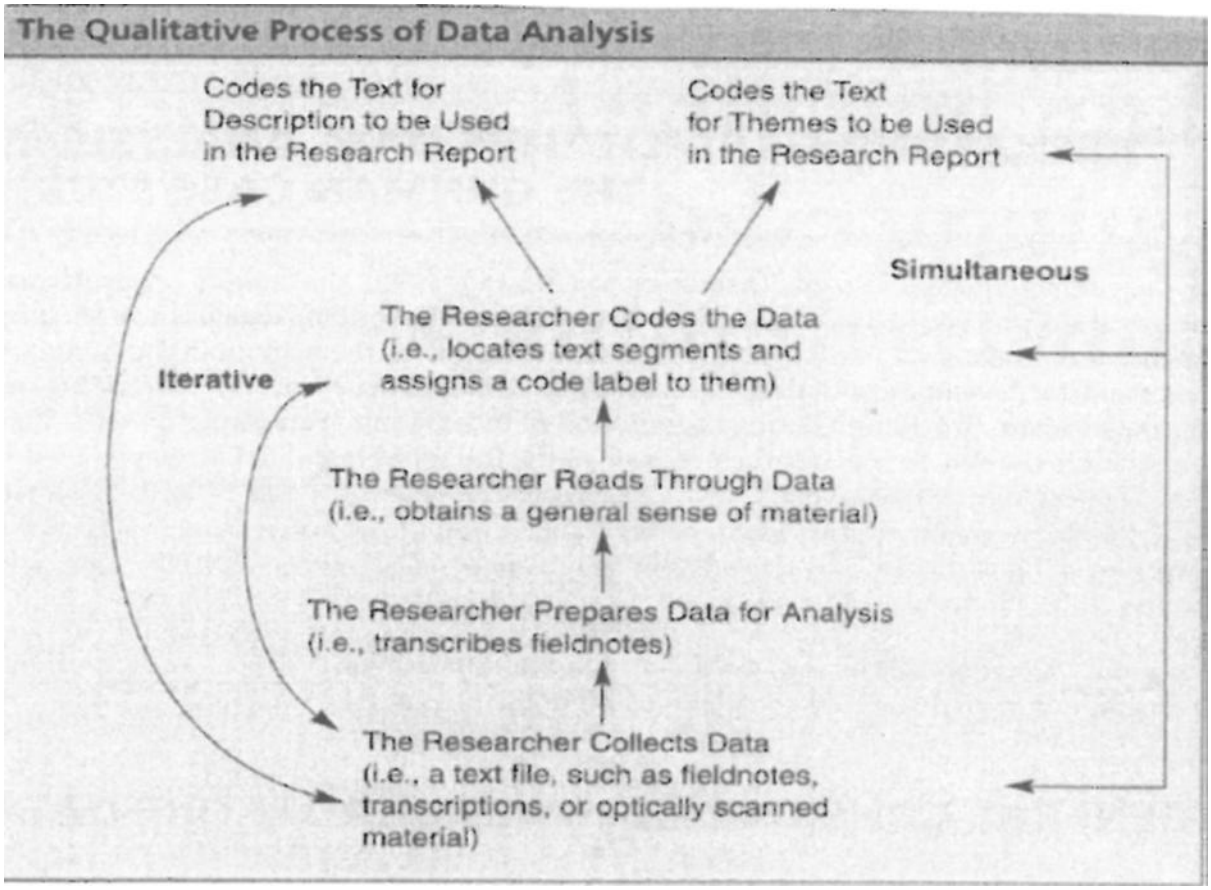


Figure 4 - Diagrammatic representation of data analysis

(Creswell, 2012, p.237)

The above diagram illustrates that qualitative data analysis is not a linear process. This concurs with Seidel's (1998, p.2) view that qualitative data analysis is "iterative and progressive", "recursive" and "holographic". The data collected through individual interviews, focus group interviews and video recorded observations were analysed by listening to audio interviews and viewing video recorded observations. The audio interviews and video recordings were transcribed verbatim and transcripts were developed. Thereafter, each transcript was read and re-read, thus I immersed myself in the details in order to gain an understanding of each participant (De Vos, 2004). Pre-service teachers' reflections were also read and re-read to get "a sense of the participants as a whole before breaking it into parts" (De Vos, 2004, p.343).

Firstly, I noted (noticed) regularities, and codes that emerged inductively from the data. Open coding was used where I assigned a word or phrase that describes the meaning of the text or segment (Nieuwenhuis, 2012). I searched for those that have "internal convergence and

external divergence" thus each code was consistent but distinct from one another (De Vos, 2004, p.344).

Secondly, after a rigorous, systemic, repeated reading and coding of transcripts major themes were developed. Transcripts were also read "horizontally, which involved grouping segments of text by theme" (Marshall, 1999, p.165). Major themes were reduced into sub-themes so that they would be manageable to analyse.

Finally, I interpreted and made sense of the data. The data was engaged with critically and links within the data were established. Different explanations of pre-service teachers' experiences and views were analysed. This analysis brought about the demonstration of the most plausible explanations of the experiences and views of pre-service teachers.

Content analysis was used to analyse the data obtained. According to Cohen, Manion and Morrison (2007), content analysis is defined as the process of summarizing and reporting written data. Content analysis can be undertaken with any written material, such as interview transcriptions (Cohen, 2007). This study used interviews as a method to obtain data on pre-service teachers' experiences of learning to teach culturally inclusive science. Content analysis involves coding, categorizing, comparing and concluding, thereby drawing theoretical conclusions from the text (Cohen *et al*., 2007). Firstly, categories were developed with meaningful words, phrases and sentences. Thereafter patterns, trends and links were developed, and finally conclusions were developed.

3.12. Rigor of the research

Validity and reliability

There are two concepts that are traditionally used to judge the quality of any research, these are validity and reliability.

According to Welman, Kruger and Mitchell (2005, p.142), "validity is the extent to which the research findings accurately represent what is really happening in the situation". Furthermore, Joppe (2000, p.1) mentions that validity "determines whether the research truly measures that which it was intended to measure or how truthful the research results are". A pilot study was conducted in order to enhance validity of instruments and methods for data generation. In this study, the tools for data generation were individual and focus group interview schedules, pre-service teachers' lesson plans, observation schedules, and related

transcripts of video recordings of lesson presentations, as well as pre-service teachers' reflective journals. These instruments were developed based on the multi-modal strategy in order to obtain an accurate representation of pre-service teachers' experiences of learning to teach culturally inclusive science. The data generation tools were selected to allow for triangulation of data. Validity was increased because the pre-service teachers' reflections and individual face-to-face interviews confirmed data obtained.

Joppe (2000, p.1) defines reliability as "the extent to which results are consistent over time and an accurate representation of the total population under study. If the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable". Reliability means that if the study was repeated using the same instruments but with different people, the research questions could still be answered in a valuable way. Reliability is increased by ensuring that questions present in instruments are not ambiguous. The pilot study enabled me to address issues of ambiguity.

"Reliability is concerned with the findings of the research and relates to the credibility of the findings" (Welman *et al*., 2005, p. 145). The findings of this study were credible because a number of data collection tools were used and thus data was triangulated. Anonymous copies of transcriptions of interviews were included in this study.

3.13. Ethical issues

"Ethics has to do with the application of a system of moral principles to prevent harming or wronging others, to promote the good, to be respectful and to be fair" (Sieber, 1993, p.14). Merriam (1998) argues that conducting a study in an ethical manner is a requirement for validity and reliability. Cohen *et al*. (2007) state that ethical issues refer to rules or behaviours which researchers have to take into consideration before conducting research. Sikes (2004) mentions that ethical issues apply throughout the research process. There were a number of ethical issues that were taken into consideration during this research.

Permission to conduct study

According to Wiersma and Jurs (2009, p.436), when conducting research in an educational setting "it is necessary to obtain permission from the site's gatekeeper". A formal application was made and approved by the Human and Social Sciences Ethics Committee (see Appendix 1) of the university where I had registered for my degree. A letter was written to the dean of

the university and head of school to grant permission for the research. Permission was obtained in writing from both head of school and dean of university.

Informed consent from participants

Informed consent refers to a decision made to participate in a particular activity after full information regarding the purpose and process, which may influence the decision itself, which is given to the deciding participant (Cohen *et al*., 2007). Informed consent was obtained from each pre-service teacher in writing with a clear indication that they could at any stage request termination or withdrawal from the research at any time without negative consequences. Participants were informed at the outset that participation in this study was voluntary.

Anonymity and confidentiality (Protection from harm)

Welman *et al*. (2005, p. 201) mentions that participants "should be given the assurance that they will be indemnified against any physical and emotional harm". Anonymity and confidentiality was assured in letters of informed consent. Pseudonyms were used in the write up of this study. All responses were treated in a confidential manner. The participants were not exposed to questions which were stressful or upsetting, or to procedures which may have had an unpleasant or harmful side effect.

Data use and disposal

Participants and gatekeepers were assured, in writing that the findings of the research would not be used for any other purpose, other than for the Masters dissertation. It was emphasised that the data would be stored for five years at the university and thereafter disposed of. Interview transcripts and reflections would be shredded and audio tapes would be incinerated.

3.14. Limitations of the study

The study of a single lesson presentation during a short period of time is a limitation in itself. An attempt to address this was made by using reflective journals to allow pre-service teachers to introspect on their lesson designs and presentations, in order to improve their understanding of pedagogy. According to Wilkinson & Birmingham (2003) the greatest strength of focus groups is their group dynamics and interactions; however, this can also be their greatest weakness. Participants may respond in ways designed to please others thereby not contributing honestly and truthfully to the discussion. Furthermore, "participants may

choose not to reveal certain information in a group setting especially that which is complicated, personal and sensitive" (Wilkinson & Birmingham, 2003, pp.108-109). Gibbs (1997) mentions that focus groups can be difficult to assemble. It may not be easy to get a representative sample and focus groups may discourage certain people from participating, for example, those who are not very articulate or confident. This was evident in my endeavours to obtain participants as some groups promised to participate, but then revoked their participation. This resulted in me obtaining other more willing participants.

3.15. Conclusion

In this chapter I discussed the research methodology that I employed. The paradigm, approach and design of the study were discussed together with the justification and rationale for my choice. This chapter provided an explanation of the data collection methods and instruments designed and employed aligning with a qualitative methodological approach. Furthermore, the triangulation of data collection methods was also discussed. The validity and reliability of the data gathered was highlighted. Finally ethical issues and limitations of the study were discussed. The next chapter will focus on the presentation and analysis of the data and major findings which emerged from the study.

CHAPTER 4

Data Analysis and Presentation of Findings

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Chapter 4

Data Analysis and Presentation

4.1. Introduction

In this chapter, the qualitative data generated through focus group interviews, individual interviews, reflections, document analysis, and video recorded observations are analysed and presented. In order to explore pre-service teachers' experiences of learning to teach culturally inclusive science, responses that are related to the research questions are analysed.

4.2. Data analysis and presentation of findings

Themes emerged from the data which were analysed inductively to provide a rich description of pre-service teachers' experiences and views of learning to teach culturally inclusive science (culturally inclusive science will mean school science that engages with knowledge rooted in indigenous knowledge systems). Direct quotations from pre-service teachers' responses are presented in verification of the emerging themes. Finally, the literature review and associated theoretical frame is presented in support of the emerging themes. The classification of the themes according to the specific research questions follows. For research question one, which is: *How do pre-service teachers view the integration of culture when they learn to teach science?* Two themes emerged for research question one, namely:

- Lack of integration of culture in Natural Sciences content modules.
- The potential benefits of the integration of cultural knowledge rooted in IKS

For research question two which is, *what are pre-service teachers' experiences of learning to teach a culturally inclusive science?* Both challenges and opportunities were revealed. The challenges experienced by pre-service teachers were explored according to the following five themes:

- Lack of content/ background cultural knowledge embedded in IKS in modules at university
- Lack of resources
- Insufficient teacher education

- Limited time to plan a lesson incorporating cultural knowledge embedded in IKS
- The CAPS document (inadequate details in curriculum policy)

The opportunities experienced by pre-service teachers were explored according to the following two themes:

- Working in groups
- The use of external human resources (IKS knowledge holders in the community, family members)

The following abbreviation will be used to distinguish among data from different sources:

- Video Recorded Observations – VRO
- Individual Interview – II
- Focus Group Interview – FGI
- Reflective Journals – RJ
- Group One – G1
- Group Two – G2
- Group Three – G3
- Group Four – G4
- Group Five – G5
- Group Six – G6

Pre-service teachers receive education from two types of modules: Natural Sciences content modules and Natural Sciences pedagogic content knowledge (PCK) modules. There are three Natural Sciences content modules namely:

- Natural Sciences 110
- Natural Sciences 120
- Natural Sciences 210

These modules are done in years one and two of pre-service teachers' teacher education.

The Natural Sciences content modules aim to familiarise pre-service teachers with content so that they are able to understand content. These content modules aim to serve as an introduction to specific concepts, all which are rooted in a western epistemology of science. These modules include content that covers an introduction to basic concepts; they serve to develop understanding of concepts through the inclusion of practical sessions, among other strategies. The teaching and learning approach of these content modules seeks to expose pre-

service teachers to core principles, theories and examples of practical application. This is achieved through lead lectures utilising traditional teaching methods.

After viewing the Natural Sciences content module templates, and enquiring from lecturers of these modules, there is no evidence of IKS content forming part of the university curriculum of any Natural Sciences content modules.

The PCK modules include Natural Sciences Method One and Natural Sciences Method Two. Natural Sciences Method One, which is usually done in year two, and Natural Sciences Method Two, which is done in year three or four, aim to equip pre-service teachers with strategies to be able to teach Natural Sciences. After enquiring from Natural Sciences Method One lecturers it was revealed that there is no integration of IK in this module.

A review of the Natural Sciences Method Two module template revealed learning theories, practical work, investigations, demonstrations, improvisations and IKS, amongst others that form part of the university curriculum to educate pre-service teachers in pedagogy of science education. One outcome of the Natural Sciences Method Two module is to develop knowledge and skills to integrate IK across the university curriculum. It includes an assessment task that requires pre-service teachers to design lesson plans which integrate IKS in the science classroom. These lessons are then assessed through oral and written presentations. A social constructivist theoretical approach underpins this PCK module, which is characterised by interactive learning.

Pure content and PCK modules are very different although both seek to develop knowledge and skills in pre-service teachers. It is interesting to note that IKS is not mentioned as part of the university curriculum of the Natural Sciences content modules, but it is mentioned as part of an assessment task in one PCK module. It is clear to see that there is no content being taught to pre-service teachers related to IKS in pure Natural Sciences content modules. IKS is only present in an assessment task tabled for completion in pre-service teacher education in one PCK module.

The above description of the Natural Sciences content and PCK modules indicate that IKS in not part of the content being taught to pre-service teachers. They are not introduced to IKS or given any content on IKS. However, they are required to plan and teach a lesson integrating IKS in a PCK module as a form of assessment.

4.3. Research question 1: How do pre-service teachers view the integration of culture when they learn to teach science?

Pre-service teachers expressed two views regarding the integration of cultural knowledge in science lessons. Their views revealed a lack of integration in Natural Sciences content modules, and the potential benefits of the integration.

These two themes are discussed below.

4.3.1. Theme 1: Lack of integration of culture in Natural Sciences content modules.

A majority of the participants indicated that there was a lack of integration of cultural knowledge rooted in IKS in Natural Sciences content modules during their tertiary education.

A majority of responses from participants clearly indicated that IKS is included in only one Natural Sciences PCK module and that they prefer IKS to be included in all Natural Sciences modules (content and PCK). This indicated that these pre-service teachers believe that the integration of cultural knowledge, which is rooted in IKS, in their learning to teach science is insufficient, and this impacts on their learning.

The following views emerged in focus group and individual interviews:

> *Why is IKS only introduced now, it is very late. It should be given more attention in science modules at the university. If IK is included in all NS modules then it will assist in learning to teach IK.* (G1 – II)

> *IKS should be part of all NS modules so we learn more about it … IK must be included in all NS modules.* (G6 – FGI)

The following journal entries further reinforced the individual and focus group interview responses:

> *My view is that IKS was integrated at a late stage and maybe if it was introduced earlier it would have helped me learn better.* (G1 – RJ 3)

> *IKS must be included in all NS modules so that this will help us learn it.* (G6 – RJ3)

The responses of these participants indicated that they would prefer IKS to be integrated in all Natural Sciences modules so that they learn better. In addition to this, participants indicated that IKS should be given more attention in the school of science at the university

and be integrated earlier whilst learning to teach science. It is deduced from the preceding responses that participants are of the view that the science education cluster at the university chooses when and where to integrate IKS. This resonates with findings from a study by Odora Hoppers (2001) which reveal that tertiary institutions set standards that they require students to reach in order to be deemed successful. But what these institutions choose to include or exclude from their content could make a significant difference to the cognition of the students that are at that institution (Odora Hoppers, 2001).

The following views arose in the individual interviews:

> *At the moment we have NS 110, 120 and 210 that deals with content, so IK should be included in all or have a separate IK module.* (G2 – II)

> *IK should not only be included in our 3rd and 4th year module, but it should be introduced from 1st year NS.* (G2 – II)

> *If IKS is included in NS 110, 120 and 210 then I will be more confident.* (G3 – II)

The following journal entries affirmed the preceding responses:

> *I think IKS should be included in all NS modules.* (G2 – RJ 2)

> *To become an NS specialist we do 3 modules for the NS learning area. In all 3 of these modules I never came across any IK… I feel that IK should be included in all modules.* (G3 – RJ 2)

Each of the 20 participants indicated that cultural knowledge rooted in IKS should be part of all the Natural Sciences content modules. It is evident that all participants expressed the need for learning IKS in each Natural Sciences module. Furthermore, the responses point out that more recognition must be given to IKS by the science education school at the university.

These pre-service teachers added that there is space for the inclusion of IKS in particular sections of the Natural Sciences curriculum at university. They went on to offer tangible ways in which IK can be integrated in their Natural Sciences content modules.

> *Firstly if we are learning about astronomy in NS 120, then IK should be incorporated at that point so we will also learn both western science and IK. Then in NS 110 we learn about nutrition, so while doing balance diet we can bring in some IK, like the Hoodia plant.* (G1 – II)

> *There is so much space for IKS to be included in NS modules. If I can make an example, in NS 110 we did soil, so IKS can be integrated. We can talk about organic fertilizer and manure. But this is not done.* (G3 – II)

These pre-service teachers have a vision for where and how IK can be incorporated in the Natural Sciences university curriculum. They advocated actively for the inclusion of IK in the university curriculum. Vygotsky's ZPD indicates that learners (pre-service teachers in this case) learn by interacting with the teacher (lecturer) as well as the module. As pre-service teachers interacted with the lecturer and the PCK module that exposed them to IKS, their learning and understanding evolved. This created awareness that IKS can be integrated in certain existing aspects of the university Natural Sciences curriculum.

Participants in this study outlined the possible spaces for increased integration of IKS in the Natural Sciences modules at the university. Pre-service teachers are able to identify how the integration of cultural knowledge embedded in IKS, with western science, can be applied in their learning to teach science. This reveals two insights: First, Natural Sciences modules at universities need to be redesigned through the inclusion of IKS and second, pre-service teachers can "through instruction which leads to meaningful learning (which is) more advanced…" be enabled to "galvanise multiple functions" (Mudaly & Ismail, 2013, p.180). The function that is alluded to here is pre-service teachers' ability to locate lacunae in university science curricula, and to transcend this, by advocating IK-related content which can be integrated in curricula.

The policy on African Indigenous Knowledge Systems (AIKS) of the university has as part of its strategies the aim to design and implement curricula to incorporate African indigenous knowledge systems.

> *The AIKS policy will facilitate the incorporation of African indigenous knowledge into curricula, and generate teaching programme* (AIKS policy, p.5).

It is clear from the responses of participants that although the university has adopted the AIKS policy, the integration and teaching of IK is lacking, that is, policy implementation appears to be out of sync with policy design, in some schools.

> *Implement curricula with innovative ways that foreground AIKS teaching methodologies and ways of knowing* (AIKS policy, p.7).

The AIKS policy highlights the aim of achieving excellence in teaching and learning, although currently pre-service teachers explicitly declare that they are not receiving enough integration of IKS in their Natural Sciences teacher education. These pre-service teachers mention that there needs to be an increase in the integration of IKS in their Natural Sciences content modules as well as their method modules.

The policy further states that it aims to:

> *Create an enabling environment that enhances excellence in teaching, learning and research in AIKS* (AIKS policy, p.7).

The environment in which these pre-service teachers are currently located does not enable them to teach and learn to teach IKS with excellence. This is due to the lack of integration in their teacher education in certain schools. This lack of integration of IKS in Natural Sciences modules makes the aim of the AIKS policy that states "Excellence in teaching and learning" of AIKS, far from achievable (AIKS policy, p.7).

It is evident that pre-service teachers view the integration of IKS as inadequate when they learn to teach science, however, they do acknowledge the benefits of the integration of IK in science education.

4.3.2. Theme 2: The potential benefits of the integration of cultural knowledge rooted in IKS

This theme is further divided into sub-themes:

- Exposure to western science and cultural knowledge rooted in IK
- Cultural knowledge rooted in IK recognises the background and identity of learners
- Cultural knowledge rooted in IK assists with learning and understanding
- Cultural knowledge rooted in IK produces better performance in science

These sub-themes are not mutually exclusive, and are discussed below.

4.3.2.1. Exposure to western science and cultural knowledge rooted in IK

The responses of all participants indicated that when cultural knowledge, which is rooted in IK, is integrated in science teaching, learners are presented with western science knowledge and IK. Participants recognised this as significant as learners will receive a holistic view of science education through the inclusion of IK.

The following views emerged in the focus group interviews:

> *Learners need to be presented with both sides of science…* (G1 – FGI)

> *It is important to expose learners to more than one way of knowing. It gives a more holistic approach to science.* (G1 – FGI)

> *We also included western modern science; we used the two in our lesson so that learners have a balanced understanding of IKS and western science.* (G1 – FGI)

The subsequent journal entries affirmed the above responses.

> *IKS provides the opportunity to explore both western modern science and indigenous knowledge.* (G1 – RJ 1)

> *IKS must be included as it gives the learner a holistic and valuable learning experience.* (G4 – RJ 1)

The responses from participants underscored the possibility of a balance that can be reached when IK is integrated with western science. This gives the learner a holistic view of science. This is reiterated by Emeagwali (2003), who postulates that with the integration of cultural knowledge embedded in IKS, learners will be provided with science teaching that evokes a balance between IK and western science. Additionally Nnandozie (2009) argues that with the inclusion of IK in science, both western science and IK will be given equal prominence in the academic arena.

> *The inclusion of IKS can also change the education system and teach learners both western science and IKS.* (G4 – RJ 2)

The preceding responses revealed that participants expressed the magnitude that the effect of the integration of IK can have on the education system at large. The possibilities for a more holistic, balanced, and valuable learning experience are highlighted. This resonates with Nnandozie's (2009, p.19) view that "the integration of indigenous knowledge will bring a total turn-around in the global education system by giving education a new look".

> *I think that the integration of IKS is important because western science is damaging our environment, thus another way of knowing is important. Learners need to be exposed to safe, pure ways of using the environment.* (G1 – FGI)

Moreover, participants indicated that the integration of IK can have a positive effect on the environment and that IK can introduce alternative ways of knowing. This is in accordance

with Ogunniyi's and Ogawa's (2008) assertion that alternative ways of restoring our natural environment are in demand. Indigenous knowledge systems are the vehicle to set this restoration in motion. Naidoo (2010, p.2) concurs with Ogunniyi's and Ogawa's (2008) assertion when he argues that "Indigenous knowledge (IK) amongst other things is viewed as critical building blocks in fostering positive attitudes for equitable resource management, the preservation of biodiversity and consists of a wide range of knowledge that has largely remained hidden from the mainstream of education".

Looking at our current state of affairs in the world, it is clear that with technological advancements have come many advantages, as well as the deterioration of the natural environment. Malia and Loubser (2003) state that the movement towards the development of other knowledge systems should be fast tracked. They further mention that the integration of IK is a method or an avenue to educate children in the hope of discovering an environmentally friendly solution to our current environmental problems.

4.3.2.2. Cultural knowledge rooted in IK recognises the background and identity of learners

All participants in the study emphasised that the integration of IK recognises the learners' background, including the prior knowledge that they possess, as well as the identity of each learner.

The following views of the significance of the integration of IK arose in the focus group and individual interviews:

> *Children learn from their parents and are exposed to science from a young age.* (G1 – FGI)
>
> *It brings the home, background knowledge in the science classroom and this is important for learning.* (G1 – FGI)
>
> *Lessons can begin with reference to learners' home…* (G1 – II)
>
> *It is familiar knowledge.* (G2 – II)
>
> *There is definitely a connection between the home of the child and the science classroom.* (G2 – II)

The following journal entries resonated with the preceding responses:

> *Learners feel included in science classrooms because there is a link between what takes place at home and in the science classroom.* (G1 – RJ 1)
>
> *I believe that IKS is important it bridges many gaps in home learning and school learning.* (G1 – RJ 1)
>
> *When incorporating IKS into the classroom it is very beneficial to the learners because the learners can give their own experiences of IKS in their backgrounds as well as their cultures.* (G2 – RJ 1)

It is clear that all participants share the view that the learner comes into the science classroom with knowledge gained from their home or backgrounds. All participants stressed the point that there needs to be a connection between the prior knowledge of the learner and the science learning in the classroom. Stears (2008) argues that the informal or background knowledge that learners possess is imperative and can be used as a foundation to learn science concepts. This is echoed by Naidoo (2010), who argues that learners do not enter science classrooms empty of science; therefore there is a great need to ensure relevance of learners' cultural backgrounds (rooted in IKS) and experiences in science classrooms. This is in keeping with McKinley's (2005) view that connecting learners' cultural background to science education has crucial importance as it makes science relevant to learners. "Learners' prior knowledge deserves recognition and may be utilized in constructing new meaning" (Collins, 2008, p.2). Recognising the knowledge that learners possess is crucially important in the learning of new concepts. Collins re-affirms this by stating that "As prior knowledge is fitted with new learning experiences, students construct new meaning" (Collins, 2008, p.1). She adds that the constructivist theory can be used to recognise the prior knowledge of learners. This theory requires learners to be actively engaged with their experiences (prior knowledge) in the process of acquiring new knowledge (Collins, 2008). This resonates with Cakir's (2008, p.195) view that "there is an important connection and interaction between the two; what a student is learning in school influences the course of development of concepts acquired through everyday experience and vice versa".

The recognition of the prior knowledge learners possess brings about the creation of an enriched learning environment. This resonates with Collins' (2008, p.8) assertion that "when learners are given the opportunity to engage actively in processing prior knowledge with new information to construct meaning, the result is an enriched learning environment".

Participants further expressed that the inclusion of IK in science affirms the identity of learners in that they feel recognised and become comfortable in the science classroom.

The following views were expressed in the focus group and individual interviews:

> *The inclusion of IKS recognises learners' identity*. (G1 – II)
>
> *It is important because if I am being taught or made reference to something that touches me, I think I will be more comfortable because it is relevant to me.* (G3 – FGI)
>
> *Learners will feel important and included when their knowledge from home is recognised in the science classroom.* (G4 – II)

The above views are further reinforced in the following journal entries:

> *Learners feel included and their identity is recognised in science classrooms because there is a link between what takes place at home and in the science classroom.* (G1 – RJ 1)
>
> *Learners feel included when you integrate culture in science lessons.* (G1 – RJ 2)
>
> *Sometimes learners might feel out of place in the class because they cannot relate to anything that is being taught. But if IKS is used as a foundation for a science lesson then they will feel included and part of the lesson.* (G4 – RJ 3)
>
> *Learners will feel included in the lesson because it will include something that they know.* (G3 – RJ 1)
>
> *Learners also feel comfortable and part of the science lesson.* (G3 – RJ 2)

The preceding responses emphasised that pre-service teachers espouse the view that learners need to feel included in the science classroom and if they are not, they cannot relate to what is being taught. Exclusion of learners in the science classroom insidiously evolves into intellectual marginalisation. Science teachers need to be cognisant of the levels of inclusion of learners and ensure that all learners are a part of the science classroom. This resonates with van Wyk's (2002) contention that teachers of science must value learners' social and cultural context. Teachers who are able to contextualise learners' backgrounds can eliminate the discomfort attached to learning science and also assist learners in connecting their indigenous

knowledge to the formal knowledge taught at school. The socio-cultural learning theory emphasises the importance of what the learner brings to any learning situation (Turuk, 2008). By recognising the knowledge learners bring into the science classroom, they become a part of the lesson.

The views of these pre-service teachers reflected two things. First, they value the socio-cultural theory which they believe should underpin school science teaching in order to create a culturally inclusive science classroom where meaningful learning can occur. Second, the value of the socio-cultural theory in teacher education emerges.

4.3.2.3. Cultural knowledge rooted in IK assists with learning and understanding

A majority of the participants expressed that with the integration of IK, the learning and understanding of learners will be meaningfully enhanced. They view this as critical to the goal of education, which is to develop the learning and understanding of learners.

The following views were expressed in focus group interviews:

> *By bringing IKS and culture in the science classroom it is relevant to learners and they are familiar with it and thus build on it. It will result in better learning.* (G1 – FGI)

> *It can be a starting block. IK is a ground for learners to stand on. It will be a familiar lesson to learners.* (G1 – FGI)

> *Because it is something they are familiar with, it is relevant. It will assist in learning science concepts. Take them from the known to the unknown.* (G3 – FGI)

> *IK moves learners from the familiar to the unfamiliar knowledge and results in learning and understanding of science.* (G4 – FGI)

The above responses were further reinforced in individual interviews:

> *If learning is relevant then learners will also feel motivated to learn. When learning is relevant it will assist in learning new concepts.* (G1 – II)

> *Relevant knowledge will be taught to learners, this will assist in learning new science concepts. It is familiar knowledge.* (G3 – II)

Learners will move from the familiar to the unfamiliar knowledge. By using IKS teachers can build on and use IKS to teach science concepts. (G3 – II)

IK is relevant learning and learners experience this daily. It takes learners from the familiar to the unfamiliar. (G4 – II)

The prior knowledge of learners can be used as a foundation to build new knowledge in the science classroom. Whatever knowledge the learner has can be used as a building block for new science concepts. (G5 – II)

Recognising the knowledge that learners possess is implicit in the socio-cultural learning theory. Turuk (2008, p.248) argues that the learner comes into the classroom "as an active meaning-maker and problem-solver." He adds that collaboration between the teacher, the learner and the content being taught enhances learning.

Prior knowledge can emanate from multiple sources including media, observations of natural phenomena and interactions with others, and is not always embedded in indigenous knowledge. It is apparent, however, that pre-service teachers in this study, hold the view that cultural knowledge, which is rooted in IK, can be used as a foundation or a building block for learning in the science classroom. This suggests that IK can be used to effectively develop the learning and understanding of learners in science. This concurs with Nnandozie's (2009) assertion that through the integration of IK, the understanding and learning of learners will be effectively enhanced. She further mentions that integrating IK moves learners from what they know (their IK), to what they do not know. This resonates with Aikenhead's (2006, p.119) assertion that cultural border crossing is "a metaphor that captures the act of negotiating the transition from, for instance, a student's home culture to the culture of school science".

The responses of participants clearly showed that they viewed the integration of IKS in science teaching as a vehicle to move learners from their own culture (prior knowledge), to the culture of school science (western science culture). The prior knowledge that a learner possesses is familiar to them and the science knowledge in the classroom is unfamiliar to them. The transition between the two bodies of knowledge can be made simpler through the integration of IKS in science teaching.

Drawing on Lantolf (2000), Turuk (2008) states that humans use tools to act directly on the physical world. These tools, according to the socio-cultural theory of Vygotsky (1978), are within a specific culture and have characteristics of that particular culture. IKS can be a tool

in the science classroom as learners from different culture use their IK to understand school science concepts.

4.3.2.4. Cultural knowledge rooted in IK produces better performance in science

All pre-service teachers in this study expressed that the integration of IK can greatly increase the performance of learners in science because they will be moving from the familiar knowledge (IK) to the unfamiliar knowledge (western science concepts).

They viewed this as integral because presently learners are performing poorly in science. This resonates with the views of Chetty (1999), Ingle and Turner (1981), Jegede (1999), Manzini (2000) and Odora Hoppers (2000), who state that learners perform poorly in science due to the conceptual gaps in learners' knowledge because teachers are unable to link prior learning to school science.

The following views emerged in focus group and individual interviews:

> *…better performance … in science.* (G1 – FGI)
>
> *Learners will learn more and marks will be better in science*. (G1 – II)
>
> *Also learners will learn better or perform better if their cultural backgrounds are taken into account in the classroom.* (G2 – FGI)
>
> *I think I will produce a better performance.* (G3 – FGI)
>
> *It is relevant knowledge. It will result in learning and understanding and better performance. I feel that it is important and it can minimise the failure rate in RSA science education.* (G6 – FGI)

The subsequent journal entries affirmed the above response:

> *My view is that integration of IK will result in better performances in science.* (G1 – RJ 1)
>
> *…it will also result in better performance.* (G2 – RJ 2)
>
> *I think it would bring better performance from the learners. (*G3 – RJ 1)

> *Many learners perform badly in science and I think it is because they do not understand science, but if IKS is part of science then learners will have something that they know about and will do better.* (G6 – RJ 1)

In emphasising the value of the socio-cultural theory in learning, Turuk (2008) asserts that learners in a science classroom do not reproduce the teachings of the teacher, but internalise what is taught to them. They then transform what they have learnt through interaction with peers, and perform independently. If learners make conceptual links in the science classroom more easily because it is presented by linking it to prior knowledge which may be embedded in IKS, they would internalise the information more readily.

The participants in this study advocated for the integration of cultural knowledge which is rooted in IKS by underscoring the positive relationship between such integration and academic performance in school science. The preceding responses of participants are echoed by McKinley (2005) who states that the underachievement/poor performance is due to a lack of connection between the home of the learner and the classroom in which the learner is found. This resonates with Jegede's (1995) assertion that there exists a gap between the reality of the learner and the science being taught at school. He further adds that this gap prevents significant learning from taking place in the science classroom. Participants view the integration of IK as a way of connecting the prior knowledge of the learner and the science taught in classrooms so that learning and understanding is enhanced. This therefore will result in better performance in science.

Teachers are the pipeline to aid the flow of learners from what they know to what they do not know, but this can only occur if teachers are aware of the cultural borders that exist in the science classroom. Aikenhead (2006) states that if teachers are unable to facilitate the transition of learners from their own cultures into the culture of science, then the responsibility is left to the learner. The learner has to "rely on resiliency to negotiate cultural border crossings into school science on their own" (Aikenhead, 2006, p. 121). What this indicates is that if the learner is not resilient enough then the transition will be unsuccessful. This could impact on the performance of the learner in that they would perform poorly.

The gap between the home of the learner and the science classroom will continue to exist if teachers do not realise the cultural borders in the science classroom and identify the need to cross cultural borders so that learner performance in science can improve. "Science teachers can help students negotiate difficult border crossings, but this is normally absent in science

classrooms because teachers are unaware that cultural borders exist for their students" (Aikenhead, 2006, p.120). This resonates with Snively's and Corsiglia's (2001, p.6) observation that "in most science classrooms around the globe, western science has been taught at the expense of indigenous knowledge." If IK is not being taught in the science classroom then science teachers will definitely ignore the need for cultural border crossing.

If teachers are not able to recognise the cultural background and prior knowledge of their learners, and realise that there needs to be a crossing over to the western science being taught, then learner performance will not improve. Learners will still be taught science concepts that do not relate to them and perform poorly in science.

The socio-cultural theory "acknowledges the dynamic nature of the interplay between the teacher and the learner" (Turuk, 2008, p.248). He adds that the teacher must be able to interact with the learner because interaction is the first step in the learning process of the learner. The pre-service teachers in this study were able to argue for the value of cognisance of socio-cultural settings in the science classroom- this reflects their shift from conventional teaching of sciences which is confined to western settings. The "actual development" of pre-service teachers' knowledge and skills, to teach science embedded in western worldviews, is transcended as they move into "higher areas of potential development" (Turuk, 2008, pp.248-249) when they embrace the socio-culturally constructed worldviews as crucial in science teaching. They shift into "higher areas of potential development" (Turuk, 2008, p.249) which is evident from their focus on learner identity, and the value of prior knowledge, rooted in IKS, in advancing scientific conceptual development from the known to the unknown.

4.4. Research Question 2: What are pre-service teachers' experiences of learning to teach culturally inclusive science?

The experiences of pre-service teachers learning to teach culturally inclusive science revealed both challenges and opportunities.

4.4.1. Theme 1: The challenges experienced by pre-service teachers.

The challenges experienced by pre-service teachers will be explored according to the following themes:

- Lack of content/background cultural knowledge embedded in IKS in modules at university

- Insufficient teacher education
- Lack of resources
- Limited time to plan a lesson incorporating cultural knowledge embedded in IKS
- The CAPS document (inadequate details in school curriculum policy)

The challenges experiences by pre-service teachers will be interrogated according to the following themes:

Table 3: The challenges experienced by pre-service teachers

THEMES	**GROUP 1**	**GROUP 2**	**GROUP 3**	**GROUP 4**	**GROUP 5**	**GROUP 6**
Lack of content/ background cultural knowledge embedded in IKS in modules at university	√	√	√	√	√	√
Insufficient teacher education	√	√	√	√	√	√
Lack of resources	√	√	√	√	√	√
Limited time to plan a lesson incorporating cultural knowledge embedded in IKS	√	√	√	√	√	X
The CAPS document (inadequate details in school curriculum policy)	√	X	√	√	√	√

- A tick in the box indicates that the group experienced that theme as a challenge
- A cross in the box indicates that the group did not experience that theme as a challenge

Table three indicates that all participants experienced challenges which included lack of content/background knowledge on IKS; lack of resources and time; and insufficient teacher education. Group six was the only group that did not experience time constraints as a challenge when learning to teach culturally inclusive science, and group two was the only group that did not mention any challenges when working with the CAPS document.

4.4.1.1. Lack of content/background cultural knowledge embedded in IKS in modules at university

All participants expressed that they did not have any background/content knowledge or exposure to IK and this posed a challenge for their learning. Participants stated that having background/content knowledge and exposure of IK is a major advantage when learning to teach culturally inclusive science.

The following views emerged in focus group and individual interviews:

> *I honestly did not have any knowledge on IKS...* (G1 – FGI)

> *…very minimal exposure to IKS…We did not have any background information or knowledge.* (G1 – FGI)

> *It was really challenging for me because I had limited content and background knowledge on IKS.* (G1 – II)

> *I had never heard of IKS before this module. It was something very new to me. I had no background knowledge of IKS or any content knowledge of it.* (G5 – II)

The subsequent journal entries affirmed individual and focus group response:

> *IK posed a great challenge to me because it was something I was not familiar with and it was foreign to me. Some of the specific challenges were a lack of content knowledge.* (G1 – RJ 1)

> *Another aspect that made this experience very challenging was that we did not have any solid grounding in IK.* (G1 – RJ 1)

> *I did not have any existing knowledge or background knowledge on IK.* (G5 – RJ 1)

It was apparent that participants found the integration of IK a challenge as they did not possess adequate background/content knowledge of IK. This impacted on the planning of their IK lesson whilst learning to teach science. The effects of this challenge filtered through to their actual teaching of a lesson integrating IK. This resonates with Ogunniyi's (2007) assertion that science teachers do not hold valid understandings of IKS or possess adequate knowledge to implement a science IKS-curriculum.

This lack of content and background knowledge links to theme one relating to the first research question. The lack of integration of IK in Natural Sciences modules at university have contributed to the lack of content/background knowledge that these pre-service teachers' possess. Although the themes are presented separately, they are not mutually exclusive, in other words, they do not exist in isolation.

4.4.1.2. Insufficient teacher education

All participants in this study highlighted that they received insufficient teacher education when learning to teach a culturally inclusive science. All participants expressed the need for more teacher education focussing specifically on IKS. Pre-service teachers indicated that they experienced a severe lack of confidence when teaching a culturally inclusive science lesson. From the above responses, participants were unsure as to why they have received minimal education on IKS yet it is part of the school science curriculum, and they will have to teach incorporating IKS in the future.

The following views expressing insufficient teacher education emerged in focus group interviews:

> *Teacher education was limited, we definitely need more.* (G1 – FGI)

> *Maybe we need more education on content so we can be more comfortable with IKS in the classroom.* (G2 – FGI)

> *But we need more education… We are still not confident to plan and implement IKS in a lesson in the future.* (G4 – FGI)

The following individual interviews further reinforced the above focus group responses:

> *Teacher education was not enough, I need more because I am still not confident.* (G1 – II)

> *The teacher education that I was provided with did not equip me adequately on IK.* (G2 – II)

> *IKS is part of the science curriculum, I don't know why we are provided with such little education because we are expected to teach it or implement it.* (G2 – II)

At the moment I am not confident in teaching IKS and the module is over. So really I can say the one module of education is not enough. I definitely need more education. (G4 – II)

What these responses indicated was that pre-service teachers experienced inadequate teacher education and this created a lack of confidence and resulted in an inability or unwillingness to implement policy. This has implications for their future practice. It is also possible that practicing teachers have similar experiences and therefore do not integrate IKS. This resonates with arguments postulated by Corsiglia & Snively (2001), Hewson, Javu & Holtman (2009), Odora Hoppers (2002) and Ogunniyi (2004) that the curriculum is a challenge for science teachers because they do not know the details of various indigenous knowledge systems within South Africa and may not be trained to teach such knowledge. In addition to this, Naidoo (2010, p.16) asserts that "indigenous knowledge is not documented and it is not readily available to teachers". IKS content is not easily accessible to pre-service as well as in-service teachers, therefore education in IKS integration and content is imperative. Pre-service teachers added that their education significantly lacked what aspects of IK to include in a lesson, and how to actually integrate IK as part of a science lesson.

The following views arose in the focus group and individual interviews:

*Teach us more on IK content and link it to science lessons. Show us how it can be incorporated in a lesson. We really need more education, not just one module. (*G1 – II)

This was a challenge once we got all our information on IKS we did not know how to put it in a lesson. (G1 – II)

Teaching us more IK content and also teaching us how to link it with science concepts. Teacher education on exactly how to plan a lesson incorporating IK. (G1 – II)

We did not even know how to include it in a lesson. (G3 – FGI)

The above responses are affirmed by the following journal entries:

I do need more education on how to integrate IK in different science lessons. (G1 – RJ 2)

It still leaves us with the issue of what to include as IK; how to include it and how can we infuse the two, western science and IK. (G3 – RJ 2)

All participants expressed a desire to be successfully educated on how to integrate IKS in science teaching. Moreover, pre-service teachers indicated that this specific lack of teacher education has left them with uncertainty regarding what aspects of IK need to be taught and how to go about teaching it with the aim of successfully implementing the science curriculum. This resonates with Dumile's (2011) view, which supports the need for teacher education by indicating that without the necessary support and education, teachers are left to ponder their own ways of integrating IKS into the science curriculum.

Vygotsky's socio-cultural theory advocates for the use of scaffolding. Turuk (2008, p.252) states that "scaffolding is an instructional structure whereby the teacher models the desired learning strategy then gradually shifts responsibility to the learner." Pre-service teachers indicated that they did not receive adequate teacher education to teach culturally inclusive science (which is rooted in IKS). It could be possible that the lecturer shifted the responsibility of learning to pre-service teachers too rapidly and did not use sufficient scaffolding to gradually shift the responsibility of learning to pre-service teachers.

Pre-service teachers supplemented methods and strategies that they prefer to be part of their education as they learnt to teach a culturally inclusive science. Participants indicated that they should be taught IK in conjunction with western science, and that outside IK specialists and community members can be used to facilitate part of their lectures to further enhance their learning of IKS.

There should be an IKS curriculum put in place at the university so we are taught various aspects of IK content, not just presenting a lesson. One module and one lesson presentation does not equip us with content and strategies to successfully teach IK or implement an IKS curriculum. (G1 – II)

The lecturers should have chosen NS topics and taught a lesson including IKS. If we saw her present a few lessons we will learn from that. Then we can also present and be given guidance. We need to see someone else like a lecturer or teacher teaching a lesson on IKS and we will pick up styles and ways on how to teach. (G2 – II)

I prefer to learn IKS in conjunction with western science. Both IK and western science should be taught equally. I did not like the way we learnt in this module, we

> *were just given a topic and asked to plan a lesson incorporating IKS. I would prefer to be given the content, taught that content, shown how to integrate IKS with western science, and then given the opportunity to plan my own lesson.* (G2 – II)

These pre-service teachers expressed a desire to copy the lecturer. This would not have resulted in "transition of knowledge from social to personal property" (Turuk, 2008, p.246). It is possible that the lecturer wanted them to transform knowledge given to them during the "processes of appropriation" (*Ibid*, p.246). It is likely that if the Natural Sciences topics were given to them, and if the lecturer engaged in role play by teaching the lesson, pre-service teachers would not have been enabled to reach "higher areas of potential development" (*Ibid*, p.249).

> *The lecturer must educate us, but they can bring in outsiders and community members to assist us with our learning. For example, if we are doing anaerobic respiration then fermentation can come into the lesson. Like how people perform fermentation to prepare the African beer. We can make that same example in our own practice. IKS content must be included in every module so we become exposed to it and get familiar with it.* (G6 – II)

Pre-service teachers are of the view that they need more assistance from Natural Sciences modules (content, strategies to integrate IKS), as well as from the lecturer (role-modelling the teaching of IKS, mimicking the lecturer). However, if they received all the necessary content, strategies and methods of teaching IKS, these pre-service teachers would not be constructing their own knowledge, rather they would engage with emulating the lecturer. Vygotsky's ZPD promotes the active construction of knowledge by the learner so that learning can occur. It appears that the structure of the module created the platform for pre-service teachers to interact with other people and resources and construct knowledge in the "inter-psychological plane" and assimilate this knowledge, and internalise it in the "intra-psychological plane" (*Ibid*, p.246). Although pre-service teachers claimed that they lacked knowledge and confidence to teach culturally inclusive science, they were able to, through co-operative learning, develop excellent strategies and learnt indigenous knowledge content, which they embedded into their lessons. They progress from feeling vulnerable and incapable to becoming increasingly confident about teaching culturally inclusive science.

As mentioned earlier, the university has adopted an AIKS policy. This policy stipulates as one of its aims the involvement of local community members to facilitate further learning.

> *AIKS aims to be a leading programme within and outside the university that engages with communities through tapping into local community resources that inform and shape community work for mutual beneficiation* (AIKS policy, p.5).

If this policy was being implemented accurately then pre-service teachers would have unlimited access to external human resources of IKS. They could use these external human resources to generate IK content and thus enhance their understanding of IKS. This would have benefited them in their education of learning to teach science lessons integrating culture. Furthermore, engaging with these external human resources would have reduced the level of difficulty experienced by participants caused by the insufficient teacher education they received.

4.4.1.3. Lack of resources

All of the pre-service teachers in the study stated that they encountered a lack of resources, specifically textbooks, in their planning to teach a culturally inclusive science lesson, as part of their learning to teach science. All participants expressed that school science textbooks do not contain any information or guidance on cultural knowledge rooted in IK. This was evident in their focus group interview and individual interview.

> *Textbooks do not cover enough content on IKS… Textbooks mainly cover the science concepts. No section on IKS. Textbooks don't even include any guidelines for us to use when planning a lesson.* (G1 – FGI)

> *Textbooks did not have any information on IKS so planning a lesson was challenging.* (G1 – II)

> *But when it comes to IK, textbooks don't even help. There is no information or activities to use or assist us. This makes the learning and teaching of IK very hard and thereby creates many challenges.* (G1 – II)

> *There are no books or even teacher guides to help us. We looked at lots of textbooks and we did not get any information. We also looked at CAPS textbooks which have the new content and those books also did not have any guide or information to assist us.* (G4 – II)

The above responses are affirmed by the following journal entries:

Textbooks did not have any information, no guidelines in teacher and learner books. (G1 – RJ1)

Textbooks have no information to assist with IKS. (G1 – RJ3)

There are no textbooks to assist us with IK. There are no teacher or learner guides (books) to assist us planning an IK lesson. The current CAPS textbooks also do not have any information. (G4 – RJ3)

The preceding and succeeding responses of pre-service teachers are echoed by Dumile (2011) who states that certain textbooks make mention of the integration of IKS, but do not provide guidance as to which components of IKS should be integrated, and how this integration should transpire.

The fact textbooks have no information on IK indicates to us that IK is considered irrelevant, thus a neglected science. (G3 – RJ 2)

This raises crucial questions which deserve to be mentioned and can be avenues for future research. Are Department of Basic Education policies couched in a post-colonial framework because this is politically correct, not because this is easily implementable? Why does this same Department of Basic Education not provide what Vygotsky (1978) refers to as tools in the form of textbooks to enable implementation of policies, such as integrating IKS in the curriculum? How are teachers (both practicing and pre-service) expected to enact curriculum in the absence of these tools? How are teachers (both practicing and pre-service) expected to appropriate knowledge as personal in the absence of these tools- how do teachers learn to enact a transformed curriculum without these resources?

Text books were of little help to us, we did not find any content that was relevant to our lesson in text books. This could be as a result of IKS still being a topic that has not received as much attention as it deserves in schools. (G3 – RJ 1)

Even the Department of Education needs to look at textbooks including IKS. (G4 – RJ 3)

But IK is disregarded or devalued because textbooks do not provide any information on IK. It was quite challenging because both new and old textbooks don't even include ways for teachers to incorporate IK in lessons. (G5 – RJ 1)

The preceding quotation is profound. The pre-service teacher identifies an important hidden feature of curriculum- that alternate knowledge systems are promoted only in policy but are not supported by creating relevant resources, and therefore alternate knowledge systems are, in reality "devalued". The new curriculum (RNCS, 2002) is underpinned by a transformational discourse designed to create and perpetuate a democratic social order, yet deficiencies related to its enactment position alternate knowledge systems as subaltern to western knowledge systems. In this way, the new curriculum perpetuates knowledge and power hierarchies of the colonial era.

4.4.1.4. Limited time to plan a lesson incorporating cultural knowledge embedded in IKS

All of the participants, except group six, indicated that the time constraints posed a challenge for them. The lack of assistance or information present in textbooks required participants to research IK on their own (external sources) and using the internet. This was revealed in their focus group interview, individual interview, and their reflections.

> *Looking for the information was really time-consuming.* (G1 – II)
>
> *Finding information was really time-consuming.* (G2 – II)
>
> *Time allocated to plan the lesson was not enough.* (G1 – II)
>
> *Time was another challenge. It took a lot of time to research the information. Planning the lesson also took a lot of time. There was also limited time to complete this assignment.* (G3 – II)
>
> *I had limited time to plan a lesson.* (G3 – RJ 2)

The above responses clearly expressed that participants required more time to successfully plan and teach a lesson incorporating IK, and this impacted on their learning to teach science. This reveals that knowledge which is rooted in alternate knowledge systems is not adequately documented: this is a factor which perhaps contributes to its marginalisation.

4.4.1.5. The CAPS document (inadequate assistance provided by the document)

The responses from a majority of participants indicated that the CAPS document did not provide them with the required information to plan a culturally inclusive science lesson.

The following views emerged in the focus group and individual interviews;

> *Even the CAPS document doesn't even help. It does not even mention how one should go about teaching using IKS. Even the document does not have information on IKS; it just had sentences on medicinal plants. We need practicals, and steps are like 5 pages, but so little on IKS.* (G1 – FGI)

> *The CAPS document which isn't that friendly. They say it is easy and user friendly but it is not. It does not help. It does not assist us in developing our lesson. It just gave us our specific aim and topic. No idea on how to actually include IKS in science lessons.* (G1 – FGI)

> *The CAPS document also does not provide any assistance. It was very challenging.* (G1 – II)

The subsequent journal entry affirmed the preceding responses:

> *The CAPS document was not user friendly. It did not help in planning this lesson yet it is stipulated in the CAPS that we need to achieve specific aim 3, which is incorporating IK in science lessons.* (G1 – RJ 1)

The Curriculum and Assessment Policy Statement (CAPS) of Natural Sciences expects teachers to embrace indigenous knowledge systems in order to deliver culturally inclusive lessons. The disjuncture between policy design and policy implementation emerges as a worrying feature of the CAPS document.

Indigenous knowledge systems and Natural Sciences

"Our forebears would not have survived if they had not been able to learn about the natural world they depended on. They made careful observations, recognised regular patterns in seasons, the life cycles of plants, and the behaviours of animals. They had theories about cause and effect too, and understood many of the relationships in the environment where they lived. These sets of knowledge, each woven into the history and place of people, are known as indigenous knowledge systems. Indigenous knowledge includes knowledge about agriculture and food production, pastoral practices and animal production, forestry, plant classification, medicinal plants, management of biodiversity, food preservation, management of soil and water, iron smelting, brewing, making dwellings and understanding astronomy. As society changes, some of that knowledge is being lost. People such as biologists, pharmacists

and archaeologists are seeking it out and writing it down before it is gone" (DoE, CAPS, grades 7-9, 2011, p.10)

Specific Aim 3: "Understanding the use of Science" (DoE, CAPS, grades 7-9, 2011, p.10). "Learners should understand the use of Natural Sciences and indigenous knowledge in society and the environment. Science learnt at school should produce learners who understand that school science can be relevant to everyday life. Issues such as improving water quality, growing food without damaging the land and building energy-efficient houses are examples of applications. An appreciation of the history of scientific discoveries, and their relationship to indigenous knowledge and different world views, enriches our understanding of the connections between Science and Society" (DoE, CAPS, grades 7-9, 2011, p.10).

Participants expressed that the CAPS document merely stipulates the specific aims, without indicating methods and strategies of how to successfully achieve the aims, in particular specific aim 3. The preceding quotation from the CAPS document affirmed the participants' views.

It was evident that there were inadequate policy guidelines, inadequate resources and insufficient teacher education to enable pre-service teachers to plan and teach lessons integrating IKS, which impacted negatively on their implementation of specific aim 3. It is possible that both in-service and pre-service teachers may choose to avoid incorporating IKS because of these multiple challenges.

Despite the fact that the majority of participants mentioned that the CAPS document did not provide them with the required assistance to plan a culturally inclusive science lesson, all six groups planned a lesson integrating IKS that achieved specific aim 3.

Table 4: Analysis of lesson plans

QUESTIONS	YES	NO
1. Are the specific aims of the CAPS policy document clearly stated?	Group 1 Group 2 Group 3 Group 4 Group 6	Group 5
2. Does the lesson plan incorporate IKS within the science lesson?	Group 1 Group 2 Group 3 Group 4 Group 5 Group 6	
3. Is specific aim 3 of the CAPS policy document achievable in the lesson?	Group 1 Group 2 Group 3 Group 4 Group 5 Group 6	

What is interesting is that although pre-service teachers cited numerous obstacles, they were able to create a lesson in which they integrated IKS and created a lesson where Specific Aim 3 was achievable.

The results from table four show that all of the groups except group five were able to clearly state the specific aims of the CAPS policy document. This was indicated in the focus group interview of group five.

> *Oh IKS is in the CAPS document? So it is in the curriculum?* (G5 – FGI)

This was affirmed in all the reflections of group five members:

> *We did not even make use the CAPS document.* (G5 – RJ 1)
>
> *We did not even use the CAPS document to plan our lesson.* (G5 – RJ 2)
>
> *I did not even know that IKS was in the CAPS document. We didn't use it. Only after this module I came to know.* (G5 – RJ)

Table 5: Synopsis of the IK topics used by each group

GROUP	TOPIC
1	Indigenous medicinal plants - Rooibos
2	Astronomy – historical development of astronomy
3	Organic fertilizers
4	Soil and water management using indigenous knowledge – (Permaculture)
5	Indigenous medicinal plants - Blackjack
6	Soil and water management using indigenous knowledge – (Permaculture)

All of the six groups planned a Natural Sciences lesson incorporating cultural knowledge embedded in IKS. The following analysis is based on the examination of the lesson plans produced by each group.

Groups one and five planned a lesson incorporating indigenous medical plants. Group one used rooibos as an indigenous medicinal plant highlighting how the use of rooibos tea can alleviate heartburn, nausea and stomach cramps. This group further incorporated the rooibos tea plant into a practical testing the pH levels of different substances. The practical also included a task where learners design and plan an investigation testing whether or not rooibos tea can be used to alleviate heartburn.

Group five used the Blackjack as an indigenous medicinal plant. This group discussed the medicinal uses of different parts of the plant. They highlighted that the stem is used to help people with prostate tumours and it also has antibacterial and anti-inflammatory properties. The leaves heal cuts and wounds and assists in boosting the immune system. Group five provided learners with a case study based on the blackjack plant with questions.

Group two planned a lesson incorporating the historical development of astronomy using early indigenous knowledge and modern development. This group presented their lesson in the form of a role play expressing how the indigenous people use astronomy presently. This practical component involved the designing of a sundial.

Group three included the use of organic fertilizer (goat's manure) in their lesson. This group further incorporated a practical investigation in their lesson where they recorded the growth of bean seeds with various measurements of organic manure. Group three also included a

worksheet with questions based on the practical conducted. Some of the questions included were: 1) provide a hypothesis for the investigation; 2) state the independent and dependent variable; 3) how can the investigation be improved.

Group four and six planned a lesson on soil and water management using indigenous knowledge highlighting the aspect of Permaculture. Group four discussed soil winnowing, soil erosion and dams and soak pits. This group included the aspect of Permaculture by demarcating a suitable area and designing a garden. Group six discussed the importance of water and soil and ways in which it can be conserved.

This group included Permaculture in the form of a practical. They discussed and demonstrated steps on how to prepare a Permaculture garden. They highlighted concepts of mulching, organic fertilizers and watering sections of the garden to conserve water.

4.4.2. Theme 2: The opportunities experienced by pre-service teachers.

The opportunities experienced by pre-service teachers will be explored according to two sub-themes:

- Working in groups
- The use of external human resources (IKS knowledge holders in the community, family members)

These two themes are discussed below.

4.4.2.1. Working in Groups

Working in groups was viewed as an opportunity which enhanced their learning to teach a lesson incorporating culture (which is rooted in IKS).

All pre-service teachers expressed that being part of a group and working with other group members enriched their knowledge of IKS. Participants viewed this as important because the majority of them had very little background and content knowledge on IKS.

The following views emerged from the focus group and individual interviews:

> *One more point I like to make working in groups was really good because we all shared our knowledge and thought each other.* (G1 – FGI)

We also taught each other clarifying the definitions. We all worked together and taught ourselves. (G2 – II)

By sharing and working in groups we developed content and background knowledge. (G2 – II)

I also learnt from my group members that worked with me. We came from different backgrounds and we learnt from each other. He built and added to the knowledge I had. We also researched and shared knowledge. We taught each other. (G3 – II)

The rest of the group members had no idea and relied on me to teach them the content. I did not mind helping because I know that we were all helping each other. (G6 – II)

Working in groups is coherent within the ZPD which promotes collaboration with peers so that further development and higher level of problem solving is achieved (Wertsch, 1985). Pre-service teachers were able to learn from their peers whilst working in groups and this enhanced their content knowledge of IKS. The acquisition of knowledge in the "inter-psychological plane" occurred through interaction with group members. The "dynamic nature of interplay" among group members enabled learning to occur from, through and in interaction (Turuk, 2008, p. 248). "Collaboration with more capable peers" (Wertsch, 1985, p.60) enabled pre-service teachers to move beyond expected levels of development, to more superior levels of development. This is in keeping with Burdett (2003) who argues that working in groups is beneficial as it promotes effective learning whilst also exposing students to the atmosphere of future work. Burdett (2003, p.177) explains that through group work students are able to learn effectively and also "negotiate meaning and manipulate ideas with others and reflect on their learning." An added advantage of students working in groups is that it strengthens social interactions between students and promotes collaboration within the group (Burdett, 2003).

The subsequent journal entries affirmed the above responses:

Within our group we discussed how to approach the task of creating a culturally inclusive lesson. (G1 – RJ 1)

Working in groups was an advantage in that group members shared ideas and guided my learning. I was able to learn from my peers. (G2 – RJ 1)

We worked well in the group and shared knowledge. (G3 – RJ 1)

I had little understanding of what I should do I therefore ask for assistance from my fellow group member. (G6 – RJ 4)

It is apparent from the above responses that pre-service teachers shared knowledge and learnt from one another. Group work afforded them the opportunity to build and add to one another's content knowledge of IKS, thereby facilitating learning within the group. This resonates with the ZPD which is a central theoretical construct of my study. Donald, Lazarus and Lolwana (2002) state that it is that critical space where a child cannot quite understand something alone, but has the potential to do so through proximal interaction with another person who has the capacity.

One of the groups expressed that learning for them was facilitated by one group member. This capable member shared and guided the other members through their learning to teach a lesson integrating IKS. This is congruent with Kinginger (2002, p.240) who argues that "the ZPD is a tool capturing the emergence of cognitive development within social interaction, when learners are provided with assistance from more – competent others (teachers or peers) as they engage in learning activity".

In addition to this, pre-service teachers mentioned that without the group work they would have been unable to plan and teach a lesson integrating IKS. This resonates with the view of Donald *et al*. (2002) who state that the ZPD is the critical space in a persons' current understanding where, through face-to-face mediation, a new level of understanding can be fashioned.

Pre-services teachers responses about group work are:

Working in groups was also a great learning experience. This lesson was really hard and I could have not managed alone but in a group we shared knowledge and learnt together. (G1 – RJ 2)

I learnt a lot from the group work really helped me and I could have not done without it. I was able to plan the lesson and learn from my group members. Working with groups has taught me a lot that I would not have got working on my own. (G4 – RJ 4)

If I had to plan an IKS lesson on my own I would have been unsuccessful. (G5 – RJ 3)

Shayer (2002) cites Turuk (2008) and states that according to the ZPD, there are certain internal developmental processes that are only activated when a learner (pre-service teachers) interacts with peers. Shayer (2002) cited in Turuk (2008) adds that interaction with peers promotes development and prompts learners (pre-service teachers) to achieve a further task independently.

The above responses highlighted that working together in groups presented participants with the opportunity to work face-to-face with other group members and develop a new level of understanding regarding IKS. Other than the collaboration in groups, a majority of the participants indicated that they learnt from the group presentation as well. Each group had to deliver their lesson integrating IKS in the form of a group presentation.

> *As the other presentations are going we are picking up ideas and learning.* (G1 – FGI)
>
> *They said it was memorable. They actually used our lesson as an example in their lesson.* (G1 – FGI)
>
> *We learnt some things from other groups that presented their lessons. We picked up ways to include it in science lessons in the future.* (G3 – FGI)
>
> *We can use other presentations and add on… We learnt from the other groups, it was interesting.* (G4 – FGI)
>
> *We did learn from the presentations that the groups did. It showed us some techniques of how to incorporate IKS in science lessons.* (G5 – II)
>
> *Medicinal plants to heal cough. Just take a plant, chop it up and boil it, and drink the water and it will heal you. Medicinal plants as a remedy. Like rooibos tea has many healing properties. I learnt this from another groups' presentation during lectures. This was very interesting.* (G6 – FGI)

The above responses extracted from the focus group interviews and individual interviews indicated that participants learnt from the other group presentations. Participants clearly expressed through their responses the memorable effect certain group presentations had on them in that they will use this knowledge in their future teaching of science. Pre-service teachers indicated that they learnt from observing presentations done by other groups. These

group presentations were located within the microteaching context. This indicates that the use of microteaching enhanced learning for pre-service teachers.

Pre-service teachers learnt whilst interacting with other groups and were able to enhance their own content knowledge of IKS. This confers with the socio-cultural theory as explained by Ellis (2000) cited in Turuk (2008). Ellis postulates that learners are able to learn new knowledge in their interaction with peers. They then internalise what they learn and are able to use this newly acquired knowledge. This is a result of the use of scaffolding as a teaching and learning technique. Pre-service teachers acquired new knowledge whilst interacting with other group presentations to be used in their future teaching.

4.4.2.2. The use of external human resources

The responses of three out of six groups indicated the use of external human resources of knowledge in planning to teach a culturally inclusive science lesson. External human resources refer to people who are not students or academics at the university. Groups one, three and six solicited IKS knowledge from community members and family members to enhance their learning of IKS.

The three groups mentioned above expressed the need to seek assistance from external IKS knowledge holders. Participants revealed that external human resources provided them with guidance and assistance which facilitated their learning of IKS.

The following views arose from the focus group and individual interviews:

> *I brainstormed the topic with family members and a local pharmacist.* (G1 – FGI)
> *We spoke to community members, people managing soil in rural areas; we spoke to people of South Beach, where we are from. We gained lots of knowledge. They guided us to the goat's manure, which is more fertile.* (G3 – FGI)

> *We consulted our parents. Fortunately my mother is in an organisation where they plant various crops in different seasons. She knows better about IKS. So we went to my homeland and got information/ assistance and guidance. I had some knowledge but I went into the community and developed that knowledge further. I built on the knowledge. I learnt from my mother… My mum and members of the community told me the goat manure is better.* (G3 – II)

The journal entries that follow affirmed the above responses:

by talking to our parents, local pharmacist. (G1 – RJ 2)

We had an opportunity to sit down with our elders and gained valuable knowledge about natural manure, planting in general and other knowledge that goes beyond manure and planting. (G3 – RJ 1)

These responses revealed the guidance and assistance that participants received from external human resources. It is clear to see that these external human resources provided participants with critical information on IKS that shaped their understanding and learning. Groups one, three and six all made use of adults in their families and in the community. This is in line with the Vygotsky's Zone of Proximal Development which is defined as "the distance between a child's actual development level as determined by independent problem solving, and the higher level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Wertsch, 1985, p. 60).

Additionally, there is a stark difference between two of the groups in the study: group six who sought assistance from external human resources, and group four who did not make use of external human resources. Both groups highlighted the practices of permaculture in their lessons.

We came up with permaculture because we went to the botanic gardens for an excursion, we learnt from botanical gardens and we used it in our lesson. (G6 – FGI)

The information we obtain on a field trip to botanical garden… helped us to find the background information on the practice of Permaculture. (G6 – RJ 3)

The preceding responses from group six clearly outlined the fact that they used informal knowledge gained from a field trip to assist and guide their planning and teaching of their lesson.

Group six visibly demonstrated the practices of Permaculture in the form of a practical demonstration, while group four merely mentioned the term Permaculture without any explanation. It is evident while observing the lessons, group four demonstrated a lack of knowledge regarding the practices of Permaculture. Group six was probably able to demonstrate their lesson more successfully because of the guidance and knowledge gained from external sources.

Group 6: *For the practical learners will go to the garden and then use the soil and take out the weeds from the soil and then level the soil to have something like this, and add manure and then add water and put leaves in with all waste materials that learners have gathered. Leaves put on the top so that the sunlight doesn't hit the soil directly and the nutrients from the leaves will go to the soil. Thank you.*

Lecturer: *Regenerating soil using this method, are you stressing this in your lesson?*

Group 6: *Yes*

Lecturer: *Ok, thank you.* (G6 – VRO)

The response of the lecturer indicated that group six presented a well-planned practical that related to the IK that their lesson incorporated. Their lesson and their practical revealed a clear understanding of permaculture.

This clear understanding of permaculture was affirmed in the individual interview and reflections of group six:

We had to improvise, we did a demonstration. We had to demonstrate a Permaculture garden using organic waste, branches and leaves. We had to prepare the soil without using any fertilizers or chemicals. We demonstrated it to the class. (G6 – II)

I learnt a lot from the field trip we went to. The pamphlets that they gave us explained the concept mulching which was used in our practical. We also observed how you plant different plants that require specific amounts of water together. We learnt how you water the long portion of the land conserving water. (G6 – RJ 1)

The information we obtained on a field trip to botanical garden helped us to find the background information on the practice of Permaculture. This assisted us in the planning of the practical aspect of our lesson. (G6 –RJ3)

By teaching learners the steps towards practicing Permaculture they will learn how to cultivate soil for gardening using only organic material (Mulching, organic manure, dead leaves and branches, etc.). (G6 – RJ 3)

The content knowledge that members of group six possessed was enhanced through mediation. This mediation occurred in the form of a field trip to botanical gardens. Mediation is part of the socio-cultural theory. Turuk (2008), drawing from the socio-cultural theory

postulates that mediation with others enhances learning and shapes learning experiences. He adds that social interaction helps the "learner (pre-service teacher) to move into and through the next layer of knowledge or understanding" (Turuk, 2008, p. 251).

Group four was unable to demonstrate the practices of permaculture in their lesson successfully:

> Group 4: *For the practical of this lesson uh... we'll be putting them in uh... the class in groups… Each group will go out into the school yard and look for a suitable spot to plant a garden… They will make a small garden using permaculture.*
> Lecturer: *That's it? Thank you, anything else? I couldn't see the point of Permaculture. Permaculture does involve strategies which help to manage soil and water. I did not see specifically how Permaculture is used to manage soil and water coming out of your practical. But when you have your students creating gardens, how do you manage the soil? Do they use organic composts? Did you mention organic compost?*
>
> Lecturer: *How else do they manage soil? How do they prevent soil erosion of this garden? Did you mention mulching? And in terms of water? What teaching from Permaculture can you use to manage water supply?*
>
> Group 4: *Uh...?*
>
> Lecturer: *On Permaculture how will you manage water supply? One of the strategies is to plant plants which require specific amounts of water, let's say little water, you plant them together. Then plants that require moderate water, you plant them together, and those that require a lot of water you plant those together. So you know you can skip watering those that need very little water every day; and just water the patch that needs a lot of water every day, you understand? So you can regulate the water, the amount of water you use ok. Thank you.* (G4 – VRO)

The response of the lecturer clearly indicated that group four lacked fluidity in the practical aspect of their lesson. There were significant gaps in their practical. They mentioned the term Permaculture but did not demonstrate any understanding of it. Their practical involving a garden did not demonstrate any practice of Permaculture. It is clear that group four did not have any knowledge of Permaculture and this is affirmed in the reflective journals.

> *The practical was a challenge. We did not know how to incorporate a practical including IKS… One of the main challenges I faced was trying to incorporate a practical activity using IKS. We did a practical for the sake of it; we didn't even understand what we were really doing. We got confused with a garden and Permaculture.* (G4 – RJ 1)

The use of external human resources in the planning and presentation of lessons incorporating IKS was clearly beneficial, as is evident by the experiences of group 6. Other sources of knowledge greatly increased the knowledge of participants that engaged with them and this was evident in the presentation of their lessons. Groups that did not engage with external human resources, however, were not as successful, especially in the practical aspects of the lesson.

Pre-service teachers viewed their learning as insufficient, support as inadequate and that they were constrained by time. These challenges forced these students to transform. Their responses indicated that they wanted to receive information (content), which they planned to copy, during their learning about IK. Moreover, pre-service teachers wanted to model or emulate the teaching strategies of the lecturer. However, they did not receive this in their teacher education. This spurred them to seek other knowledge holders such as community members, family members and informal knowledge gained on a field trip. These pre-service teachers become agents of their own transformation. Initially their expectation was to be a passive recipient of content and strategies to teach IK. Pre-service teachers' learning expectations were not met during their teacher education and this forced them to transform from passive recipients to active generators of strategies to teach IK. These students became responsible, motivated and thus took control of their own learning. They took control by using community members as repositories of knowledge. This reveals that they positioned alternate knowledge holders as legitimate teachers thereby signalling IK as valuable and important. These alternate knowledge holders moved pre-service teachers beyond the boundary of where they should be, and into their ZPD. In addition to this, they worked in groups and collaborated with one another seeking information on IK. It is evident these pre-service teachers' learning journeys were characterised by self-motivation, responsibility for, and control of their own learning. They became agentic in their transformation from passive students to active constructors of knowledge.

It is apparent that pre-service teachers moved from a position of not knowing how to teach culturally inclusive science to one where they were able to successfully teach a science lesson integrating IKS, by learning to teach using the ZPD. Pre-service teachers were visibly motivated through the use of the ZPD. This resonates with Walker's, Pressick-Kilborn's, Sainsbury's and MacCallum's (2010, pp. 18-19) assertion that "the creation of zones of proximal development involves assistance with the cognitive structuring of learning tasks and sensitivity to the learners current capabilities. Socio-cultural Vygotskian and traditional motivational theorists have observed that these aspects of the ZPD make it an inherently motivational zone." It is evident through pre-service teachers' experiences of learning that they displayed a great sense of motivation, though they did not receive IK content from the lecturer, and textbooks did not provide IK information. The absence of content information from and role-playing as a teaching strategy by the lecturer forced these participants to progress beyond the expected level of competence to more advanced levels.

Pre-service teachers also took responsibility and control of their own learning and this was produced through the use of the ZPD. This resonates with Walker *et al*. (2010, p. 19), who assert that, "additionally, working within the ZPD is inherently motivating because it involves the transfer of responsibility or control, for learning from the teachers or more capable other to the learner. This transfer of control is motivating for the student as it acknowledge student mastery of the task, and hence the learners' developing efficacy."

4.5. Conclusion

In this chapter, I analysed the findings that emerged inductively from the data. The findings were presented in the form of themes in response to the two research questions that framed my study. The findings included pre-service teachers' views and experiences of the integration of culture whilst learning to teach science. Pre-service teachers expressed two broad views regarding the integration of culture. The first view was the lack of integration of cultural knowledge, rooted in IKS, in Natural Sciences content modules. The second view related to the potential benefits of the integration of cultural knowledge in science lessons. The experiences of pre-service teachers learning to teach a culturally inclusive science revealed both challenges and opportunities. These pre-service teachers expressed a lack of cultural knowledge rooted in IKS, insufficient teacher education, a lack of resources, time constraints, and inadequate assistance provided by the CAPS document as challenges. In spite of these challenges, pre-service teachers expressed that working in groups and the use of

external human resources were opportunities for them to learn to teach culturally inclusive science. Literature was presented in substantiation of the themes that emerged. The next chapter will focus on a summary of the main findings together with recommendations and conclusions.

CHAPTER 5

Summary, Recommendations and Conclusions

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Chapter 5

Summary, Recommendations and Conclusions

5.1. Introduction

This qualitative study sought to explore pre-service teachers' experiences and views of learning to teach a culturally inclusive science which is embedded in indigenous knowledge systems. This chapter serves to recapitulate the main findings that emerged inductively from the data. These findings contribute towards answering the two critical questions which guided this study. First, a summary of the key research findings addressing each research question is presented. Second, a discussion of the recommendations directed to teacher education institutions, university educators and school curriculum designers brings this chapter to a conclusion.

5.2. Summary of key research findings

This chapter captures the responses of pre-service teachers to the two critical questions that framed my study, namely:

1) How do pre-service teachers view the integration of culture when they learn to teach science?
2) What are pre-service teachers' experiences of learning to teach culturally inclusive science?

The responses to the above questions will be presented as themes that have emerged out of this study.

For research question one, two themes emerged, namely:

- Lack of integration of culture in Natural Sciences content modules

The findings revealed that pre-service teachers are of the view that there is a lack of integration of culture (rooted in IKS) in Natural Sciences content modules. Pre-service teachers share the view that this integration is necessary so that they can become culturally responsive teachers. They experienced this lacuna in the university science curriculum as potentially debilitating. It was found that pre-service teachers believe that more attention at

the university should be diverted towards the integration of IKS in Natural Sciences content modules. A significant finding was that pre-service teachers provided practical solutions to address the paucity of IK-related information in Natural Sciences content modules.

- The potential benefits of the integration of cultural knowledge rooted in IKS

This study revealed that pre-service teachers believed that exposing learners in the science classroom to cultural knowledge that is rooted in IKS is beneficial because this enables learners to receive a holistic view of science and not a fragmented one. Findings showed that by integrating IK in science teaching, the backgrounds and identities of learners are affirmed as significant. This is of benefit to the learners as they now become a part of the lesson- this makes for an inclusive science curriculum at school level. Pre-service teachers in this study argued that through the integration of IK in science teaching, the learning and understanding of learners will be meaningfully enhanced. Another important finding is that the inclusion of IK can potentially improve the performance of learners in science. This is significant given the dismal performance of South African learners in international tests (TIMMS). Pre-service teachers revealed that improvement in learner achievement in school science classrooms can be facilitated by teaching science in a way that moves learners from familiar knowledge to unfamiliar knowledge.

Figure five illustrates the views expressed by pre-service teachers whilst learning to teach culturally inclusive science.

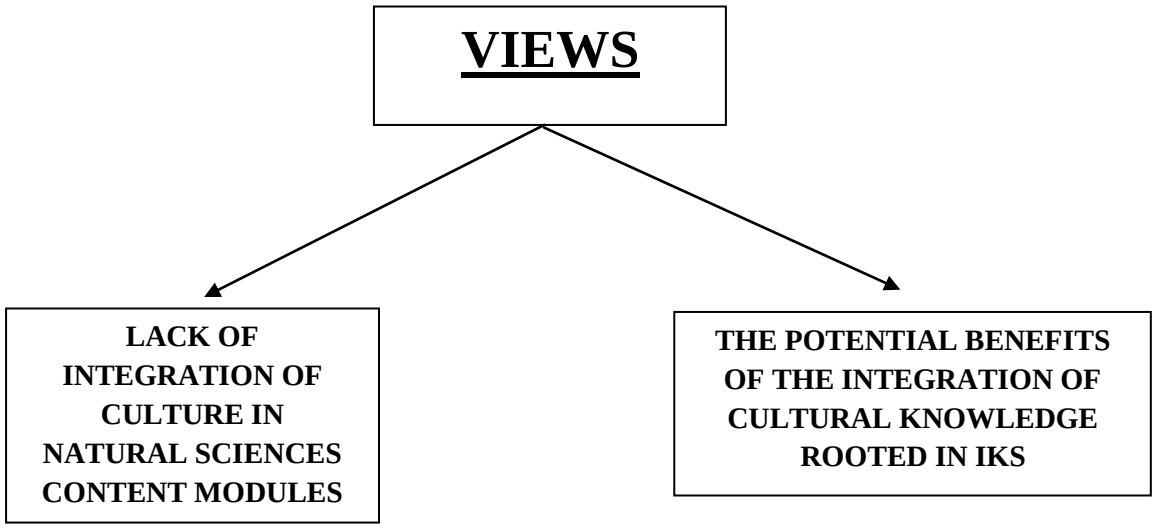

Figure 5 - Views expressed by pre-service teachers whilst learning to teach culturally inclusive science

Figure six illustrates the experiences of pre-service teachers whilst learning to teach culturally inclusive science.

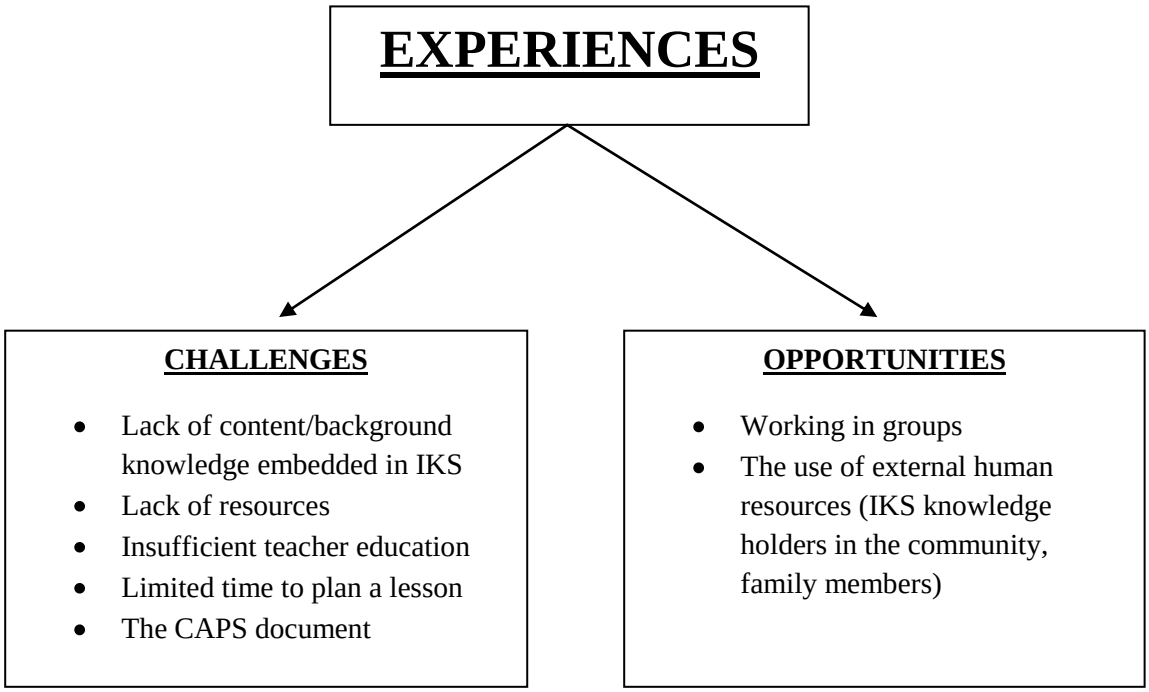

Figure 6 - Experiences of pre-service teachers whilst learning to teach culturally inclusive science

For research question two, two themes emerged, namely, challenges and opportunities experienced by pre-service teachers.

Challenges experienced by pre-service teachers whilst learning to teach culturally inclusive science (rooted in IKS).

The findings revealed that pre-service teachers experienced challenges in the form of the following:

- Lack of content/background cultural knowledge embedded in IKS
- Insufficient teacher education
- Lack of resources
- Limited time to plan a lesson incorporating knowledge embedded in IKS
- The CAPS document (inadequate details in school curriculum policy)

It was found that the challenges experienced by pre-service teachers negatively affected the levels of success achieved by pre-service teachers in learning to teach culturally inclusive

science. An important finding from the study is that pre-service teachers are of the view that they are receiving inadequate teacher education from the university. The teacher education that they receive does not equip them with the necessary teaching methods that are required for them to successfully teach culturally inclusive science (that is embedded in IKS).

- The opportunities experienced by pre-service teachers whilst learning to teach culturally inclusive science (rooted in IKS).

Findings revealed that pre-service teachers experienced opportunities whilst learning to teach culturally inclusive science in the form of the following:

- Working in groups
- The use of external human resources

The findings revealed that the challenges experienced by pre-service teachers outweighed the opportunities expressed by them. However, pre-service teachers are of the view that working in groups and making use of external human resources greatly assisted them in learning to teach culturally inclusive science. The findings from this study further revealed that although pre-service teachers were heavily challenged, they were still able to find opportunities that assisted them in their learning to teach a culturally inclusive science.

5.3. Recommendations

It is evident that pre-service teachers experienced challenges as well as opportunities whilst learning to teach a culturally inclusive science. In addition to this, pre-service teachers view their teacher education as deficient, however they do realise the potential benefits of the integration of culture (which is rooted in IKS) in science. Teachers are expected to adapt to frequent changes in educational policy (Mudaly & Ismail, 2013). Currently, with the implementation of the Curriculum and Assessment Policy Statement (CAPS), science teachers are expected to embrace culturally-infused science lessons which are embedded in indigenous knowledge systems. For science teachers to successfully implement a culturally inclusive science curriculum, teacher education is of vital importance. Ogunniyi (2007) and Govender (2009) argue that many science teachers do not hold valid understandings of IKS or possess sufficient knowledge to implement a science IKS-curricula. This brings to mind the following observation that curriculum reform is "not a neat, linear movement from one curriculum space to another. Rather, it is fraught with tensions, conflicts and contradictions that are indeed necessary for change to occur" (Maistry, 2011, p.119 cited by Mudaly &

Ismail, 2013). The following recommendations are made based on the findings of the study. The recommendations are directed for teacher education institutions, university educators, curriculum designers and should also prove useful for further studies in the area of a culturally inclusive science education (which is rooted in IKS).

5.3.1. Recommendations for teacher education institutions

Firstly, university modules, especially Natural Sciences, should be in sync with the university policy which promotes and values IKS. Teacher education institutions should include culture (which is rooted in IKS) in all Natural Sciences modules. Pre-service teachers should be exposed to IK content as well as implementation strategies in Natural Sciences content and pedagogic content knowledge modules. The university should aim to develop an IKS resource centre and conduct workshops to assist pre-service teachers with the implementation of a science IKS curriculum.

5.3.2. Recommendations for university educators

University educators at teacher education institutions need to be culturally responsive themselves. They need to be cognisant of the multicultural learner populations that pre-service Natural Sciences teachers will be interacting with when they begin their teaching. By doing this, university educators convey to pre-service teachers the critical characteristic of being a culturally responsive teacher in the Natural Sciences classroom. University educators need to incorporate the various teaching styles and strategies needed to implement a culturally inclusive science rooted in IKS. This study has shown how pre-service teachers can be stimulated by an activity designed to enable them to transcend intellectual boundaries and acquire higher levels of knowledge, by engaging with a multitude of resources within and outside the university. The development of university students as independent thinkers who are responsible for their own learning can be facilitated if university educators design their modules carefully.

5.3.3. Recommendations for curriculum designers

University and school curriculum designers need to provide assistance to teachers (practicing and pre-service) to implement a science IKS-curriculum. They need to design the school policy documents for Natural Sciences in a way that makes them possible to implement, which is crucial. IK concepts and topics should be included in textbooks together with examples of how IK can be integrated into school science. Furthermore, teacher and learner

guides which incorporate IK could be designed for Natural Sciences. These guides should illustrate, using content and examples, how Specific Aim 3 of the CAPS curriculum can be implemented and achieved. This type of support is indispensable for the achievement of Specific Aim 3 of the CAPS document. The university curriculum, which is designed for pre-service science teachers, should incorporate IK in both content and PCK modules. There should be articulation between AIKS policy and university curricula, to meet the goals of disciplines specifically, and the university more broadly.

5.3.4. Recommendations for further studies

There is a scarcity of literature in the area of pre-service teachers and a culturally inclusive science education. This study contributes to the discourse of culturally inclusive science education. Studies which specifically explore how pre-service teachers integrate culture (rooted in IKS) in science teaching are of importance. Further studies on the aspects of culture (rooted in IKS) that pre-service teachers incorporate in their science teaching should be undertaken. Critical exploration into the articulation if IKS- related policy and practice in education, at school and university levels, are worthy of being included on future research agendas.

5.4. Limitations

Due to the time frames designated for the completion of the Masters research, it was not possible to be extensive in data generation. This study was conducted at only one teacher education institution. It is therefore necessary to mention that the findings of this study cannot be generalised to encompass other teacher education institutions. It is suggested that further research be conducted involving more teacher education institutions. This study was dependent on the information expressed by participants. The use of multiple methods enhanced the validity of this study.

5.5. Conclusion

In this chapter, I presented a summary of the main research findings addressing each research question. Recommendations were made based on the findings and the discussion of the findings. These recommendations evolved from the insights of this study and were directed to teacher education institutions, curriculum designers and university educators.

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APPENDICES

1. Ethical clearance from the University of KwaZulu- Natal
2. Letter to the Dean of the university
3. Letter to the academic leader of Science and Technology Education
4. Letter to pre-service teachers (informed consent)
5. Reflective journal schedule
6. Observation schedule
7. Document analysis schedule
8. Focus group interview schedule
9. Individual interview schedule
10. Pre-service teachers reflective journals
11. Video recorded observation transcript
12. Focus group interview transcript
13. Individual interview transcript
14. Professional editing approval letter

APPENDIX 1

7 August 2012

Ms Raeesa Ismail 205505755
School of Science,Mathematics and Technology

Dear Ms Ismail

Protocol reference number: HSS/0671/012M
Project title: Pre-service teachers' experiences of learning to teach culturally inclusive science

EXPEDITED APPROVAL

I wish to inform you that your application has been granted Full Approval through an expedited review process.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the school/department for a period of 5 years.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

.....
Professor Steven Collings (Chair)

/pm

cc Supervisor: Dr R Mudaly
cc Academic leader: Dr Davids Davids
cc School Admin:Mrs Sindhomoney Naicker

Professor S Collings (Chair)
Humanities & Social SC Research Ethics Committee
Westville Campus, Govan Mbheki Building
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APPENDIX 2

Dear The Dean of the School of Education

I am a Master of Education (M.ed) student at the University of KwaZulu-Natal Edgewood campus and currently engaging in a research project which is entitled "Pre-service teachers' experiences of learning to teach culturally inclusive science". I seek permission to conduct this research within the school. The purpose of this project is to explore and understand pre-service teachers' experiences of learning to teach culturally inclusive science in the Natural Science Method 2 Module at the Edgewood campus. In addition the study will focus on how pre-service teachers' learn to culturally inclusive science and pre-service teachers' views on the integration of culture. I will collect data from 24 pre-service Natural Science teachers using multiple methods such as individual interviews, focus group interviews, observations and reflections. The interviews will be audio recorded and the lesson presentation will be video recorded. The findings of the research will not be used for any other purpose other than the Masters dissertation. The data will be stored and disposed of at the end of the research. Pseudonyms will be used to protect the identity of participants. All information disclosed will be kept in confidence. The participation in this research is voluntary and should participants desire to withdraw or terminate their participation in the research, this may be done without any negative consequences.

Thank you

Yours faithfully

Raeesa Ismail (student no. 205505755)

Cell no: 0844814290 Email: 20505755@stu.ukzn.ac.za

Supervisor: Dr R Mudaly Email: mudalyr@ukzn.ac.za

APPENDIX 3

Dear Academic leader of Science and Technology Education: Dr. M Stears

I am a Master of Education (M.ed) student at the University of KwaZulu-Natal Edgewood campus and currently engaging in a research project which is entitled "Pre-service teachers' experiences of learning to teach culturally inclusive science". I seek permission to conduct this research within the school. The purpose of this project is to explore and understand pre-service teachers' experiences of learning to teach culturally inclusive science in the Natural Science Method 2 Module at the Edgewood campus. In addition the study will focus on how pre-service teachers' learn to culturally inclusive science and pre-service teachers' views on the integration of culture in the science classroom. I will collect data from 24 pre-service Natural Science teachers using multiple methods such as individual interviews, focus group interviews, observations and reflections. The interviews will be audio recorded and the lesson presentation will be video recorded. The findings of the research will not be used for any other purpose other than the Masters dissertation. The data will be stored and disposed of at the end of the research. Pseudonyms will be used to protect the identity of participants. All information disclosed will be kept in confidence. The participation in this research is voluntary and should participants desire to withdraw or terminate their participation in the research, this may be done without any negative consequences.

Thank you

Yours faithfully

Raeesa Ismail (student no. 205505755)

Cell no: 0844814290 Email: 20505755@stu.ukzn.ac.za

Supervisor: Dr R Mudaly Email: mudalyr@ukzn.ac.za

APPENDIX 4

Dear: Pre-service teacher

I am a Master of Education (M.Ed.) student at the University of KwaZulu-Natal Edgewood campus. I am currently engaged in a research project entitled, "Pre-service teachers' experiences of learning to teach culturally inclusive science". The purpose of this project is to explore and understand pre-service teachers' experiences of learning to teach culturally inclusive science in a Natural Science Method Module at a tertiary institution. In addition the study will focus on how pre-service teachers' learn to culturally inclusive science and pre-service teachers' views on the integration of culture. I would like to collect data from you by multiple methods such as; individual interviews, focus group interviews, observations and reflections. The interviews will be recorded on audio tape and the lesson presentation will be video recorded. The findings of the research will not be used for any other purpose other than the Masters dissertation. The data will be stored and disposed of at the end of the research. Pseudonyms will be used to protect the identity of participants. All information disclosed will be kept in confidence. The participation in this research is voluntary and should you find that you wish to withdraw or terminate your permission for the research, you may do so without any negative consequences.

Thank you.

Yours faithfully

Raeesa Ismail (student no. 205505755)

Cell no: 0844814290

Email: 20505755@stu.ukzn.ac.za

Should you have any queries you can contact my supervisor Dr.Ronicka Mudaly.

Telephone no: 031- 260 3643

Email: mudalyr@ukzn.ac.za

Acknowledgement – Pre-service teacher

I, _____ (full name and student number) hereby confirm that I understand the contents of the document and the nature of the research project. I grant consent for my participation in the research and for data to be collected. I am at liberty to withdraw permission, should I so desire, without any negative consequences.

_____

Signature of pre-service teacher

_____

Date

_____

Phone number

APPENDIX 5

Reflection Schedule

Pre-service Natural Sciences teachers are required to reflect on their experiences of learning to teach culturally inclusive science.

The reflection should be 2-2½ pages

The reflection should include the following points:

1) What aspect of culturally inclusive science (rooted in IKS) did you try to incorporate into your lesson?
2) How did you attempt to incorporate this aspect of culturally inclusive science (rooted in IKS) into your lesson?
3) Tell me about your experience of learning to teach culturally inclusive science (incorporating IKS in lessons)?
4) What were some of the specific challenges that you encountered when attempting to incorporate culturally inclusive science into your lesson?
5) What opportunities arose when attempting to incorporate culturally inclusive science in your lesson?
6) Do you think it is valuable to incorporate culturally inclusive science in your teaching? Explain.
7) What is your view on the integration of culture (rooted in IKS) when you learnt to teach science?
8) What other factors do you think need to be considered when deciding to incorporate culturally inclusive science into one's practice?
9) Did you seek any assistance when attempting to incorporate culturally inclusive science in your lesson?
10) From whom did you seek assistance (e.g. IKS knowledge holders in community, lecturer, fellow group members etc.)?

APPENDIX 6

Semi – Structured Observation Schedule

Culture integrated lesson observation schedule
Learning Area: Natural Sciences Date: Pre-service Teacher Group No.:
Grade: Topic:
1. Topic Breakdown:
2. What aspect of culture (rooted in IK) is used during the lesson presentation?
3. Brief description of how culture (rooted in IK) is integrated / How did the group incorporate culture/IK in their lesson?
4. Pre-service teachers activities
5. Students activities
6. What resources are being used?

7. Description of how the resources are being used?

8. Analysis of lesson

8.1 Did the pre-service teachers manage to identify the culture (IK) that relates to the topic?

YES	NO	NOT CLEAR

8.2 Are the pre-service teachers able to bridge the gap between western science and non-western science?

YES	NO	NOT CLEAR

8.3 Did the students identify themselves with the aspect of culture rooted IKS presented?

YES	NO	NOT CLEAR/COULD NOT TELL

8.4 The integration of culture (IK) resulted in

Total confusion in the flow of the lesson	Students understanding the science concepts better	No effect

9. General comments about integrating / incorporating culture (IK) in a Natural Sciences lesson

APPENDIX 7

Document Analysis Schedule

- Questions guiding the analysis of pre-service teachers' lesson plans

1. Are the Specific Aims of the CAPS policy document clearly stated in lesson plans?

2. Does the lesson plan incorporate culture (rooted in IK) within the science lesson? If so, what are the strategies/activities employed to incorporate culture which is embedded in IKS into the lesson?

3. Is Specific Aim 3 of the CAPS policy document achievable in the lesson?

APPENDIX 8

Focus Group

Interview Schedule

1) According to you what is culturally inclusive science?

    1.1) Could you give me some examples of culturally inclusive science?

2) Is it important to teach culturally inclusive science (rooted in IKS)?

    2.1) Why do you think this is the case?

3) What factors do you think will influence your decision to teach culturally inclusive science (rooted in IKS)?

4) What were the factors that guided your group in your lesson design?

    4.1) What were some of the challenges which your group encountered when you integrated culture (rooted in IKS) in your lesson?

    4.2) What were some of the opportunities that enabled or allowed your group to integrate culture (rooted in IKS) in your lesson?

5) What is your view on the integration of culture (rooted in IKS) in science education?

6) Did you engage with any external sources (e.g. IKS knowledge holders in community, lecturer, fellow group members, etc.) to enhance your knowledge of culture (rooted in IKS)?

APPENDIX 9

Individual Interview Schedule

1. Tell me more about your experiences of learning to teach culturally inclusive science (rooted in IKS).

2. In your focus group interview you mentioned that culture (rooted in IKS) is included in only one of your method modules and that it should be part of all your Natural Science modules as well. If you had more exposure, content and background knowledge on IKS, how would that impact on your learning to teach science lessons incorporating IKS?

3. Your focus group interview highlighted the following as challenges that you experienced;

   Lack of content/background knowledge, how did you address this? Who assisted you?

   Lack of resources; how did you address this? Who assisted you?

   Insufficient teacher education, how did you address this? Who assisted you?

4. Teacher education has been expressed as a particular challenge.

   How should this be addressed, in your view?

   Who should be at the forefront of providing teacher education?

   What kind of teacher education do you envisage?

   How should the teacher education be provided?

   Are there any teaching methodologies that teacher trainers (lecturers) should be using to teach pre-service teachers, that you think are useful?

5. Can you suggest how this lack of teacher education (specifically content and how to teach it) influences your learning to teach culturally inclusive science embedded in IKS?

6. How would you like to be trained to teach culturally inclusive science (rooted in IKS)?

7. In this module, whilst learning to teach culturally inclusive science (rooted in IKS) explain to me how you were taught to include culture / IKS in science teaching.

   Was it helpful?
   What methods or strategies would you prefer to help you learn better?

8. Your group and your reflections stated that culturally inclusive science (rooted in IKS) is valuable and important. Can you elaborate on this? Tell me a little bit more.

9. Linking the home of the child and the science classroom was highlighted as important in your focus group interview. Can you tell me how this can benefit the learner?

10. Do you think teachers need to be sensitive to learners' culture (IKS) in the science classroom?

11. If you receive the relevant teacher education; resources; and guidance to teach culturally inclusive science (rooted in IKS) in the science classroom, how successful do you think you will be in ensuring learners perform well in science?

12. Do you think the inclusion of culture / IKS in science education will improve the results of South African learners in science?

13. It was mentioned by many groups that an IKS Resource Centre should be established at the university. How would this influence your learning to teach culturally inclusive science (IKS)?

APPENDIX 10

G1 - RJ 1

In our lesson presentation of a culturally inclusive science lesson we incorporated the aspect of medicinal plants, specifically the Rooibos plant. We attempted to incorporate indigenous knowledge of medicinal plants by incorporating the use of the Rooibos tea plant for medicinal uses. We did this through a 'content' activity on the background and factual information on Rooibos. In a follow up lesson we planned a practical investigation into the use of Rooibos to alleviate heartburn. By doing this we covered a broad knowledge base on Rooibos, as well as a scientific way of testing its' uses.

Whilst planning a culturally inclusive science lesson we found it difficult deciding which culture and information we wanted to select. We were unsure as to whether or not it would be a good idea to use a plant that we would not have access to, as we really wanted a hands-on approach in our lesson. Also, due to the diversity of the number of medicinal plants, we wanted to choose one with relevance to learners that they could use daily.

We had the chance to combine our different ideas and perspectives on the Rooibos plant to plan a holistic lesson. Initially we looked at it from different views but found common ground in trying to develop the best possible approach. I also grew my personal knowledge vase on Rooibos through exploring medicinal plants.

My experience of learning to teach culturally inclusive science was very challenging. Initially we were scared and lost; we did not really know how to actually plan a lesson including IK. Being in my 4th year of study planning normal western science lessons and teaching is quite easy and comes naturally to me. But planning a lesson including IK posed a great challenge to me because it was something I was not familiar with and it was foreign to me. Some of the specific challenges were a lack of content knowledge, textbooks did not have any information, no guidelines in teacher and learner books, and finally the CAPS document was not user friendly. It did not help in planning this lesson yet it is stipulated in the CAPS that we need to achieve specific aim 3, which is incorporating IK in science lessons.

My view on the integration of IKS (culture) is that it was exposed a late stage in my teacher education. IKS should have come in my 2nd or 3rd year of study and in every NS content module.

Another aspect that made this experience very challenging was that we did not have any solid grounding in IK. We need strategies and activities on how to actually integrate IK in a lesson. I found that once we had all the information it was actually quite hard to put it in a lesson.

My overall experience was positive. I found that IK is really interesting and helps one learn better. I think that the inclusion of IK will really be enjoyable for learners. It will be science that they can relate to. This module had opened the door for me and I will definitely use IK in many science lessons next year. At least I know that I will be successfully implementing the science curriculum with regards to CAPS. I will not be skipping sections. Working in groups was also very beneficial to me. I would have never managed to plan and teach a lesson on IKS on my own for the first time. Working with other group members enabled me to develop my own learning and understanding.

I think it is valuable to incorporate culturally inclusive science in teaching because it provides a critical approach to teaching. In being critical, learners are given the opportunity to explore both western modern science and indigenous knowledge, and draw their own conclusions. I think indigenous knowledge presents helpful and insightful information as to how our ancestors understood life before science.

I think it is important to consider learners' diversity when incorporating indigenous knowledge into teaching. Consider learners' diversity in terms of culture, previous knowledge, knowledge conflicts and personal beliefs in terms of indigenous knowledge, versus western modern scientific views.

My view on the integration of culture (IKS) in science lessons is that it is very important because it is relevant to learners and takes into account prior knowledge. Learners feel included in science classrooms because there is a link between what takes place at home and in the science classroom. My view is that integration of IK will result in better understanding and thus better performances in science. Learners need to be given a holistic idea and maybe they will see science as exciting and fun because it is relevant to them. I personally believe that the inclusion of IKS is very important because it will change the entire education system.

We sought assistance from one another in our group. I also asked my mother and grandmother about any medicinal plants they had heard of or used. I went through resources on the internet as well. Within our group we discussed how to approach the task of creating a

culturally inclusive lesson. We also consulted our lecturer via email as to whether or not we were on the right track to developing our lesson.

G1 - RJ 2

I was really scared initially because my topic and the idea of teaching culturally inclusive science is foreign to me and I only have a basic limited knowledge with regard to this. I did not understand why I had to now teach a lesson on IKS because I never did it in any NS content modules. The knowledge I do have is bits and pieces that I gained from the lectures Dr Mudaly did on IKS. I know Dr Mudaly told me that our topic can be taken directly out of the CAPS document but I really battled to work out where the topic was in the CAPS document and how to incorporate it in a lesson. I also did not know where to start with the assignment. So we as a group decided to go and research by talking to our parents, local pharmacist and looking up information on the internet. To my surprise I saw that within South Africa we have lots of indigenous medicinal plants that I did not even know about and this was overwhelming as I did not even know where to begin with that long list. I then decided to look up journal articles with regard to indigenous medicinal plants and found an article on rooibos and how it helps alleviate heartburn and its other fantastic properties. I knew that we could incorporate this into a lesson. So we got back together as a group to discuss what research we had obtained and we decided to use rooibos as our medicinal plant. We then worked together from there. We wanted to incorporate in the lesson both a western view as well as indigenous knowledge to provide students with a balanced and not biased outlook. We also wanted to bring in our lesson how technology and changing farming methods has an impact on the cultivation of the crop and allow students to think and be critical of South African and western practices. I did not bother to look up in Natural science textbooks- to look for indigenous knowledge in them- because I haven't really noticed before that section in the textbook so knew that the internet will be a far better resource. I also knew that Dr Mudaly would have also helped us if we needed help but we like to do the work on our own to a certain extent and did ask her once if we were on the correct path with our idea. Another challenge that we faced as a group was there was no set content that we had to teach so we had to go through a lot of information and figure out what may be relevant to the students and what they will enjoy but is important to learn. We were also lucky at this point because I found on the internet a booklet that was for Grade 9 Natural science that taught about rooibos but had no practical components within the booklet as it was mostly case studies and comprehensions. It also did not have set content on IKS. We used this booklet as well as the rest of our information to come up with the content to teach. The teacher education that I did have was 2 lectures that Dr Mudaly presented on indigenous knowledge

which I did find useful and we also took the information from her lecture which was in our course book and incorporated it into our lesson. I do feel that while we will learn a lot through this module I feel that IKS is such a broad concept that we will still have to research more and find out more for when we go out and teach. I do feel though that the lecturer has opened up this topic for a lot of us and given us this opportunity to work with the different topics and start to enjoy the topics and learning. However I do need more education on how to integrate IK in different science lessons. I have found this experience to be positive and enjoyed being exposed to IKS. I would definitely use it in my classroom and think it would be worthwhile doing it with my students as it's relevant and interesting.

I can honestly say that before this module, I knew little or nothing about indigenous knowledge and its application within the science classroom. I am extremely westernized and I have never thought of using indigenous knowledge due to the fact that it does not have a scientific backing. But my perspective has changed due to this module and research into this topic. Working in groups was also a great learning experience. This lesson was really hard and I could have not managed alone but in a group we shared knowledge and learnt together. This really developed my personal learning and content knowledge. We chose to do our presentation on Rooibos since we were given the topic of IK-medicinal plants. To start off this assignment we went and looked up and tried to find some information in the CAPS document. We then went our separate ways and looked up information over the internet. We also used our course packs and the information that Dr Mudaly provided us with. We chose Rooibos after reading a fact in a journal which said that African women use Rooibos tea during their pregnancy to alleviate heartburn. We took this information and came up with our lesson from this point.

We incorporated medicinal plants into a lesson that deals with the human body and healthy living. The lesson with Rooibos as a medicinal plant follows from the topics on alimentary canal and balanced and unbalanced diets, and how you can use both western and indigenous knowledge to help alleviate heartburn as well as telling them about other medicinal properties of the plant. We chose to teach the lesson in an unbiased manner and give credit to both the western medicine as well as medicinal plants that are used.

Our group did not know much about indigenous knowledge and medicinal plants so this was a challenge for us to go out and look for information. We as a group also had come up with the idea for a practical, and use the information we have researched and incorporate the

information into a practical for students. I also battled to find the necessary information in the CAPS documents and I had difficulty in adapting my research to what I have read in the CAPS documents.

Indigenous knowledge creates relevance for students and they can use this knowledge and apply it to the lesson. Students learn more if the content is relevant to them and some westernized views are not relevant to South Africans. We could also create a truly South African lesson and promote South Africa and our heritage and how we should conserve our diversity.

Yes, I do believe that incorporating IKS into a lesson is valuable and relevant in science. I think a lot of pre-service teachers do not have the knowledge needed to fully and successfully implement IKS into their lessons. It is a lot of work that is needed to successfully implement IKS into a lesson, which is not always what a teacher will put in and would rather take the easier and simpler road. To teach constructively you need to know your students' knowledge and social context, and by incorporating IKS into the lesson, this allows more relevance to a students' knowledge.

You should consider the relevance of the IK to the students and how this knowledge can be incorporated in such a way that students see the knowledge as important and meaningful. A western view as well as an indigenous view should be represented to students so they can come up with their own conclusions and are not lead into believing just the teachers' view. Make sure of all the information and try to gather all the facts.

We as teachers want to move towards a constructivist classroom and in order to do that we have to incorporate relevant and applicable knowledge to the students. IKS should be incorporated into the lesson because it is knowledge that is relevant and applicable to the students and allows them to remember more information. By including IK in science lessons it takes into account prior knowledge and backgrounds of learners. Learners feel included when you integrate culture in science lessons. Teaching and learning is more relevant and it eliminates cultural conflicts. What is also important about IKS is that it is relevant and can be seen while some western science topics can't be seen and are just theories. IKS is also applicable to the student's lives and they can use it in their everyday lives. It is important to have a connection between the home and the science classroom as then the subject is more applicable and enjoyed more and Natural Science is not just seen as a subject that has no use.

Both views- both western and IKS should be incorporated into lessons so students get all the facts and not just a biased view that is sometimes portrayed by teachers.

Yes we did seek assistance. We used our families, lecturer and our pharmacists. We worked together as a group and discussed every aspect of the project. We used our course packs and multiple internet resources, as well as the CAPS document.

We worked well together as a group and found this exercise really productive. This module is helping me and preparing me for the classroom where I will incorporate IKS. However, I do feel that we need more education of what content of IK to include in lessons and how to actually include it.

G1 - RJ 3

When I first heard that we are doing a lesson on IKS I was a little taken back because I was not familiar with this topic. There was little existing/content knowledge as I can't really remember being taught this at school and just briefly now in the module at campus. I was never exposed to teaching any lesson incorporating IK at university, yet we are expected to implement a curriculum that expects us to include IK in lessons thereby achieving specific aim 3. However after doing research on my own and with my group I felt a little more comfortable with this topic and had a positive experience of teaching IKS.

Firstly as a group we were unsure of what aspect of our topic we were going to discuss. Our topic on medicinal plants was quite a broad topic and as a group was not sure about the types of plants that held these medicinal properties, as well which were indigenous to South Africa. So as a group we decided to go home to do our research individually and when we meet again, discuss our findings. And it was agreed that our main topic will be Rooibos, our medicinal plant. We had chosen the topic Rooibos as there is much debate about this plant both locally and internationally.

For our lesson we incorporated the topic medicinal plants with Rooibos. According to the CAPS document we link the specific aim one, knowing Natural Sciences. Specific aim 2 investigating phenomena in Natural Sciences and specific aim 3 appreciate and understand the history, importance and applications of Natural Science. In society specifically dealing with 3, I understand the different cultural contexts in which indigenous knowledge systems were developed. In specific aim 2.6 was design/ plan a simple investigation/ experiment as well as knowledge strand 1 matter and materials and knowledge strand 4 - The human body and healthy living. The greatest problem was just understanding the topic and choosing a plant indigenous to South Africa. We were unsure at first how to teach it and what practical we could conduct to go along without our topic. There is limited information and content around IKS so this really made it difficult to plan a lesson. Textbooks have no information to assist with IKS. One thing I can say is that I enjoyed working in groups because it really helped me learn. As a group we shared knowledge and ideas, this really developed my own learning and knowledge.

Opportunities were when we were able to come up with ways to compare the different ph. levels of hydrochloric acid and Rooibos tea. As we were learning about Rooibos and researching the properties it was interesting to share that knowledge with the class.

It is important to include culturally inclusive science in teaching as leaners need to know about surrounding cultural knowledge and beliefs which were developed from indigenous knowledge.

You need to find ways to link it to previous knowledge that learners have gained e.g. investigations where a practical was done to demonstrate the ph. levels.

Factors, such as being able to have the material and resources to teach IKS. The correct knowledge and evidence to back it up.

My view is that IKS was integrated at a late stage and maybe if it was introduced earlier it would have helped me learn better.

I believe that IKS is important it bridges many gaps in home learning and school learning. When teaching IKS it will link to many of the learners prior knowledge making it relevant because they feel they can trust this new knowledge gained because they had previously learned it from family members, community etc. I feel that IK and western science should work together and add to the present knowledge.

We have spoken to our lecturer in terms of our topic and if it was possible to combine it with acids and bases as well as the human body and healthy living. We consulted with each other as a group as well as doing our own research.

G2 - RJ 1

In order to incorporate IKS into our lesson on astronomy, we had included how the indigenous people had used medicine in the early days, by use of medicinal plants and also by using the weather to determine when and how the people would get sick. The indigenous people could predict weather changes by looking at the behaviour of different plants and animals. The indigenous people also used the sun, the moon and the stars in order to tell date as well as time. Most of their daily activity depended on the weather, the plants and the world around them.

We attempted to incorporate this into the classroom, by using a role play method of teaching. The learners would have been required to act out the different types of IKS used in the modern and pre-modern times. They would have also been required to create, in groups, a sun dial and demonstrate how this would have worked for the indigenous people.

For me the experience was terrible. I personally dislike this particular section of the Natural Science syllabus and so it was rather difficult for me to properly and enthusiastically engage in the lesson. Usually when you enjoy something, it is much easier and more enjoyable. So there was a bit of initial difficulty with getting my brain and body ready for the task. Existing knowledge for this section was minimal, so at least one good thing came out of this assignment that is I developed some knowledge. I was required to do lots of reading and research in order to be able to assist the group members with the assignment as a few of them enjoyed this topic and were easily able to complete the task without my help. Working in groups was an advantage in that group members shared ideas and guided my learning. I was able to learn from my peers. I would say the experience turned out to be a positive one, despite all the ups and downs and boringness of the topic. I was exposed to a lot of new information and made me realize that whether I like it or not I will be required to teach sections that I may not be too happy about and also sections that I may not be too familiar with. It is a part of the teaching cycle and as teachers we have to be open to learning new and different ideas all the time. Yes, resources were available for this lesson and we happened to have some of the resources readily available at home from previous lessons. As far as information goes, the internet was a huge help in that department and it gives lots of ideas for what you could do in your lesson. Text books weren't that helpful as lots of in depth reading was required and as third year university students we simply lack the time to do that.

Some of the specific challenges that were encountered were the lack of content knowledge of IKS. This was possibly the most difficult challenge to overcome and not really having an interest in the IKS section was not much help. Limited time to research and complete this task was a challenge because there is no guide in the textbook to help us.

As a teacher, by incorporating cultural science in the classroom, we also learn a great deal and we can make connections between what the learners have experienced and the content we are teaching.

I feel that indigenous knowledge is important because significant contributions to global knowledge have come from indigenous people, such as in medicine because they have a good understanding of their environments. Indigenous knowledge is developed and adapted continuously to changing environments and passed down from generation to generation and closely linked with people's cultural values. Indigenous knowledge is also useful to the poor, as their main income is dependent on indigenous knowledge, the struggle for survival, to produce food and to provide for shelter. When incorporating IKS into the classroom it is very beneficial to the learners as well as the teachers because the learners can give their own experiences of IKS in their backgrounds as well as their cultures.

Yes, I do think it is valuable to incorporate culturally inclusive science in teaching because then it is easier for the learners to relate to the content taught and once the learners relate themselves and their background to what's being taught, they find it easier to learn and understand. But I feel that IKS should have been introduced to us earlier like in NS 110 so that learning to teach it would be easier.

There are other factors that need to be included such as how the learners will respond to their past and background being brought up in the classroom.

Because this was a group task, the group members had contributed equally in the gathering of information, and the incorporation of the topic into the lesson. The internet was used for gathering the information as textbooks did not provide any help.

Most of the work was done within the group, although we did consult with the lecturer whether we were on the right track or not.

G2 - RJ 2

The topic that we had to work with was astronomy. IKS was something that was new to us, so we had to do a lot of research before we could actually plan our lesson. Once we got a clear understanding of what IKS is we discovered that there are many ways in which people of the past used indigenous astronomy in the past. We as a group decides to do a role play in which we brought about the different ways in which people used astronomy in their day to day lives. People used astronomy to predict the weather, if certain insects such as ants were approaching, it meant that rain is approaching. A new moon indicated that it's perfect time for farming. We acted out different scenes to teach learners how IKS was used in the past.

We did think of using a power point to bring our topic about but then we realized that not a lot of students like to read a power point. even when they do read it they don't fully understand the concept completely, children understand when they are being spoken to and since IKS is something new that's being introduced to them we thought it would be nice to do a skit so they can watch us carry out the day to day activities of people in the past, we felt by watching this they would understand the indigenous knowledge of astronomy better.

Since IKS was something that wasn't new to me, it was abit hard to incorporate it in my lesson, astronomy wasn't a very topic to get information on most of the information we were getting was very irrelevant to that of what we were looking for. However after sifting a lot of information we found what we were looking for. After completing the lesson I've decided that IKS is very important and it changed my thoughts and perceptions of indigenous knowledge. I realized that IKS is very important because it's important to know things about the past so we know where our existing knowledge comes from. However if IKS wasn't included in the natural science method module I wouldn't have known about it at all, therefore I think IKS should be included in all NS modules so we have a better understanding. Because the knowledge that we have obtained is too little we will have to do more research in order to broaden our knowledge.

We had a lack of resources, we had to do a lot of research in order to get the information that we wanted. We had a lack of knowledge of IKS to do this lesson, therefore before we can teach our lesson we had to learn the concepts ourselves. We had some trouble of how to incorporate IKS into our lesson but after some consideration we came up with a role play.

We had the opportunity to brainstorm ideas of how we wanted to teach astronomy, we broadened our knowledge when we were planning our lesson. We had an opportunity to work together in groups and share and teach each other.

I feel that IKS is very valuable to students because it's important to know how existing knowledge came about. Now we have climatologist to predict the weather but in the past people used the moon to predict the weather, it's interesting to know how much things have changed over the years. Learners feel included when you integrate culture in science to the lesson because it makes the lesson more learners centered rather than teacher centered. Children are more comfortable to share their knowledge that was taught to them by their families.

Yes it is valuable to incorporate culturally inclusive science in teaching because it results in better understanding for the learner and it improves learner understanding. It will also result in better performance.

You need to consider the cultures of everyone and if what you are going to be teaching doesn't have a negative effect on ones beliefs. Make sure that you introduce the topic in a fun and interactive way so that students will find it easier to understand this new concept.

The only assistance that we had was from the internet, class discussions and from our natural science method module. We didn't really consult with people out of our group because not many people knew about astronomy.

We got assistance from the internet and the module. Personally my group members helped me a lot, this was really helpful. They enabled me to plan this lesson; we shared ideas and taught each other.

G2 - RJ 3

The aspect of culturally inclusive science which we, as a group, attempted to incorporate into our lesson was astronomy. The main topic of our lesson was the historical development of astronomy, early indigenous knowledge and modern developments. This was a difficult aspect to include in our lesson on indigenous knowledge systems, as we had never encountered the topic previously. We then decided to use a role play to act out the information on IKS.

We as teachers in training understand that sometimes it is easier to relate to information, and understand information if it is presented in the form of a role play, as it is easier to see exactly how things were at that specific time as opposed to hearing the information read out in a monotone by the educator, or being presented in the form of a booklet which tends to become boring for the learners (when learners are presented with a bulk of information they tend to lose concentration when work is read out to them). Therefore we decided to use a role play to show learners the historical development of astronomy.

The topic indigenous knowledge systems or IKS was a new topic which we encountered only at a late stage in tertiary level. We were not given prior knowledge with regards to IKS and this posed problems for us as students because it became difficult to understand and incorporate in lessons. Despite the problems mentioned above, we had not covered our topic "historical development of astronomy, early indigenous knowledge and modern developments" in lectures, and therefore we were required to research the topic extensively. Research was not easy as Google scholar had very little information regarding the topic, and our university library didn't have books pertaining information on IKS. Apart from finding difficulty in researching IKS, the group could not decide how to present the information to the learners, a way in which they would understand easily. Another problem which we encountered was that of the practical component. We could not find a suitable practical for astronomy in the earlier days, but eventually settled on using the sundial as our practical.

There was very little information available with regards to IKS on the internet as well as books. We experienced difficulty in accessing information from our university library as we were told that there were no books in the library on IKS. Presenting the information in a unique, easy to understand, and lesson appropriate manner was difficult as the information which we came across was slightly complex and inappropriate for the grade which we were teaching. We therefore had to simplify the content to suit the grade in question.

We found interesting ways of incorporating IKS into our future lessons.

My view on the integration of IKS is that IKS is of extreme importance in today's educational system. I believe that it is important for learners to understand where today's scientific knowledge first originated from, and how man previously used this knowledge to benefit him in terms of agriculture, medicine etc without the use of modern technology. We as educators need to take into consideration that learners come from different cultures and backgrounds, each of which are unique and rich. The learners have different knowledge in terms of heritage, traditions, cultural practices etc and by incorporating IKS into the current educational system, we are allowing them to broaden their minds in terms of understanding the own cultures. By doing so we are teaching learners to preserve their traditions and cultures, and become tolerant of other cultures as well. Apart from the points mentioned above, many learners already have a rich understanding of IKS as their grandparents, parents, aunts, uncles and other elderly community members impart their knowledge to the younger generation (they pass down their knowledge to the younger generation so that their knowledge is not lost). The university needs to look at introducing pre-service teachers much earlier to IKS to help us learn better.

Yes, because many learners already have a good understanding of IKS and by incorporating IKS into the lessons, we as educators are broadening their knowledge and giving them a better understanding of it.

Learners' backgrounds, prior or existing knowledge, cultures and traditions need to be taken into account when incorporating IKS into lessons.

Apart from seeking assistance from our fellow group members, and using the internet, we did not seek assistance elsewhere. We did not consult community members, family members, lecturers, lecture notes (due to the fact that our topic was not covered in the course pack). Fellow group members.

G2 - RJ 4

We tried to incorporate indigenous knowledge of Astronomy in class. We went on going on this by introducing the term indigenous knowledge, what is astronomy and what it means and how is it different from today's science? How did the indigenous people use astronomy in their everyday lives like: They used the stars to plant, the sun for traditional beliefs and the moon to predict weather patterns.

We went on this by asking the class about what their culture says about astronomy. Then explaining the terms on indigenous knowledge and how it is different from modern science. Also we said we will divided into groups and they either will be given the topic of "how did the indigenous people use astronomy in their daily lives" or "the modern developments of astronomy", so they can use their own knowledge of astronomy and what they have learnt in class

Honestly I never liked the idea of doing a lesson which incorporated indigenous knowledge systems, especially with our topic of astronomy. And our lack of knowledge of the topic and also after doing three modules of natural sciences this is the first time we introduced to the topic of IKS, which is in our method module. We never have enough of knowledge and how to incorporate IKS in our lessons. For our lesson took us a lot of time to get research on the topic. And the only place we found information was on the internet the library had no books of IKS.

We had the following challenges when we were making the lesson plan such as

Poor content knowledge of IKS

Lack of training,

The CAPS document helpful,

No information in the textbooks.

Did not know how to go about making a IKS lesson plan.

-Collaborative learning

-Learner and teacher centered learning

IKS is very important in a classroom because it includes learners and their own cultural knowledge in a lesson. It shows the learner the connection and differences between their culture and the science, therefore terminating cognitive conflicts for learners.

Yes, because it helps learners to relate to a topic from their own cultural understanding. it also makes learners to see the similarities and differences between their culture and modern sciences. This will broaden learners understanding of the topic. Lastly learners will more likely to contribute to the lesson because they can speak from own experiences.

Many things need to be included such as:

The conflict in will cause between a learners cultural knowledge and modern sciences.

The teacher has to be aware of all the different cultures and their views on the current topic.

The teacher needs to be able to see links and difference between learners' culture and modern sciences.

We consulted each other when making the lesson and how to make the lesson culturally inclusive.

We never ask anyone or consult anyone for information on indigenous knowledge besides each other in the group.

G3 - RJ 1

In our lesson we included the use of natural manure in planting and growing beans, we also included a video session in which students watch a video that taught them how water is managed via culturally inclusive ways.

Please refer to the attached lesson plan for a detailed description of our lesson.

From the offset we knew that we were faced up with a huge challenge. We did not know how to (best) plan for the lesson in order to teach our students, hence this posed as a challenge to us. We did not know whether what we were doing was really what was required of us and so, initially we felt lost and not knowing what to do. However, soon as we were certain with what was required of us we were more confident with ourselves and were able to plan a suitable lesson for our students. We did not really need any training to handle or work with manure, manure was something that we had both worked with before and it's not really challenging to work with it. However, one has just got to know that too much manure in soil works against the growth of a plant, hence we needed to know the amount (or ratio) composition of manure to soil of which at first we did not know. This was also the essence of our lesson. Text books were of little help to us, we did not find any content that was relevant to our lesson in text books. This could be as a result of IKS still being a topic that has not received as much attention as it deserves in schools.

A lack of knowledge of the topic in its broadest and specific senses. We also had difficulties planning for the lesson. The incorporation of indigenous knowledge in our lesson was also a challenge since this was a new concept to us of which we had little exposure to.

We had an opportunity to sit down with our elders and gained valuable knowledge about natural manure, planting in general and other knowledge that goes beyond manure and planting. We also afforded ourselves the opportunity to work with soil and manure ourselves. We were able to plant, something that we had not done in a very long time.

Yes, I think it is part of inclusive education for which I think it would bring better performance from the learners as they will feel included in the lesson because it will include something that they know. It is very crucial that the lesson should be planned appropriately with the concern to learners' diversity.

It is important to integrate IKS in the lesson because it allows for peer learning as they do not belong to same culture. Learners feel included as I mentioned above and lesson takes into account learners' prior knowledge and their daily practices may help them when doing their school practical in science studies. Lesson with IKS is more relevant to learners as it incorporates something which has to do with their backgrounds. It also helps bridging the gap between home and school and gives parents more chances to assist their children with their school work regardless whether they were formally educated or not.

Culture diversity should be considered in order to incorporate all learners. The other factor should be the context learners they find themselves in. This takes into account the knowledge used and materials that they should be indigenous to the learners and that community.

We felt that our knowledge is limited as we have never practiced planting in our lives and we had to seek for assistance to enhance our knowledge.

We had to travel to rural areas to get the best manure used to catalyze and keep the soil well productive. We went to the lecture for guidance as we felt our topic was not clear enough as to what is needed from us. Due to a conflict caused by the seeds when they growing with regards to our knowledge and expectation, we had to consult Durban municipality workers that were responsible with soil management and we found that the soil that we used had already been fertilized as a result of inappropriate growth of plant.

We worked well in the group and shared knowledge.

G3 - RJ 2

The aspect of culturally inclusive science which we incorporated into our science lesson was the management of water and soil using indigenous knowledge systems. We discussed the use of organic fertilizer (natural manure).

Our lesson was planned for grade 9 learners. We introduced the lesson by recapping from the previous lesson. Learners discussed how they managed soil and water in their homes. A video was used in the lesson showing how soil and water is managed in different areas. The video was Farming and Water Management in MtowaMbuArusha Region, Tanzania. The learners then discussed what they had learnt from the video and reported to the class. The second part of the lesson involved a practical on the preparation of organic manure. Learners conduct practical investigations in groups and complete questions based on the investigations. In our lesson we infused both western science and indigenous knowledge without privileging any one.

From the outset I knew that this experience was going to be a challenging one. When we were told that we were required to plan a lesson incorporating indigenous knowledge systems, I was really scared. Planning lessons and teaching it was never a challenge to me. I planned many NS lessons and gained confidence teaching it during practice teaching. However planning a lesson incorporating IK was really challenging and difficult for me.

Initially we were lost, we did not know where to start and how to actually plan a lesson including IK. Some of the challenges that we were faced with was lack of content/ background knowledge, lack of resources e.g. textbooks, teacher education, no experience or exposure to teaching IK, and limited time to plan a lesson.

Lack of content knowledge - We did not have set content knowledge to help us plan a lesson including IK. The module introduced us to what is IK and its importance, but we did not have set content as what exactly to include as IK and how to actually incorporate it into a lesson. We have experienced a lot of IK growing up with elders such as; farming techniques, food preservation, and planting. Although we had experienced IK we still experienced great difficulty planning a lesson including IK because we did not know what to include as IK and whether it will be suitable for the grade 9 learners. The module notes also did not provide us with content to assist us to plan a lesson. Generally in all our modules we receive a pack of notes which we make use of not only for assignments but also in our practice teaching, and

most definitely for future teaching. The pack of notes that we received was notes on what is IK and articles. Examples and lessons and activities were not included. The fact that IK is new and foreign to us resulted in great difficulty planning a lesson including IK.

Lack of resources - resources needed for the lesson was not available and we had to travel for into rural areas to obtain manure. Textbooks also did not have any information on IK and how to actually include it in science lessons. We went through many books in the library for grade 9 NS and we found nothing. That fact textbooks have no information on IK indicates to us that IK is considered irrelevant, thus a neglected science. The value of IK and its importance is not known to many. I think that is the reason why textbooks overlook IK and its value to science education.

Teacher education – the only education that I had received was this one module where we had to present a lesson including IK. This was not sufficient and did not provide us with the necessary implementation skills and content to assist in incorporating IK in science lessons. This module made us aware of its importance and it can be linked to western science education. The CAPS policy document also does not provide any help. It still leaves us with the issue of what to include as IK; how to include it and how can we infuse the two, western science and IK. There should be separate IK modules run at the university to provide assistance for us. An IKS resource centre should be present on the university to provide additional assistance.

No experience or exposure to IK – to become an NS specialist we do 3 modules for the NS learning area. In all 3 of these modules I never came across any IK. It is only in this module when I came to know about IK and its requirement in the school curriculum. I feel that IK should be included in all modules and provide us with notes and activities on how it is incorporated in NS lessons. With some training we are left in a situation of uncertainty. I wonder how qualifies teachers teach including IK in their lessons without training.

Limited time – this experience was challenging because of the limited time provided to successfully plan a lesson. Planning a lesson including IK required a lot of time and effort. We had to do endless research and sift for information on IK, then find links to western science, and then plan the lesson. Notes and activities are not provided in textbooks for us to make use of or add to it.

This experience of learning to teach culturally inclusive science was insightful and positive. I became aware of the importance and value of IK. Teachers training enhanced my knowledge; however I feel that I need more to help me with its implementation. I learnt from other groups and will certainly use it in my future lessons.

IKS is valuable and important in South Africa's multicultural education system; it is important because it is relevant and takes into account what learners are exposed to at home. Learners also feel comfortable and part of the science lesson. It takes into account the prior knowledge and backgrounds. Learners feel free to respond and contribute to discussions in the classroom. IK creates a link between the home and the science classroom.

We sought assistance from family members, community members, and our own personal experiences. We learnt from other as well.

I would definitely incorporate IK in my science lessons in the future.

G4 - RJ 1

Initially, I had a lot of doubt about incorporating IKS into a science lesson because I felt it was irrelevant. To teach and to incorporate IKS into the lesson was a challenge for me because IKS is not something I am familiar with. IKS is a whole new aspect to me and this isn't something I've learnt before. Once I researched the term IKS, I had a brief idea about what it entailed but there were still many difficulties that I experienced incorporating IKS into my lesson. One of the main challenges I faced was trying to incorporate a practical activity using IKS. We did a practical for the sake of it; we didn't even understand what we were really doing. We got confused with a garden and permaculture. Even though we had sufficient information about what IKS entails, in my opinion, we need more information on how to apply and incorporate IKS into western science.

This was a positive experience because I was given the opportunity to work collaboratively with other peers and build our knowledge on IKS. This was a challenging task but overall I gained a lot of new knowledge that will assist me in the future. After engaging in this activity, I've realised that IKS is very essential and it will allow learners to engage actively in the lesson.

When incorporating IKS into the lesson, I got the opportunity to research information about IKS and I learnt more.

It is valuable to incorporate IKS in the science classroom because learners need to know where science came from and it takes into account learner's knowledge. It also promotes inclusivity. Learners feel as If they know something and they will be eager to participate in the classroom. It takes into account learner's prior knowledge and their background which is very important. IKS must be included as it gives the learner a holistic and valuable learning experience. It makes learning relevant. There is a connection between home and the science classroom. Learners are able to express their views respectably in the classroom about their culture and beliefs in terms of IKS. IKS can be used as a foundation for their learning. Learning about IKS will enable learners to have a balance with what they learnt and they will learn both IKS and western science.

Factors that should be considered when deciding to incorporate IKS into one's practice should be their prior knowledge and how well they can apply their knowledge of IKS in the science classroom.

Yes, my group and I did seek assistance from our lecturer on how to apply IKS to western science. We used the internet to retrieve other information. We worked as a group and assisted each other.

G4 - RJ 2

Our group incorporate soil and water management in our lesson. The main focus was to teach learners methods and different ways to save and manage water as well as manage soil using indigenous knowledge systems that can be used in the present day.

Firstly, the introduction of our lesson was a proper definition of IKS, we also asked learners if they know what IKS is and if they know of any methods that they know of. In our development, because our focus for this lesson was soil and water management, we then taught the learners different ways to manage soil and water. Some of the methods we taught were: soil winnowing, planting tall shady trees to shade the soil so that the soil does not dry out, making homemade fertiliser, building dams, making soak pits, permaculture and planting crops to prevent soil erosion. Then in our conclusion we let the class ask questions and we briefly went over the methods again. For the assessment, the class was asked to make fertiliser at home using organic waste products and bring this to school. They then had to make their own garden in the school yard using permaculture. This garden should incorporate soil and water management. This would be an assignment because it will take a few weeks for much progress of their crops.

When I first started learning about culturally inclusive science I thought that it would just be a few minutes of the lesson so I did not think that it was very important. This was the first time I came across IKS because I never did it in other NS modules. I would say that that was my initial attitude towards it. Then I realised that it could be important because more than one lesson was spent on learning it plus our presentation was based on it. I still did not think it was very important until started paying attention to other presentations from the members of my class. I did not fully understand what IKS was as well until i actually started listening to other presentations. My lecturer did do a good job on explaining to her best ability but i do not really understand what the link was from learning IKS to natural science. After this module I can definitely say that I know a lot more than I did before dealing with IKS so learning it was very interesting. Books did not help us because they did not have the wide amount of information that we needed. We used the internet and personal knowledge. We used soil for our lesson as a demonstration so that was easy to access and we showed them a lot of pictures as well.

The part of our lesson that was easy was getting definitions. The difficult part was finding different methods and the most difficult was coming up with a practical lesson for the

learners. Although we did eventually think of one, the still did not know fully how to incorporate IKS into it.

The opportunity that I feel I benefitted the most from, personally, was the fact that I came across many methods of IKS other than just soil and water management. While I was researching the topic, there were many other fascinating methods that people used before and I can see the link between IKS and modern, western methods now. I benefitted from this a lot because my knowledge has broadened more on this topic.

I think it is important to incorporate IKS in teaching because you can connect with learners on a more personal level. When learners feel a connection between the teacher and themselves, they feel more open and free to speak up in class. They can also relate to this topic because their family members may be still using many of the methods that may be discussed in class. It's also good to know the history of where western methods came from as it gives a better understanding and appreciation. The inclusion of IKS can also change the education system and teach learners both western science and IKS.

When teaching IKS we need to take into consideration that background of learners and try to link it to their lifestyles of their family history. We also need to link it to modern science so that learners can see the relevance of learning IKS. Also, the lessons need to be fun and enjoyable otherwise it can get quite boring. The teacher can come up with fun activities such as planting gardens and to show the learners some wonderful methods that are not used in modern times.

When we came up with our lesson plan we used mainly the internet and our own knowledge, we did not really ask anyone else. I don't have grandparents or any elderly people living near me. My parents did not know anything really on soil and water management using IKS. So I relied on some common sense with almost everything that was put into the lesson plan. The internet was used for proper definitions and just to make sure everything made sense. Our group members did the same as well and we worked together to put the lesson plan together.

G4 - RJ 3

Our lesson incorporated the topic on soil and water management. We asked the learners to give their views that they might have shared with their families at home. As part of our lesson we discussed the method of soil management called soil winnowing. We discussed indigenous methods of soil and water management.

For me I felt very afraid and unsure about this task. I felt this experience difficult and challenging. I was unsure as to what was IKS. To incorporate IKS in a science lesson was very hard. In our group we did not know what to do and how to apply IK in a lesson. I had no background knowledge of IKS and no content knowledge to assist me. We had only been exposed to western science and I was not sure what IKS was important. I did not know how to decide what in IKS was relevant and what was important. I had always thought IKS was not important and that western science was more important because that is what we were always taught at school. I never experienced IK or even had seen a lesson on it and now I had to incorporate it in a lesson. I feel that I was not prepared enough to teach IKS because I had no exposure to the content. I feel that if you have no knowledge of something it is very difficult to talk about it. If you are not confident about IK it is very difficult to teach it. Our lecturer only gave us an introduction of IKS but nothing to help us integrate IKS in a science lesson. Integrating IKS and western science was a great challenge for me because I did not understand how to link the two. The CAPS document was also useless. Not even textbooks assisted me. I was very afraid because usually in science you can use a textbook to teach yourself something but now we had nothing to help.

I think that IKS must be integrated in science teaching because it is relevant to learners. If learners are being taught something that is familiar to them then it will be easier for them to move to something that is unfamiliar to them. The prior knowledge of learners must be used in the science classroom because learners are a resource. The knowledge learners get from home is important and there must be a link between the home of the learner and the science classroom. The integration of IKS in science teaching can create the link between the home of the learner and the science classroom. Sometimes learners might feel out of place in the class because they cannot relate to anything that is being taught. But if IKS is used as a foundation for a science lesson then they will feel included and part of the lesson and will want to learn. Learners understanding of science will also be better if IKS is included. If they understand better then they will perform better in science. I feel that IKS is very valuable and

must not be overlooked in the science classroom. If learners are seen as part of the lesson and the teacher is referring to something that they have experienced then they will be happy to be part of the lesson. Many learners perform badly in science because they do not understand what the teacher is saying. IKS can be the link that allows the learner to understand a concept and then link it to a modern science concept. Including IKS will also make lesson easier for learners to understand and they will be comfortable to share and discuss their experiences. Including IKS in science will provide a link between IKS and western science and give learners a more holistic learning experience.

Teachers must use the knowledge of learners in the science classroom. It is a resource and it is something the teacher can build on. If learners are ignored then will not want to learn anything and this will affect their performance in science. I think many learners in South African schools feel left out because nothing in science is related to them. Teachers also need textbooks and resources to assist them in teaching IKS. Right now there are no textbooks, but the curriculum requires IKS to be taught.

We need to be given notes on IKS and solid content to help us expand our knowledge. It is difficult when you have no knowledge. Notes that we got had limited information. I need detailed notes and the lecturer must teach us the notes. IKS must also be part of all our NS modules because it is very important. If we get more exposure to IKS then we will be more confident teaching IKS. At the moment I am not confident to teach science lesson integrating IKS. Practicals we very hard to come up with as we had never seen an IKS practical. We need practicals in our lectures that show us how IKS can be visualised to learners. Right now we have no content and also no methods and strategies to show learners what is IKS. The presentations that we did was my first exposure to IKS and IKS practical and I learnt a lot. I need to see more lessons incorporating IKS so that I can develop my own strategies and methods to use in my teaching. Lecturers need to show us IKS videos or maybe IKS experts can come in and tell us about IKS. We need more exposure through different media. Even the Department of Education needs to look at textbooks including IKS. Maybe even an IKS centre can be set up at university so that we can access IKS information. This will us expand our content knowledge and our methods of teaching IKS in science classrooms.

G4 - RJ 4

The aspect that my group and I focused on was on the management of soil and water using indigenous knowledge systems. This was the treatment and use of soil and water.

Having just a general understanding of the system, IKS was researched so that we would be able to understand and interpret it well. The aspect of managing soil and water was then researched along with methods that have been previously used by people that were not as modern as today. Methods used by a specific group of people in a particular area or society were needed and was researched.

The lesson would start off by the teacher informing the learners about the lesson ahead. A questioning session would take place where the teacher asks learners if they have knowledge of IKS and if so, what are the methods they have heard of regarding soil and water management. Students will share their knowledge and this will cover the introduction of the lesson.

The development will take place as a discussion between teacher and student and also students amongst other students. The teacher will provide some info about soil and water management using IKS. This will give students a primary understanding of one aspect, using IKS. The development also includes a practical activity, which will enhance the learners understanding and there by successfully promoting knowledge construction through 'learning by doing'.

In conclusion of the lesson, learners will be asked questions to test learned knowledge of the day. Learners will also be permitted to ask any questions that they feel they need to, in order to rectify any misunderstanding regarding the management of soil and water using IKS. As part of the lesson an assignment will be given, this will incorporate IKS and the aspect of soil and water.

At first hearing about IKS, I was very sceptical about the whole thing. It seemed like something that would not interest me. I had some sense of disregard towards it and no enthusiasm to learn about it. A challenge for me was actually getting to know more about it, in terms of research and understanding and also the application of it. Personally I had no existing knowledge of the aspect, and it is only doing this NS method module that I was exposed to this aspect and learning. Well having given the relevant information I would say that it could be a positive experience in learning, as now learners will be familiar with things

today, as they had to have come from somewhere. I would say that methods and procedures today are kind of reflections of the past as they are practised to achieve the same outcome in much modernised ways today. Finding information posed a little challenge as not many sources speak much about incorporating IKS in any aspect today. Textbooks have served no help or very little, as they possessed nothing I needed in order for me to complete my research.

A specific challenge would be, not having or accessing enough information, also how I would sequence it and put it together. I wasn't sure about how I would explain it as well.

During this experience I was able to research something I never thought would actually benefit me. The group work really helped me and I learnt a lot. I was able to understand conditions of the past and how much it has changed now.

I would definitely say that incorporating IKS in science is valuable, because everything around us is science, and all these things have some origin. It is valuable as learner's knowledge expand as well the educators. It shows how far we have come, through latest innovations and practices. The inclusion of IKS with western science will add to learners' knowledge and create a balance between the two.

Incorporating IKS in science promotes inclusivity of learners in the classroom. This type of learning acts upon the learners' prior knowledge and cultural as well as societal backgrounds. It removes conflicts in learning as now learners need to find similarities and differences between home and school science and be able to cross this border, and by doing so learning becomes relevant.

Some of the things that need to be considered are that not all learners will understand or agree on the same things due to their different backgrounds. So now it is the teachers duty to do research on the backgrounds of students so that all aspects of culture can and will be included in the learning process and thus all learners will feel included.

Assistance was asked from our lecturer and she was helpful in giving us a rough idea on how we should go about incorporating IKS in our lesson. The internet served as our main source of information. I learnt a lot from the group work really helped me and I could have not done without it. I was able to plan the lesson and learn from my group members. Working with groups has taught me a lot that I would not have got working on my own.

G5 - RJ 1

The aspect of culturally inclusive science which we as a group incorporated into our lesson was the black jack as a medicinal plant.

We first passed the back jack plant around the classroom and discussed the different parts and functions. We then discussed the medicinal properties of the black jack. This lesson was planned for a grade 9 Natural Science class, so we gave them a worksheet with five questions for them to answer. Learners had to read a case study on the black jack and answer the questions. The practical aspect that we included was drawing and labelling of the parts of the black jack plant. We were able to incorporate IK using the black jack plant. We planned a lesson using both western science and IK. We used both knowledge systems in this lesson.

When I first received the topic and came to know that we were required to plan a lesson incorporating IK I was really scared. I was afraid because IK is something new to me and I was not familiar with planning a lesson including IK. I am able to plan science lessons and successfully do this during TP. However, when I was required to include IK I felt afraid because it was not something I was exposed to or familiar with. During my 3 years of study I never came across any teaching of IK so it was really foreign to me. We did 3 NS modules and no IK was taught or included in the content module. This experience was really difficult and challenging firstly because I did not have any existing knowledge or background knowledge on IK. I have experienced IK at home with my elders and family members, but it is not sufficient to actually plan a lesson. Secondly, when I looked through textbooks I could not find any information on IK. Textbooks explain western science concepts very nicely with a range of activities and case studies to use in lessons. But IK is disregarded or devalued because textbooks do not provide any information on IK. It was quite challenging because both new and old textbooks don't even include ways for teachers to incorporate IK in lessons. After this module I came to know that IK is a requirement and it is something that teachers should be practicing in science classrooms. I wonder how teachers currently teaching in schools are implementing IK.

The third challenge for me was that once I found information on IK using the internet, I did not know how to actually include it in the lesson. I personally feel that teacher education is very important in implementing IK in a science curriculum. In the module that trained us to teach culturally inclusive science we basically discussed what IK is; its importance; and its space in the science curriculum. Teacher education should also include IK content, what IK

to include for each grade, teaching strategies and an IK resource pack with activities and case studies to help plan lessons.

The forth challenge for me was the lack of teacher education with regards to IK. For Natural Science we have to do 3 content modules and 2 method modules. Only in the final method module we are exposed to IK. IK should be included in all 3 content modules and method modules. We should be introduced to IK in each module so we have exposure and also at the same time develop as a teacher. Also during the content modules we are provided with course packs containing notes that really assist us and I feel that IK should also be included in the course pack so that we can use it in our future teaching.

This experience of learning to teach culturally inclusive science was very positive for me because now I am aware of the requirements of the NS curriculum. Teacher education was not enough but at least I am aware of IK and its importance. I did learn and pick up form the other group presentations which I can use in my future teaching. This experience made me wonder how current teachers are teaching, are they successfully implementing the curriculum? Or are they just skipping IK during lessons?

Some of the opportunities that enable me to incorporate IK in our lesson was the NS method 2 module. The module exposed me to IK and its importance. The content assisted and provided me with a wide variety of notes that I used in the lesson. Journal articles also provided us with some facts that were used in the lesson.

I think it is valuable to incorporate IK in lessons because it includes learners in the classroom. Learners are comfortable and are able to share. It is valuable because it results in understanding and assists learners in learning science concepts. It moves learners from the familiar knowledge to unfamiliar and this will result in learning. I enjoyed the other groups' presentations and learnt a lot, so I think that learners in a science classroom would enjoy lessons incorporating their culture.

My view on the integration of culture (IKS) in science lessons is that it results in learning and understanding. I think that learner will perform better in science because learning is relevant. Learners feel included when you integrate culture in science lessons. It takes into account prior knowledge and backgrounds, therefore it is important. IK makes learning relevant. There is a connection between the home and the science classroom. When there is a

connection between the home and the science classroom it eliminates cultural conflicts and allows learners to move from familiar to unfamiliar resulting in understanding.

The factor that needs to be considered when incorporating IKS in science lessons is teacher education. Teacher education is of vital importance. Other factors will be learners' backgrounds. We also need to take into account that learners can also serve as an important resource in the lesson.

We sought assistance from our lecturer and fellow group members. We shared and learnt from each other as a group. We did not even use the CAPS document to plan our lesson.

G5 - RJ 2

In our lesson of incorporating culturally inclusive science we were given the topic of medicinal plants. We chose to do a lesson incorporating the black jack plant.

We began the lesson by passing the black jack plant around the class for learners to look at and whilst that was happening we discussed the parts and functions of the black jack plant. This lesson was designed for a grade 9 class. We discussed the medicinal properties of the black jack plant and then gave them a worksheet with a case study and questions to answer. The practical part of our lesson included the drawing and labelling of the parts of the black jack plant. Our lesson focused on both IK and western science.

When I got the topic and what we had to do I was very afraid and unsure of what I had to do. IK is something I never came across and now we had to teach a lesson incorporating it. I knew nothing about IK because I was not exposed to it. All I could feel was fear because I was thrown in the deep end. Teaching NS lessons are not difficult because I am familiar with the content. But incorporating IK in a lesson was very new to me and I had never had any experience teaching a lesson including IK. The fact that I had no prior knowledge of IK was a great challenge. To plan an entire lesson including IK was difficult because I had no background content to help me or guide me.

When we met as a group we decided to go to the library and look for books on IK, but we found nothing. NS textbooks also contained nothing on IK. The textbooks had a lot about western science topics but nothing on IK and how to teach it or incorporate it in an NS lesson. This was another great challenge because I was hoping that textbooks would assist me as I knew nothing about IK. There are no strategies or information about how to teach IK. All members of our group experienced this and we then decided to use the internet. We found a lot of information on IK, bit we did not know what was relevant and how to include it in a lesson. The lecture notes also didn't have any strategies or methods to including IK in lessons. I feel as though we needed more teacher education as well as content to help us perform our task. Maybe even having lessons on incorporating IK so that we can watch and pick up strategies and that would have helped us. This lack of teacher education was also a great challenge for me. We were given a course pack but that only had a few notes and some articles that helped us but was not enough we needed more.

If I received more exposure to IK and was more familiar with it I am sure I would have been able to plan a lesson with less challenges. I would have been more confident and know exactly what to include in my lesson and not waste time having to search for content. The issue of time was another challenge because a lot of time was used up searching for information on IK in textbooks when there was nothing to be found. If we had textbooks with specific sections on IK and guidelines of how to actually teach IK it would assist us.

My experience of learning to teach CIS was altogether positive. I am now aware of IK and how important it is. I never knew that it was a requirement in the NS curriculum, but now I am aware of it. Watching the other groups present their lessons also helped me as I learnt from them about IK content and also how to incorporate IK in NS lessons. The NS method 2 module gave me the opportunity to be exposed to IK for the first time. The articles and notes helped me become aware of IK and learn about it.

I believe that IK is valuable and is needed in science classrooms. IK is knowledge that learners possess so it should be recognised in the class. IK is familiar knowledge that learners have and should be used as a foundation to build new knowledge. The prior knowledge of learners can assist them in understanding other science concepts and could help them perform better in science. Some learners sit in the science class and don't understand what is happening. But if there is something that relates to them like IK, then they will feel more comfortable in the class and feel a part of the lesson. IK should be incorporated in NS lessons so that learners are made to feel included and not ignored. Teachers also need to be trained more on how to include IK in science lessons because textbooks do not have anything on IK. I don't know how current teachers are teaching IK without textbooks and education. I also think that something must be done on campus to help students, like a resource centre where they can access IK resources. Teachers from schools can also use this facility to grow their content knowledge of IK.

We got assistance from group members and our lecturer. We shared ideas and information and we learnt from each other. We did not even make use the CAPS document.

G5 - RJ 3

In my lesson I tried to be very multicultural in saying that I took into consideration that maybe not all the learners will be known to the indigenous plant I was to use in my task. I catered for the all children of different races because if I used the plant for example, siringa berry leaves, some the children would not even know about so it will call for distracted behaviors in class. So I did research on the plant known as the blackjack in which I found that all races have been exposed to it weather it getting caught on your clothes when walking through a garden or actually using it for some of its great uses.

In my lesson I planned to teach the learners about indigenous knowledge that has done things for mankind that they should know about and even so continue using its properties for the purposes that the older generations use to use it for. I basically had a worksheet explaining the history of the plant and its uses back in the day and then explain to them how this plant for example, which parts of the plant was used for different types of sicknesses. I then was to pass around a model of the plant to each child and after they have a look at the plant the learners are to draw what they see labeling mainly the leave, the stem, the flower and the root. After this activity the learners are to answer an activity that I have planned out for them incorporating what they have learnt about this indigenous plant with me standing as an aid of help when required.

I have enjoyed this topic which was not even taught to me as a scholar when it is of such importance. I learnt a lot from the group presentations and working with other group members. The fact that the learners will know about how these certain indigenous plants will help them know how and where that tablet is from when they ingest it. When planning my given task I have learnt so much whilst researching indigenous plants its knowledge that was not known to me and I was shocked at how companies use these plant without even giving it any recognition, as an upcoming teacher I feel that I will enjoy teacher education workshops and this will encourage older teachers to understand what they teach. If I had to plan an IKS lesson on my own I would have been unsuccessful.

Resources were not hard to find as everything is on the net. I had used journal articles which was very scarce on indigenous knowledge.

I felt that still there could be learner who will not fully understand the topic as I am not fully trained in that topic, so I was mainly on the points that I found in my research, because I felt

that if I was trained for this aspect I would use real life examples that this plant is in use for and make learners aware of factual evidence that I would acquire if I was professionally ready to teach this topic. I did not even know that IKS was in the CAPS document, we didn't use it. Only after this module I came to know.

It is very valuable as explained earlier it is a form of knowledge that a learner should be taught as it affects their daily lives in a way. I have the opportunity to find out what more these plants can actually do for mankind and inspire the learners that not everything they take is found in that state indigenous knowledge plays an important role in modern society. Learners will obviously feel included knowing that the plant that they sometimes step on can cure a head ache or a cut; the lesson will be involving learners full on so they stay directed to the aim of the lesson. Their backgrounds and how each learner now uses indigenous knowledge will surface causing learners to ask questions to understand better. The connection on how their parents or elders have been using this knowledge will click to them as some of them could have been blinded by the fact that they witnessed the uses of indigenous knowledge but could not understand it.

Yes I was not sure if I was on the right track so I sought assistance from my tutor who gladly helped my group understand what we were doing and teach us on how we could incorporate our lesson in a better way. I never came across IKS before in any other NS modules. We was not taught this before so it was quite difficult to prepare something that we as a group was not even sure about so we needed a trained professional to help us. Same goes for learners at schools. The only factors I could think about were race and social backgrounds which will see that we have a non-biased lesson.

G6 - RJ 1

In our lesson we incorporated the topic of water management using the idea of permaculture (gardening). We chose this topic because IKS can be used to manage water using cultural gardening. We used different types of waste materials to create man-made soil particles in a particular portion of land. We also used a practical in our lesson.

This experience was very difficult for me. It was very difficult to incorporate IKS in our lesson. We were never exposed to it and we had to now include it in a science lesson. I was very afraid of doing this because I did not know what IKS to include. In other modules we never did IK or even discussed it, but now in this module I had to present a lesson using IKS. I had no experience or knowledge of IKS, only very little that I knew from my home, but nothing like what we had to present in our lessons. It was very challenging for me as I had no background or content knowledge on IKS. Our lecturer also never showed us a lesson on IKS for us to see and pick up hints. We were just thrown in the deep end. We also had problems coming up with a practical part for the lesson, but because one of our members had some IKS knowledge we managed to develop a practical. Even textbooks did not help us because it had nothing on IKS only on other science topics. There was a lot on other science topics with activities and case studies but nothing on IKS. This was a great challenge for me as I needed something to help me understand IKS and how to use it in a lesson. Even the CAPS document had nothing on IKS to help me. It is supposed to be a guide for teachers but it did not guide me or help me understand IKS and how to teach it.

In my view IKS must be integrated in science teaching because it is important and relevant. Learners have knowledge and teachers must use this knowledge in the lesson so that learners feel like they are part of the lesson. Sometimes learners sit in the science classroom and are confused they do not know what they are learning. If they are actively involved in the lesson then they will understand better. If IKS is part of the curriculum then learners' home knowledge will be linked to the science in the class. Learners will feel that what prior knowledge they have is not disregarded but it is relevant to the science lesson. Learners will feel more comfortable in the classroom and will want to contribute to the lesson, and they will then understand better and get better results.

IKS is very valuable in science. Learners will be part of the lesson and feel included. This will help them understand better and they will want to learn more. If they are learning and understanding then they will be performing well in science. Many learners perform badly in

science and I think it is because they do not understand science, but if IKS is part of science then learners will have something that they know about and will do better.

Teachers must consider the knowledge that learners bring into the science classroom. The prior knowledge of learners is very important and teachers must use it in their teaching and not ignored learners. Teachers must be trained properly to teach IKS. If they do not get the required training then I think they will not be implementing the curriculum correctly. Textbooks must have information on IKS because we need it to plan lessons and also to increase our knowledge. Now we have no textbooks to help us and it is difficult, but with more resources and maybe a resource centre on our campus with books and guides on IKS we can successfully implement the curriculum when we go out to teach. We also need notes on IKS. In other NS modules we get course packs with notes to guide us, but for this module we did not get anything to assist us or help us develop or knowledge of IKS. This was also a challenge for the group.

We got assistance from one group member who had some previous knowledge of IKS from another module that he did. I learnt a lot from the field trip we went to. The pamphlets that they gave us explained the concept mulching which was used in our practical. We also observed how you plant different plants that require specific amounts of water together. We learnt how you water the long portion of the land conserving water.

I feel that in this module we were given only an introduction of what is IKS. To teach IKS we need more training on how to teach it. We were given little notes that only told us what is IKS and nothing else. Right now I am not familiar with IKS and I am not confident to teach lessons including IKS. If IKS was included in all NS modules then we would become more familiar with it and develop more content knowledge. Also we need more notes for us to refer to. We only got an introduction to IKS. We need more activities and case studies on IKS. If we have IKS in all our NS modules then we will see more lessons on IKS and pick up different ways and methods to teach incorporating IKS. Also we had great difficulty coming up with practicals on IKS so that we can learn from it. Maybe even if outside experts on IKS come to lectures and share knowledge with us it will give us more exposure to IKS. The notes given to us must be taught to us so we can understand how to teach IKS to learners.

G6 - RJ 2

Our lesson we included the topic of water management using the idea of permaculture (gardening). We felt that this topic was important and could be used because IKS can be used to manage water using cultural gardening. In our lesson we used some different types of waste materials to create man-made soil particles in a particular portion of land. We did a practical also to show the class how permaculture can be used. We did a lesson plan with all the requirements and then did the practical.

I was not very happy when I read what we had to do. My experience of IKS was very little and I was not confident with teaching it. I did not know what is important in IKS and how it must be incorporated with another science concept. It was very challenging for me. I felt like I was alone because I had no help. Even my other members did not know what to do so we all were afraid. I needed someone to help me and explain exactly what I need to do. I had problems with a practical for the lesson, but because one of our members had some IKS knowledge we managed to develop a practical. The other members did not know much of IKS. Even textbooks did not help us because it had nothing on IKS only on other science topics. The CAPS document had nothing on IKS.

IKS must be integrated in science teaching because it is important. IKS is relevant to learners and the knowledge they possess must be used in the classroom. Learners must be actively involved in the lesson then they will understand better. If IKS is part of the curriculum then learners' home knowledge will be linked to the science in the class. Learners will feel that what prior knowledge they have is not disregarded but it is relevant to the science lesson. Learners will feel like they are comfortable in the classroom, and they will then understand better and get better results.

IKS is very valuable in science. Learners will be part of the lesson and feel included. This will help them understand better and they will want to learn more. If they are learning and understanding then they will be performing well in science. Learners' prior knowledge is very important and it must use it in their teaching and not ignored learners. Teachers must be trained properly to teach IKS. Textbooks must have information on IKS because we need it to plan lessons and for ourselves. We must be given notes to help us in our lectures. We get course packs with note, but we did not get anything to assist us or help us develop or knowledge of IKS. This was also a challenge for the group.

We got assistance from one group member who had some knowledge of IKS from another module that he did.

I did not receive enough education on how to teach IKS. In the lectures we got an introduction of IKS but no notes or explanations of how to teach IKS. We did not even see a lesson on IKS. Only in presentations I saw IKS being incorporated in science lessons. We need IKS to be part of all NS modules so that we receive more exposure to it. Right now I am not happy to teach IKS because I don't have any notes or textbooks to guide me. I do not know where to start. In our teacher education we need to be exposed to more IKS and be given notes on IKS. We need notes so we can know what IKS is relevant because there is a lot of IKS out there. Case studies and activities on IKS must be given to us so that we can read about IKS and develop content knowledge as well as strategies and methods to incorporate IKS in science lessons. We also need to see practicals on IKS. When we were planning our lesson we could not find any practicals on IKS. If we are exposed to more practical lessons on IKS we will be able to incorporate it into science lessons. In this module the presentations helped us because we learnt from other groups. We need more presentations like these. Maybe IKS workshops can be done on campus to help us learn more about IKS. IKS professionals can come and share knowledge with us and we can learn from them.

G6 - RJ 3

In teaching learners about Permaculture, science of gardening that uses the principles of nature. Learners will understand how people have long been living in harmony with nature, looking after their natural resources, including water and soil. Learners will learn from permaculture that gardening used to be done in ways that did not harm but benefited the environment. Because indigenous people took care of the environment, by protecting their water sources and replenishing their top soil whenever they wanted to do their cultural activities. By teaching learners the steps towards practicing Permaculture they will learn how to cultivate soil for gardening using only organic material (Mulching, organic manure, dead leaves and branches, etc)

First Culturally Inclusive Science was out of my vocabulary due to that I was not exposed to such knowledge at school, so I used to think that Science was only based on western knowledge, until I was taught that the Science curriculum stipulates that indigenous knowledge science should be incorporated in the classroom, that is when I began to value it. As someone with no experience on teaching IKS in science, it was necessary that I get enough information to my lecturers, because there is no so much information of this nature on the internet and book, so resources were lacking

My challenges included lack of exposure to Culturally Inclusive Science lessons, maybe if had experienced this at school was going to be able to link it with course work, and we were not given enough information on preparing a culturally inclusive science lesson. IKS must be included in all NS modules so that this will help us learn it.

Opportunities included reflecting on my experiences on the indigenous knowledge I had, as someone who grew in rural areas, I had a lot of experiences regarding that, so I was able to make examples of what we were taught in this module, so it was more meaningful to me.

Yes it is, because it is based on background information that we all experience on our daily lives, to it is more meaningful than western science, which sometimes does not match with our social context. Learners can relate easily with culturally inclusive science, because it is more meaningful to them, they can understand it better.

It equips us as we are expected to incorporate it in science classrooms, as stipulated by the new curriculum. This is important because it makes science relevant to learners. Learners can

relate to their social experiences in understanding science concepts. This is very advantageous to learners, and the teachers as well

Understanding learners social background and experiences is one major aspect that needs to be considered.

Yes.

The information we obtain on a field trip to botanical garden helped us to find the background information on the practice of Permaculture. This assisted us in the planning of the practical aspect of our lesson.

More notes and Case studies with examples of lesson plans should be provided to us. We need indigenous knowledge experts to come on campus and share their knowledge with us. Teachers who have experience on using IKS in the Classroom may come and enlighten us on what to expect when attempting to incorporate IKS in the classroom

We were given enough information on the concept of IKS but not incorporation IKS in the classroom, then we were given Assignment to design a lesson that incorporates IKS with practical activity. This was not so helpful since we were not guided on how to do this, and we were not given feedback on whether we did as expected, and what to improve. Only recently have we seen our assignment marks.

With the training I had experience I have to been exposed to, since I have done two Modules that deal with equipping us with knowledge and skills necessary for incorporating IKS in the classroom, I can be successful in ensuring that learners perform well in Science. Because by making Science relevant to learning, that develops passion for science, and learners will be able to construct their own knowledge, thus enhancing their learning.

Yes, learners will be able to understand science on their social context, thus it will be more relevant to them, and their stereotypes would change. Because, science has been long viewed as a body of knowledge that is mainly from the West, divorced from their everyday life.

G6 - RJ 4

In our group we used permaculture (gardening) as best example of IKS. As our lesson was the management of soil and water by using IKS; therefore we used cultural gardening as our practical example of showing how to manage soil and water. Whereby different types of waste materials including the fallen plant's leaves was being used to create the man-made soil particles in a particular portion of land.

The lesson was being designed as following: Learning outcomes, assessment standards, specific aims, prior knowledge, links to the nest lessons and developments. All these aspect were shown in lesson plan including the grade and topic to be covered. The most important thing is how we arrange our practical which links to IKS.

We firstly, level the soil particles in the cardboard, and place some newspapers being levelled. We then add soil on top, pour and level manure and other raw materials. Then after the plants leaves were placed on top covering the soil surface. So that they going to decomposed and form part of soil particles.

I can say I personally got challenged about this lesson plan, since I had little understanding of IKS and this system was new to me. But with the assistant of my fellow group members I ended up being enlightened and understanding what we should do and how we are going to attack it.

We struggled at coming up with a practical example of managing soil and water using IKS but since one of our group members was familiar with the IKS strategies, he ended up pointing many examples to do. On that way my challenged was being resolved.

I ended asking more question so to enhance my knowledge and understanding.

Yes; since it changes theories into practice; therefore learners tends to understand the content better and they become actively engaged on their understanding through teaching and learning process.

IKS makes leaners feel included when integrating culture in science lessons. It is important because it takes into account the prior knowledge and backgrounds. It makes learning relevant since it reviews knowledge connection of home and science classroom.

Yes since I had little understanding of what I should do I therefore ask for assistance from my fellow group member.

IKS content must be included in every module so that we become familiar with the IKS and pick up different strategies to teach IKS

Given content and taught that content

More examples of IKS need to be taught in order to make student to better understand IKS from western science.

Textbooks would contain IKS content and teaching strategies to assist both the teacher and learners.

Yes; relevant knowledge will be taught to learners. This will assist in learning new concepts. Learner's prior knowledge is taken into consideration and this will results in understanding.

APPENDIX 11

G4 – VRO - M2U00022 & M2U00023

Group 4 -Our topic today is soil and water management using IKS. Specific Aim 3, strand 2: Life and living. It also teaches students practical skills.

Introduction: the teacher will inform the learners of the topic and what the day's lesson will entail. Due to the diversity of the class, learners will be asked to share their knowledge of ways their parents or grandparents managed soil and water using IKS. By doing this the teacher will be able to know learners prior knowledge and be able to build on that knowledge, this is also known as constructivism. The teacher will discuss the different ways soil and water can be managed with regards to IKS and build on their prior knowledge and introduce them to different IKS as well.

For the further development of the lesson, the teacher will explain and discuss the different soil and water management methods using IKS. After a brief discussion the teacher will then give those methods e.g. soil winnowing. This method is actually used for grain, but it can also be used for soil if it is not too dry or too wet. They will throw the soil up into the air and the wind will blow out all the sediments and the stuff that doesn't need to be there, the lighter stuff that doesn't need to be there makes it infertile. Soil erosion that's a major problem when soil is washed away by heavy rains. So what we can do is plant crops so the roots hold the soil in place. And we have here the first picture, shows soil erosion; the water has been washing away the soil. Now the soil cannot be used, it's gone hard and the nutrients have been washed away. In the second picture we have prevention for soil erosion, as you can see on each step there are crops planted so the soil doesn't fall of the bank, so the soil is saved and it can be used.

Fertilizers can be home made. You can use egg shells, tomatoes and stuff that you are not using. This is used when soil nutrients are no longer in the soil, so you can replace the nutrients with all this stuff, like the first picture those are things you can use from home and the second picture is making the fertilizer.

And there is another problem when soil gets too dry in dry seasons, now for that you can use shady trees, palm trees have big flat leaves and they are tall. So if you plant them in a place where you don't want the soil to be dried out, leaves will create shade. So the soil at the bottom doesn't get dried out because evaporation is prevented.

Dams and soak pits: Dams are created in order to save water. Water will be collected in the rainy season so that it is available when it is a dry season. Soak pits that collect extra rain water can also be used. This is a soak pit that you can see...Ok so...

Lecturer - NO, no he must explain...

Group 4 -For the practical of this lesson uh... we'll be putting them in uh... the class in groups. Each group will have uh... five individuals and why we are doing this is because this is uh... like this activity needs a lot of work like we can't have like two students and we can't have more than five because then we will have passengers and like everyone can get involved if you put five individuals in that group. Each group will go out into the school yard and look for a suitable spot to plant a garden using resources they were requested to bring from home in the previous lesson, like potato peels and all other stuff that can decompose, and can be used for gardening. They will make a small garden using permaculture.

In conclusion the teacher will ask learners questions to test their knowledge of the days lesson. Um... by receiving the learners' feedback the teacher will be able to improve their methods of teaching, as well as the information that was uhm... delivered to the class.

Lecturer - Times up, did you tell them it was seven minutes?

Group 4 - Yes.

Lecturer -We'll give you one more minute...

Group 4 - Can we show them?

Lecturer - You have too, that is the thrust of the presentation, and you have to do it quickly.

Group 4 - Ok, we have soil here to show winnowing. This was dirty soil that had things that we didn't want in it and after it was winnowed it was clean like this, so this is soil that can be used in gardens.

Lecturer - That's it?

Group 4 -Yes.

Lecturer - Thank you. Anything else? Thank you to this group for your presentation be careful about reading from the slide and not making eye contact. Your slides should have only points and not full sentences. I couldn't see the point of permaculture. Permaculture

does involve strategies which help to manage soil and water. I did not see specifically how permaculture is used to manage soil and water coming out of your practical. If you used... the shade one was good, to prevent evaporation, that I agree. But when you have your students creating gardens, how do you manage the soil? Do they use organic composts? Did you mention organic compost?

Group 4 - Yes

Lecturer - How else do they manage soil? How do they prevent soil erosion of this garden? Did you mention mulching? In terms of water? What teaching from permaculture can you use to manage water supply?

Group 4 - Um...?

Lecturer - On permaculture how will you manage water supply? One of the strategies is to plant plants which require specific amounts of water, let's say little water, you plant them together. Then plants that require moderate water, you plant them together, and those that require a lot of water you plant those together. So you know you can skip watering those that need very little water every day; and just water the patch that needs a lot of water every day, you understand? So you can regulate the water, the amount of water you use ok. Thank you.

G6 – VRO - M2U00032 & M2U00033

Group 6 - We are covering managing soil and water using IKS. We chose to go about this using horticulture; we will be looking at permaculture. Our lesson plan is designed for grade 7 and the topic is soil and water, it will last 45 minutes.

The teacher will begin the lesson by asking learners questions...

The questions will prompt learners to think and engage in a class discussion where they will challenge and add to their prior knowledge.

In the development the teacher listens to the learners' responses and elaborates their answers stressing the importance of conserving soil and water. Conservation of water is important in sustaining lives and stating facts like did you know that South Africa is expected to run out of fresh water resources by 2015. Those are the type of points the teacher will stress. Explanation given to learners of how plants absorb water and how the water cycle happens. Then the teacher will give learners an example that they can use in their own school garden to manage water and soil using sustainable practices, e.g. permaculture. Permaculture is a way of cultivating using the principles of nature by mimicking how the system of nature works in growing plants. As you know no one tills the soil and plants grow without anyone looking after them, so there is a system and permaculture takes that system and it is holistic with nature.

For the practical learners will go to the garden and then use the soil and take out the weeds from the soil and then level the soil to have something like this, and add manure and then add water and put leaves in with all waste materials that learners have gathered. Leaves put on the top so that the sunlight doesn't hit the soil directly and the nutrients from the leaves will go to the soil.

Thank you.

Lecturer - Regenerating soil using this method, are you stressing this in your lesson?

Group 6 -Yes.

Lecturer - Ok, thank you.

APPENDIX 12

G2 - FGI -9: 30

Raeesa - Good morning, I am sitting in with group 2 and I am interviewing them on their experiences of learning to teach a culturally inclusive science. Culturally inclusive science is school science that is embedded in indigenous knowledge systems (IKS).

Group 2 - Good morning.

Raeesa – Firstly, what aspect of IKS did you include in your lesson?

Group 2 – We used Astronomy in our lesson. How the African culture used Astronomy to better their lives. They used Astronomy to find out the weather, to see when is the correct time to plant crops, to find out about sickness. Like it is raining now and that rain impacts on your sickness at the moment.

Raeesa – So that is how you included IKS in your science lesson.

Group 2 – Not just about traditional beliefs, how it was developed till now, till modern times. How they used IKS in the past and developed it over the years.

Raeesa – So tell me a little more about your lesson, how you went about conducting your lesson start → development.

Group 2 – Firstly we were a bit confused about how we were going to present the information. We never encountered IKS before and we did not know how to incorporate it into a lesson. We then decided that we will use a role play, because learners actually learn better when the see something as compared to reading it of a power point.

Raeesa – OK, so firstly you had great difficulty trying to incorporate IKS in a lesson.

Group 2 – Yes, because it is a new topic, we also wanted it to be interesting for the learners. You can't tell learners this is IKS. There needs to be interaction with the class.

Raeesa – How did the students in the class react when you presented the lesson?

Group 2 – Some were a bit confused as to what we were doing. We did not explain anything to them that this part of our role play was part of our lesson. We just started the play, and then they understood.

Raeesa – And did they enjoy the lesson towards the end?

Group 2 – Yes, they understood.

Raeesa – It all resulted in understanding. So according to you what is culturally inclusive science?

Group 2 – I will think like all cultures are taken into consideration in the science classroom. Example in evolution, culture is not spoken about. Mainly big bang, scientific, no creationism. IKS brings in all cultural aspects e.g. Indians, Africans.

Raeesa – Could you give me some examples of culturally inclusive science?

Group 2 – Err…

Raeesa – You could also give me some examples of what the other groups used in their lessons. How did they incorporate IKS in their lesson?

Group 2 – Medicinal plants used to cure chicken pox (Indian). Turmeric and sling berry leaves. Knowledge passed down from one generation to the next.

Raeesa – So if I speak to you of science topic, you are able to give me examples of science topics. But if I have to ask you about IKS, you are not familiar with it.

Group 2 – Yes, we did not do anything of IKS in any of our modules. We were not exposed to IKS. This is the first time we doing IKS in our method module.

Raeesa – But you are expected to teach it in the science classroom.

Group 2 – Yes- we are and we are unfamiliar with IKS and its application in the science classroom.

Raeesa – OK, so you are unfamiliar with IKS. But are you comfortable teaching using IKS in lessons?

Group 2 – No, not comfortable teaching IKS.

Raeesa – Not comfortable teaching IKS.

Group 2 – Because it is the first time. It's new and challenging.

Raeesa – It is new, challenging.

Group 2 – But I think with time we will be able to. We are exposed to it now. Maybe more training on content so we can be more comfortable with IKS in the classroom.Maybe two method modules to help us with the actual content on IKS. Maybe aspects of IKS should be included in the Natural Science module to help us incorporate it in lessons. Now we are lost.

Raeesa – So if you did not have this pedagogic content knowledge module on IKS, you would have great difficulty teaching it in a classroom.

Group 2 – Yes, great difficulty.

Raeesa – At least now you are exposed to aspects of IKS in science.

Group 2 – Yes.

Raeesa – So, is it important to teach culturally inclusive science? Is it important to incorporate IKS in science lessons?

Group 2 – Yes, definitely.

Raeesa – Definitely.

Group 2 – Because we don't want children to forget where they came from. We want them to use what they are exposed to at home, in the classroom. We want them to use what they know and experience. We now only focus on modern times. IKS is not boring, it is interesting. There needs to be a balance with IK and western science.

Raeesa – Don't forget, by including IKS in science lessons it sort of incorporates learners prior knowledge? It takes into account what the learners already know.

Group 2 – Yes. It broadens their knowledge. We should not forget traditional knowledge and backgrounds. Learners in science classrooms must be able to share where their own personal knowledge came from. E.g. their granny's and grandfathers. You don't have to always go to the doctor and take their medication; it can be done in traditional ways.

Raeesa – So, would you say that a learner would respond better in a science classroom if we incorporate IKS? Maybe at the outset taking into account their background?

Group 2 – Yes, it will result in better understanding.

Raeesa – So you feel learners will learn better?

Group 2 – Yes – they will be more open to talking and responding. They are familiar. From personal experience they will be able to answer questions moving from what they know, to a new science topic or concept.

Raeesa – Why do you think it is important to include culturally inclusive science or include IKS in science lessons?

Group 2 – Children are different. In the African and Indian community you have 1 elder that tells children how they went about doing certain things.

Raeesa – So in a science classroom you feel it is better to teach or start a lesson with aspects learners are familiar with, and then build on their knowledge?

Group 2 –Yes, definitely.

Raeesa – So what factors do you think will influence your decision to teach culturally inclusive science?

Group 2 – It depends on your understanding of IKS.

Raeesa – And what about teacher education? Will it influence your decision to teach culturally inclusive science?

Group 2 – We are teaching in multicultural and multiracial schools, so it will be good to incorporate IKS.

Raeesa – What were some of the challenges which your group encountered when you integrated IKS in your lesson?

Group 2 – We did not know what to do. We did not know what to teach and also how to teach it… there was no information on IKS. No books and resources on IKS.

Raeesa – OK, so your first challenge was that you did not know what to do, not exposed to IKS previously, IKS was new to you, and then your second challenge was the amount of information/ content available, accessing information. So how did you get the information?

Group 2 – It took a lot of time. We used the internet. No books on IKS.

Raeesa – OK so just to confirm your challenges, when you were asked to design and present a lesson incorporating IKS you did not know what to do because you were not exposed to IKS. Amount of information available was a challenge. Besides that, any other challenges?

Group 2 – I think the only other challenge was how we were going to present the lesson. We has a practical part, we had a hard time thinking about a practical. We came up with a sundial. We used it as a demonstration to tell time.

Raeesa – What were some of the opportunities that enabled or allowed your group to integrate culture or IKS in your lesson?

Group 2 – What you mean opportunities?

Raeesa – What allowed you to integrate IKS in your lesson? What enabled you?

Group 2 – We used a role play. We had a narrator and it was the 3 of us. It was about the weather. We were all part of an African tribe. We were talking about the rainy season is here and how we can tell when it is the right time to plant crops.

Raeesa – So by using a role play you were able to incorporate IKS in your lesson.

Group 2 – We showed them how it was used in their daily lives.

Raeesa – What is your view on the integration of culture or IKS in science education? Do you think it should be included in science lessons?

Group 2 – It should be included/ integrated in science lessons. It is important.

Raeesa – You think it is important. Even though you feel you do not have adequate content knowledge to assist you and help you with the incorporation of IKS? In your view, you still feel that it is important to incorporate IKS in science lessons?

Group 2 – Yes.

Raeesa – So when you go out into schools will you incorporate IKS in science lessons?

Group 2 – Yes, definitely.

Raeesa – OK.

Group 2 –We can try because we still don't have much knowledge of IKS.

Raeesa – So if you were not trained to teach or learn how to incorporate IKS, would you incorporate it in the science classroom in the future?

Group 2 – No – no training, so will not know how to incorporate it.

Raeesa – So if there was no teacher education on culture, specifically IKS. Or if you were not introduced to culture or IKS in the university pedagogic content knowledge course then you would just ignore the teaching of IKS and culture in science classrooms.

Group 2 –Yes, we won't know the importance, no content knowledge and background on the integration of IKS in science. We were lost.

Raeesa – I am sure you observed a few groups presenting their lessons with the integration on IKS. Are you picking up different ideas to help you?

Group 2 – Yes.

Raeesa –Will that assist you and help you with ideas on how to incorporate IKS or culture in science lessons?

Group 2 – Yes, definitely. The more content we are exposed to the better we can teach science, so taking into account learners cultural backgrounds.

Raeesa – The main issue here is that you do not have enough background, no content knowledge on IKS to assist you and help you incorporate it in science classrooms. So I think that is one of the greatest challenges that you are having and you experienced.

Group 2 – Yes – yes.

Raeesa – It is also something that in-service teachers are currently experiencing right now.

Group 2 – Yes it is also a challenge for us, with not much training and knowledge of how to incorporate culture and IKS in science.

Raeesa – Do you think that teacher education is important to help you incorporate IKS/ cultural backgrounds in science lessons?

Group 2 – Yes, it is very important.

Raeesa – Teacher education is important, you feel that teacher education is a must?

Group 2 – Yes. If it was not for this method module we would not even know of IKS and how to teach it. I will be taking things from this method module in my science classroom when I qualify.

Raeesa – So if it was not for this method module you would not know about IKS?

Group 2 – We heard of the term IKS, but we did not know how to include it in a science lesson.

Raeesa – OK.

Group 2 – This module is very beneficial to us in successfully implementing the CAPS curriculum.

Raeesa – It will help you achieve aims of the CAPS document, specifically specific aim 3.

Group 2 –Yes, but we should have more modules and time allocated to learning about IKS and how to teach it in science. If there is more time in learning to teach IKS and culture then we also will have a better understanding. This is the first time we exposed to IKS in our third year of study. We need more content and ways to teach IKS.

Raeesa – OK, detailed content on ways/ strategies to incorporate IKS.

Group 2 – Yes.

Raeesa – By listing to you, all of you seem as if you value IKS.

Group 2 – Yes.

Raeesa –You believe that more time should be allocated to IKS in teacher education?

Group 2 – Yes. If more time is allocated then we can successfully incorporate it in science lessons.

Raeesa – OK. Firstly, you value IKS, you feel there is a need for IKS, and more time should be allocated when learning to teach IKS.

Group 2 – Learners should be exposed to IKS in school.

Raeesa – Maybe made aware of it?

Group 2 – It can result in all learners understanding science too. They feel included.

Raeesa – Do you feel that if we incorporate IKS in science lessons it will result in better understanding, corporation with learners?

Group 2 – Yes, because it is something that they can relate to. That is the most important that learners are able to relate to science concepts. We are intermediate – senior phase, we are working with small kids. They are very sensitive. Whatever they do and practice at home or every day, they want to relate it to science and share it in the classroom. We have to take into account their cultural backgrounds. For example the things that their grandmother does to treat ailments and flu. It can be used as a basis in the science classroom. We can use it as prior knowledge. This knowledge cannot be disregarded in the science classroom.

Raeesa – OK, so build on it in a science classroom.

Group 2 – Yes, yes.

Raeesa – Did you engage with any external sources to obtain you information on IKS?

Group 2 – We did not have knowledge on how to plan a lesson incorporating IKS.

Raeesa –Did you obtain information from IKS knowledge holders, people in your community, your lecturer, fellow group members? How did you obtain information on IKS?

Group 2 –We did not speak to older people at home… just the internet.

Raeesa – OK.

Group 2 – We worked together as a group, sharing information.

Raeesa – OK, you learnt together as a group.

Group 2 – Yes and our lecturer covered some aspects with us.

Raeesa – OK so you worked as a group and your lecturer enhanced your knowledge of IKS.

Group 2 – If we did not know what IKS was, we will not be able to plan a lesson.

Raeesa – OK, so you enhanced your knowledge on IKS by obtaining information from each other and lecturer.

Group 2 – And the module itself. It helped us with some content knowledge.

Raeesa – Did you learn from your lesson?

Group 2 – Yes, a lot.

Raeesa – OK, let me just recap. One of the challenges was that you were not too familiar with IKS; you did not have enough content knowledge and education on IKS. Also you were not exposed to IKS.

Group 2 – Yes.

Raeesa – Your opportunities or what enabled you?

Group 2 – Was the use of role play and the module.

Raeesa – Your view of IKS? You believe that IKS should be incorporated in science lessons?

Group 2 – Yes, we think it is important. It is important for learning. Also learners will learn better or perform better if their cultural backgrounds are taken into account in the classroom.

Raeesa – OK. So taking learners from what they know to new knowledge?

Group 2 – Yes, it will assist them learning new concepts in science.

Raeesa – You did make a point that teacher education is very important.

Group 2 – Yes, to help us incorporate IKS in science lessons.

Raeesa – Thank you very much for allowing me to interview you today.

G 5 –FGI - 13: 15

Raeesa - Good day, I am sitting in with group 5 and I am interviewing them on their experiences of learning to teach a culturally inclusive science (school science which is embedded in indigenous knowledge systems) (IKS).

Group 5 – Good day.

Raeesa – Can you tell me about your lesson, just a brief summary?

Group 5 – We did a plant, an indigenous plant (IKS). Initially we chose the Thulsi leave that was mostly used by Indians. We then found more relevant information on the Black Jack plant. They grow wild and are used by many different cultures. It is used for healing purposes. It was called the Ucadodo. The stem is used to help people with prostate tumours and also antiviral properties. The leaves help to heal cuts and wounds. The black jack grows in the wild. I thought that the black jack was just a bush. So our lesson was about explaining it to the learners and showing it to them. Back in the day this plant was used to heal wounds and it is still used. For example if you place the leaf on an open wound or cut, it will heal in a day. We found this in many articles. The stem was used for nutritional purposes – boost your immune system and suppress hunger. We explained the history of black jack because learners may have run around in the bush and it may get stuck on them. Many leaves are familiar with black jack. We had the black jack plant in class and sent it around the class. We also explained the parts and functions to learners. The practical part was they had to draw and label it.

Raeesa– So the aspect of IK that you incorporate in your lesson was the properties and uses of the black jack plant?

Group 5 – Its medicinal uses.

Raeesa – According to you what is culturally inclusive science?

Group 5 – Teaching in a way and being aware that learners came from different backgrounds. Taking into account different methods. It is a combined knowledge. It is a science for all. It gives a quality education. Science that takes into account various views, includes all knowledge forms.

Raeesa– Could you give me some examples of culturally inclusive science?

Group 5 – Medicinal plants, food preservation, farming methods, cover leaves.

Raeesa – Do you think it is important to include IKS or culture in science lessons?

Group 5 – My personal opinion yes it is important. IK is important. Most learners value it in their homes. We don't need to tell them about it. I use IK at home all the time. We use slinga berry leaves for chicken pox. We use IK all the time. For example the Hoodia plant – found long ago – slimming products, contain the hoodia plant. So modern medicines are also using or taking from IK. IK is science.

Raeesa – So you feel it is important to include IK in science lessons?

Group 5 – Very important.

Raeesa – Why do you think it is important?

Group 5 – It is relevant to learners. It takes into account their experiences and background knowledge. It makes lessons easier to understand. It links home knowledge to school science. It is important because learners are exposed to IK all the time. Learners experience it. Learners also feel more comfortable in class. They respond and share knowledge. IK is relevant and familiar. I would definitely use IK in my classroom. You can't only teach western science that brainwashes a child. They are and need to be made aware of another science, which is IK. IK will assist in learning any science concept and content will be made easier to learn.

Raeesa– So you feel it is important?

Group 5 – Yes, it will result in better understanding. IK is a starting point. It will definitely result in better performance. IK is relevant knowledge. IK is familiar, it will assist in learning content.

Raeesa – What factors will influence your decision to teach culturally inclusive science?

Group 5 – Huh?

Raeesa – Why would you teach culturally inclusive science? Why would you incorporate IKS in science lessons?

Group 5 – Because it is important. I went through it and learnt better as a university student. Learners are exposed to IK all the time directly and indirectly, so it is important knowledge to

use in science lessons. I will never skip the topic like other teachers do. It is relevant to learners. Learners will be more involved and comfortable in a science classroom. Some part of the black jack has antibacterial properties and we can use this in our science lesson. Maybe in a section, bacteria. Learners understand better.

Raeesa – And did you learn better?

Group 5 – Yes I did, way better.

Raeesa – Tell me about your experience of learning to teach culturally inclusive science. Tell me about your thoughts, feelings, difficulties, etc.

Group 5 – We found it difficult and hard. I did not have much knowledge, this was the first time I was taught on IKS. It was new to me and I did not have knowledge to design a lesson. We experience IK all the time but to put it in a lesson it was hard. I did not know how to do it. It was challenging and entailed lots of research. It took a lot of time. I was not exposed to IK in training.

Raeesa – So it was a challenge to you, you did not have much content knowledge and you were not exposed to teaching IK?

Group 5 – Yes, schools need to incorporate IK in science lessons.

Raeesa – But it is a requirement of the curriculum. It should be taught or included in lessons.

Group 5 – Oh IKS is in the CAPS document? So it is in the curriculum?

Raeesa – Yes, the CAPS document clearly outlines it in specific aim 3.

Group 5 – Oh, that's good. It is important.

Raeesa – Yes.

Group 5 –So if it was not for this module I would not have known about IKS and that I should be teaching it in science lessons. If it was in the textbook. I will just read it out.

Raeesa – Do you feel that the module provided you with enough teacher education on IKS?

Group 5 – Yes, but maybe more to further it and add to lessons. We observed groups, I learnt from them. I need to know more on how you lay it out to the learners. I want more content and strategies to teach IK. Maybe how IK can be integrated in each science section. Some

content to help because textbooks do not help. I need to know what aspects to include in a lesson.

Raeesa – Let me just recap. You did experience difficulty and challenges. The challenge was that you did not have content or background knowledge. It was new and you did not know how to teach it. You also feel you need more strategies to assist you in planning lessons incorporating IKS.

Group 5 – Resources too were a challenge. Textbooks did not help. I used journal articles and an e book.

Raeesa – You used electronic resources?

Group 5 – Yes.

Raeesa – What were some of the opportunities that enabled or allowed your group to integrate IKS in your lesson?

Group 5 – Sorry?

Raeesa – What enabled you to integrate IKS in your lesson?

Group 5 – We worked as a group, we learnt together and shared. The lecturer assisted us and guided us. But we did not get content to help us, like notes and worksheets with examples.

Raeesa – What is your view of the integration of culture in science lessons?

Group 5 – It is very valuable and important.

Raeesa– Why is it valuable?

Group 5 – It is relevant to learners. It helps learners understand science. It helps in learning and it will improve learners' results.

Raeesa – Did you engage with any with any external sources to enhance your knowledge of IKS?

Group 5 – We worked as a group and learnt from each other. We worked with our research together. The lecturer and the introduction notes on what is IKS.

Raeesa – Do you think that teacher education is important in helping you incorporate IK in science lessons?

Group 5 – Yes, definitely. Teachers are dumbstruck, I don't know how teachers teaching in schools plan lessons or teach including IK in lessons. We are trained and it is still hard and challenging. The workshops teachers go for they should incorporate IK in it to help them. They should have modules and courses on IK to help teachers.

Raeesa – So you saying that in-service teachers also need teacher education?

Group 5 – Yes a lot. I don't know how they teach it or if they are even following policy.

Raeesa – OK. But now you are given teacher education.

Group 5 – I am aware of IK and its importance but if it was not for this module, I would ignore IKS and that's the honest truth.

Raeesa– So the module helped you?

Group 5 – Yes to an extent. I still need more content and strategies to take into the classroom. I need a variety of strategies to help. I learnt from other groups and picked up ways. I can also improve on that and add on. So the module was helpful.

Raeesa– Is there anything else you would like to share?

Group 5 – No, that was all. I feel that not only pre-service teachers should be trained but also in-service teachers. They also need training.

Raeesa – OK, through workshops?

Group 5 – Yes.

Raeesa – Tell me more about your experience.

Group 5 – It was a positive but challenging experience. It was informative and interesting. I now know that it is in the curriculum and at least I will successfully implement the curriculum with specific aim 3. Lucky for this module because I would not know anything.

Raeesa– Thank you so much for allowing me to interview you.

Group 5 – No problem, anytime.

APPENDIX 13

G3 - II -11: 00.

Raeesa– Good morning I am sitting in with a member of group 3 and I am conducting an individual interview on their experiences of learning to teach culturally inclusive science.

Interviewee – Good morning.

Raeesa – Tell me more about your experiences of learning to teach culturally inclusive science.

Interviewee – It was challenging because we have a little knowledge on how to teach a lesson incorporating IKS. As a result this little knowledge of IKS made me less confident on how to tackle such a lesson. Incorporating IKS is hard and difficult and very challenging. This was my first experience I was never ever exposed to the teaching of IKS. Only in this module we are studying about IKS. We were never taught how to plan a lesson including IKS.

Raeesa – Why was it challenging?

Interviewee – You see the training we received was not enough. IKS is only included in this one module. We had one or two lectures on what is IKS, its importance, and its place in the CAPS document. Then we were given topics and we had to plan and present a lesson including IKS in groups. This was really hard because we had no experience and limited content knowledge. Because the training was not enough I do not feel very confident about teaching IKS. I am really not confident. I am confident teaching other science topics and lessons but IKS is hard because we did not have much training. You see IKS is new and it is not present in textbooks so this does not even help.

Raeesa – In your focus group interview you mentioned that IKS is included in only one of your method modules and that it should be part of all your Natural Science modules as well. If you had more exposure, content and background knowledge on IKS, how would that impact on your learning to teach science lessons incorporating IKS?

Interviewee –If IKS is included in all the NS modules then I will know more. I will have more knowledge and it will assist me in planning a lesson successfully with minimum challenges. I will have more exposure to IKS so I will know how to actually plan a lesson

incorporating IKS. I will know IKS content and I will also know how to integrate the two; IKS and western science. If IKS is included in NS 110, 120 and 210 then I will be more confident teaching it. I will become familiar with the IKS content. I will pick up styles and strategies and this will assist me in the future.

Notes and worksheets will be provided so this will be an added resource to me. When IKS is included in all NS modules then learning to teach IKS will be more effective. When you are exposed to something you become more and more confident. If in this module we were exposed to various strategies of incorporating IKS my learning will be better. I would prefer the lecturer actually teaching me how to include IKS in a lesson. I need the lecturer to discuss the IKS content with me and then showing us how it can be included in a science lesson. I have never been taught IKS, I had no experience so now we need to be taught it for us to successfully plan a lesson and teach it in the future.

Raeesa – Your focus group interview highlighted the following as challenges that you experienced;

> Lack of content/ background knowledge. How did you address this? How did you overcome this?

Interviewee – We consulted our parents. Fortunately my mother is in an organisation where they plant various crops in different seasons. She know better about IKS. So we went to my homeland and got information/ assistance and guidance. I had some knowledge but I went into the community and developed that knowledge further. I built on the knowledge. I learnt from my mother. I also learnt from my group members that worked with me. We came from different backgrounds and we learnt from each other. He built and added to the knowledge I had. We also researched and shared knowledge. We taught each other. Community members added to that knowledge. My mother assisted me.

Raeesa – Who else assisted you?

Interviewee –Community members, group members, mother and internet. The lecturer assisted us during the consultation time because we were lost at first. We did not know if we were doing the correct thing. Planning a lesson including IKS was new to me. The lecturer did give us some direction, she did assist.

Raeesa – Lack of resources; how did you address this?

Interviewee – It was hard to get the manure. We travelled far and we went into my homeland. We got goat manure that is recommended as a better fertilizer. My mum and members of the community told me the goat manure is better.

Raeesa – Who assisted you?

Interviewee – My mother and community members and the group members got the seed from his homeland. We even checked textbooks for assistance but it did not have any information. This was a challenge. We generally make use of textbooks for all our assignments but with IKS there is no information. I don't know why textbooks leave out IKS because it is now part of the curriculum. But IKS was in the NCS curriculum and it is in the CAPS so I don't know why it is ignored. We also used the internet. But that was really time consuming, we did not really find what we were looking for. Then when we found some information we did not know how to put it in a lesson. Also the information was not for our level in the lesson. We felt overwhelmed with the information.

Raeesa – Insufficient teacher education; how did you address this?

Interviewee – Teacher education was not enough so we consulted our lecturer to enhance our understanding, she gave clarity. The lectures were not enough; it did not deal with the content of IKS which we need. The lecturer gave us guidance and assistance. We also had to learn on our own. We learnt from each other as a group. We shared our knowledge and understanding. The teacher education was enough because we need more content. The content must be taught to us and be discussed in class. Just observing other groups present a lesson on IKS is not enough learning. We did learn new ways of including IK in lessons but it is definitely not enough for me to teach it with confidence.

Raeesa – Who assisted you?

Interviewee – Community members, mother, lecturer and group members.

Raeesa –Other than these, were there any specific challenges you encountered?

Interviewee – Incorporating IKS information into the actual lesson itself was very challenging. When we got the information we did not know what to do with it. It was hard to put it in a lesson. We did not know what IK to include and how it fits with our lesson. We did not know how to include IK to achieve our outcomes in the lesson. Time was another

challenge. It took a lot of time to research the information. Planning the lesson also took a lot of time. There was also limited time to complete this assignment.

Raeesa – Teacher education had been highlighted as a particular challenge. How should this be addressed?

Interviewee –One module is not enough because we do not get sufficient knowledge and there is also limited time. Maybe if we had more modules including IKS then we will develop confidence. IKS should be included in all NS modules, in this way we will have exposure to IKS and also we will gain more content. IKS is not included in any textbooks or teacher guides so it is the university's responsibility to train us accordingly and also provide us with detailed content. I need to be taught about IKS, the content needs to be discussed during lectures and then planning a lesson will be easier. One method module is really not enough. In this method module we are learning to teach IKS, but how can we learn successfully if we don't know the content well. The IKS content should be discussed in all our NS modules e.g. NS 110, 120 and 210. Then learn how to teach it in the method module. I need to be more exposed to IKS. I need to be taught content on IKS before I am asked to plan a lesson. We can also have a separate IKS module in NS and this will help with the understanding. This module should include all the strategies that can be used to teach IKS.

Raeesa – Who should be at the forefront of providing teacher education?

Interviewee – The lecturer should provide the training because they are experienced in the knowledge. They will provide us with sufficient IK needed. Also the lecturer can have workshops and talks on IKS. This will help us expand on our knowledge of IKS. The lecturer can also invite community members to the lectures and we can learn first-hand practical knowledge from them. Then the lecturer can explain it and expand on it, and show us how it can be integrated with western science.

Raeesa – What kind of teacher education do you envisage or visualise? (Need)

Interviewee – I need to be taught more on IKS. One module is not enough. I need more content knowledge. We need to be provided with practical examples. The lecturer should teach us a lesson incorporating IKS and show us how to go about doing it. We can observe

the lecturer and then learn. When we observe we learn more. I can pick up strategies and styles on how to include IKS in science lessons.

Then the lecturer can give us a chance to plan and present our own lesson. We were like thrown in the deep end in this module because we did not have any idea how to include IKS in a lesson. The lecturer can also show us videos and this will because we will learn IKS content and how to include it in a lesson. When we know the content we can gain confidence and we can grow and expand on that knowledge.

Raeesa –How should the teacher education be provided?

Interviewee – The lecturer should teach us. IKS should be included in all NS modules. The lecturer should provide us with examples of lessons. Like they must do lessons in the lecture and we observe. The lecturer can bring in past students to present their lessons then we will have an idea. We have group presentations in this module but it is not enough because we don't know the content well. The lecturer should provide us with training but with that they should bring in outsiders and various examples. We can learn from others and build our knowledge. In our training we need to be taught and if we are taught then we will know what to do.

The reason why IKS is so challenging for me is because this is the first time I am coming across it at university. If never came up in any other NS module. Like we have to teach balancing equations in NS; we did it in NS 210 and we were taught t with worksheets and strategies, so I know how to teach it in schools. But IKS was not included in any content module and it is part of the curriculum and is a requirement. Only in this module is it included. There is so much space for IKS to be included in NS modules. If I can make an example, in NS 110 we did soil, so IKS can be integrated. We can talk about organic fertilizer and manure. But this is not done. If it is done like that then my planning will be less challenging. We need to be exposed to IKS in our content modules then we can integrate it in our future lessons.

We need to be taught content first, and then given an opportunity to plan and present our own lessons. We can also work in groups and share and learn from each other. A good form of teacher education is when IKS is included in all NS content modules and also as a separate IKS in science module. In this way we can learn and get more familiar with IKS, it will enhance our learning and make me more confident now and also in the future.

Raeesa – Are there any teaching methodologies (methods/ styles) that lecturers should be using to teach pre-service teachers that you think are useful?

Interviewee –The lecturers must teach us first. Methods can include workshops, talks, presentations and discussions. The lecturer can present lesson on IKS. We need to be provided with examples of lessons and lesson plans. Most importantly we need to be taught the content first then how it is included in a science lesson. We also need to be prepared with various strategies and getting more familiar with the CAPS. We need more exposure to IKS. The lecturer should provide the training and prepare us with IKS content and how to go about teaching it. We need to be exposed to different content where IKS can be included. We need ways and examples on how to go about achieving specific aim 3.

Raeesa – Can you suggest how this lack of teacher education (specifically content and how to teach it) influences your learning to teach IKS?

Interviewee – My learning will be challenging and I will not be confident with IKS. I will not even know where to start. If training is not enough then how can I learn successfully? There will be gaps in my learning. I will not be able to teach properly in the future. If there is a lack of training in the content then I will also perform poorly. For one to learn successfully adequate training needs to be provided and one method module is really not enough. If I am not trained properly and adequately I will not be able to achieve specific aim 3 in my lesson. IKS is really difficult.

Raeesa – How would you like to be trained to teach IKS?

Interviewee – Firstly IKS should be included in every NS module so that we become familiar and have exposure to it. If IKS is included in every module we can pick up different strategies and styles to teach IKS. When we are exposed to IKS we get more familiar with it and gain content and confidence teaching it or even doing an assignment on it. During lectures we need more notes, worksheets and case studies. We also need examples of lesson plans because the CAPS document is hard to use. The lecturer should organize workshops on campus or invite community members to talk or teach us. More training on how to conduct practicals involving IKS is needed.

We also need to observe the lecturer presenting a lesson and we can learn from her. The group presentation of an IKS lesson was helpful, I did learn a lot from other groups but I do still need more content. I need more notes around the actual IKS content rather than notes on

what is IK and its importance. I need to be taught western science together with IK in lectures so I know how to actually fit it in and what IK to fit in lessons.

When I have solid content then I can also learn on my own and improve and create my own lessons, building on that knowledge. We don't have to only learn from the lecturer, we can learn from workshops, seminars, presentations, and past year students, or group members.

Raeesa – In this module, whilst learning to teach IKS, explain to me how you were taught to include IKS in science teaching.

Interviewee – Basically we were never like taught. We did not learn any content. We just presented lessons in groups. You see, this is a method module so no content is really taught. But prior to this we never did any IKS content in any NS modules. So we were not taught the IKS content and exactly how to include it. That is why this experience was really challenging. We were given tasks and were told what is IK and its importance and its place in the NS curriculum. But we were not really taught. We had to plan a lesson including IKS and this was really hard. Some of us had IKS from our own personal experiences but we did not know how to actually include it in a lesson. We had to work and learn on our own.

Raeesa – Was it helpful? Was it helpful to learn in this way?

Interviewee – It was a bit, but I do need more help in IKS content. You see we did not even know a lot about IKS. This module made us aware of it and made me aware of its requirement in the school curriculum. I did learn from group presentations. I learnt how IKS can be integrated with some science topics. At this point of completing the module I still need more training in terms of content and how to actually include IKS in lessons. This module was really difficult and hard.

Raeesa – What methods or strategies would you prefer to help you learn better?

Interviewee – We should be given more content and actually be taught that content or discuss that content. We need to observe the lecturer teaching a lesson and we can learn from them how to incorporate IKS in lessons. I need to be exposed to IKS so I can get more familiar with the content. I need more activities and strategies/ worksheets/ notes on IKS. I want more examples like how IK can be included in western science. I want different western science topics and how IK can be included in that topic. Even some case studies that I can use in TP.

Raeesa – Your group and your reflections stated that IKS is valuable and important. Can you elaborate on this? Tell me a little bit more.

Interviewee – It is important because it is relevant and learners will understand science concepts. When learners understand then they will perform better. When science is relevant then learners will enjoy it and feel comfortable and included in the lesson. It is very good that it is included in the CAPS policy document because it can be used to build on new knowledge. But to teach using IK, one requires a lot of training, from the first module of NS.

Raeesa – Linking the home of the child and the science classroom was highlighted as important in your focus group interview. Can you tell me how this can benefit the learner?

Interviewee – Science is everywhere and we experience it all the time at home. It will definitely benefit the learner. Learners will move from familiar to the unfamiliar knowledge. By using IKS teachers can build on and use IKS to teach science concepts. It can benefit the learner because the prior knowledge is taken into account. IKS can be used as a foundation to build and expand on new knowledge in the science classroom. It will benefit the learner because lessons will be relevant and taught with reference to the learners. Learners will understand better and perform well.

Raeesa – Do you think teachers need to be sensitive to learners' culture (IKS) in the science classroom?

Interviewee – Yes. If teachers are aware and consider all learners in the classroom then all learners will be included and feel part of the class. Learners will be free to share and contribute to the lesson. This can result in better understanding and they will do well in science.

Raeesa – If you receive the relevant teacher education, resources and guidance to teach IKS in the science classroom, how successful do you think you will be in ensuring learners perform well in science?

Interviewee – I will be successful in teaching IKS because I will be trained well. If I am trained and I have resources and I can achieve specific aim 3 and teaching IKS will not be such a challenge. I will be confident. If I am trained well then I will teach well, with confidence and I can produce good results in science. Is I am given proper training and taught how to include IKS, then IKS will not be so challenging. If textbooks have information and if

textbooks include IKS then teaching will also be easy. Planning a lesson will be easy and less challenging. The university should provide us with an IKS teaching manual including notes, content and worksheets. Then we can use it to plan lesson when we teaching.

Raeesa – Do you think the inclusion of IKS in science education will improve the results of South African learners in science?

Interviewee – Yes, if I am trained well with IKS I will have the knowledge and I can use that knowledge to teach and then learners will understand and they will perform better. Relevant knowledge will be taught to learners, this will assist in learning new science concepts. It is familiar knowledge.

Raeesa – It was mentioned by many groups that an IKS resource centre should be established at the university. How would this influence your learning to teach culturally inclusive science (IKS)? What is your view?

Interviewee – It will be good. It will help me and improve my learning. I will learn and improve my learning. I will learn more and learning to teach IKS will be easier. I will have access to more resources and I can get guidance and assistance. This centre will include knowledge that I will make use of. My learning experience would be better and I will learn better with minimum challenges.

Raeesa – Ok. Thank you so much for allowing me to interview you.

G 6 – II – 16:30

Raeesa – Good afternoon I am sitting in with a member of group 6 and I am conducting an individual interview on their experiences of learning to teach culturally inclusive science.

Interviewee – Good afternoon.

Raeesa - Tell me more about your experiences of learning to teach culturally inclusive science.

Interviewee – My experience was really challenging and difficult. The knowledge that we were given on IKS was limited; but the work and assignment that were given was really hard. We had to plan a lesson including IKS in groups. We did not know how to make a lesson plan on IKS. We were confused on what IK to include and how to include it. There was limited information available. Google did not have much. Textbooks did not have any information on IK or any guide. My group members did not know anything. I did Biology so I came across IKS on one account, but very vaguely, so I had some idea. But still it was challenging. The module itself did not really help us, so this made it even more challenging. The module did not provide us with notes, case studies or worksheets to assist us planning a lesson, incorporating IKS.

The lecturer did not even teach a lesson on IKS to show us how to go about incorporating IKS. We had to learn in groups on our own and this was really hard. This is a method module, we were supposed to be taught how to teach IKS, but we were not taught. I did not really know how to apply IKS in a lesson. We need to be trained on how to implement IKS in lessons. Resources were challenging. Like I said earlier textbooks don't help us at all. When we go to Google we don't know what IK to use and how to use it. We don't know what aspect of IK to use for each grade. Generally textbooks stipulate this for us and we improvise along the way. But now textbooks don't even have any information or ideas for us to use in lessons.

Raeesa – In your focus group interview you mentioned that IKS is included in only one of your method modules and that it should be part of all your Natural Science modules as well. If you had more exposure, content and background knowledge on IKS, how would that impact on your learning to teach science lessons incorporating IKS?

Interviewee – It would be very good. It will have a positive impact on my learning because I will get familiar and exposed to it, so my learning experience will not be challenging. I will also gain confidence with the context. If IKS is included in NS 110, 120 and even 210 then I will learn better and we can pick up styles and strategies. We will learn how to include IK in lessons. We will also be exposed to examples by the lecturer and we can apply this in lessons on the future. The lecturer needs to show examples of how IKS can be integrated with western science and then we can use these examples in schools when doing our lessons. And also it will help in other modules because we know the content. We should do IK and western science content in NS 110, 120 and 210 and learn how to integrate the two or teach it in the method modules. In this way we would learn better and also have an understanding as to what we should do in planning a lesson incorporating IKS. I would learn better when IKS is included in all NS modules. This will assist me in successfully planning a lesson with minimum challenges. The IKS content to include in the lesson will be familiar to me and easier to identify. I would be more confident teaching IKS and I would develop better teaching styles and strategies.

Raeesa – Your focus group interview highlighted the following as challenges that you experienced; Lack of content/background knowledge, how did you address this?

Interviewee – We had to learn the content on our own. We had some personal experiences on IKS but we did not know how to use it in the lesson. We researched a lot, this was very hard. Whatever information we had we met and taught each group member. We shared our ideas and we planned the lesson. There is not a lot of information even in Google. We checked textbooks and there was no information or ideas on how we can include IK in lessons. Basically we did research. The visit to the botanical gardens also assisted me.

The rest of the group members had no idea and relied on me to teach them the content. I did not mind helping because I know that we were all helping each other. Without content knowledge it is really hard to plan a lesson. When one is trained well in the content then the teaching and planning of a lesson will not be difficult.

Raeesa – Who assisted you?

Interviewee – The internet and the visit to the botanical gardens. Then we worked as a group and shared ideas. Some of us had personal experiences of IK knowledge and we used it in our lesson.

Raeesa – Lack of resources; how did you address this?

Interviewee – We had to improvise, we did a demonstration. We had to demonstrate a permaculture garden using organic waste, branches and leaves. We had to prepare the soil without using any fertilizers or chemicals. We demonstrated it to the class. Textbooks also did not help so it was challenging for us. Generally we use textbooks to plan all our lessons, this time textbooks never help us.

Raeesa – Who assisted you?

Interviewee – The internet was a resource we used. We got information that we used and helped us develop our content knowledge on IKS.

Raeesa – Insufficient teacher education, how did you address this?

Interviewee – We had to train ourselves with the content. We were not taught the content in any modules. This was a great challenge for us. We were not taught on how to actually apply and integrate IKS. We researched and then got some information, and then we had to teach it to each other and share ideas. We had some personal experiences so this helped us to do the practical – the garden. We basically just researched and taught ourselves the content.

Raeesa – Who assisted you?

Interviewee – The internet, group members and our personal experiences.

Raeesa – Other than these, were there any specific challenges you encountered?

Interviewee – Yes. Firstly the CAPS document was hard to work with. The change in curriculum was also a challenge. We needed to adopt and learn another curriculum. You see we were trained 1st year with the NCS and planning a lesson in that way. Now we are learning the CAPS in 3rd and 4th year. This was really challenging. Secondly, teacher education did not provide us with enough content knowledge on IK, so searching for IKS information and teaching ourselves was hard. We did not even know whether the IK is suitable for a particular grade. Thirdly, limited time to do this lesson or plan this lesson. We rushed and did this lesson. Lastly, when we eventually got the information we did not know how to apply or incorporate this in an actual lesson. This experience of learning was really challenging. I think we should be taught the content first and then asked to plan a lesson. We need to be given more notes or a course pack to help us plan lessons. We need more

information on IK so that we can use it in a classroom. Exposure to IKS. You see IKS is a new topic and we are not given much exposure to allow us to confidently teach it. I think that teacher education is responsible for this. There should also be a separate module on IKS in science so this will also give us more assistance in learning about IKS. It can include IKS topics and how it fits with western science.

Raeesa – Teacher education has been expressed as a particular challenge. How should this be addressed, in your view?

Interviewee – We need to be taught about IKS. IKS content should be included in all NS modules. We need to be shown the links with western science. We cannot learn everything on our own, but if we were given like examples of lessons and notes to assist us that would help. The lecturer should invite community members and IKS experts to come in in and teach us some IKS. Then the lecturer can recap on it by telling us how it can fit in with western science. We should have workshops to provide us with guidance on IKS. We need notes and case studies to help us. The lecturer must teach us first and then we can present our own lessons as groups. I need to be prepared with the content. I cannot teach if I don't know the content. Training cannot be just one lesson presentation; it should be continuous in all NS modules.

Raeesa –Who should be at the forefront of providing teacher education?

Interviewee – The lecturer. We must be taught properly. At the moment I feel I need more training. The NS module is not enough. IKS should be part of all NS modules so we learn more about it. This module does not go very deep. We need styles and strategies on how to teach IK. We need presentations, pamphlets and more books to help us. This module did not provide us with enough. We need more assistance with the actual application of IK in a science lesson. The lecturer must have workshops and bring in community members and this will help us.

Raeesa – What kind of teacher education do you envisage (need)?

Interviewee – We should be taught IKS. The content of IKS is important and we should be taught it. The university should take an initiative to design an IKS curriculum so that lecturers should follow. One module is not enough to learn about IKS and how to teach it. If the SA

curriculum stipulates that IK should be taught, then training should begin at the university. The university should produce teachers who are well equipped to teach IKS.

Raeesa – How should the teacher training be provided? How would you prefer to learn?

Interviewee – The lecturer must show us how to plan a lesson. He/she must teach us step by step what to include as IK and how to include it in a lesson. We must be given lots of content and how we can include that content in a lesson. We must be taught to link the two IK and western science. We must be provided with activities and case studies. The lecturer must bring in videos and show us how to include IK. The lecturer must bring you Masters students to come and teach us a lesson and show us how to include IK in your teaching. We must be given a course resource pack and we can use this in schools. I did learn from other group presentations, but I would prefer that lecturer to teach and we learn from her. She must bring in a teacher from a school and he/she must teach and we can see how they teach including IK. The teacher must show us how to develop a practical to include IK in a lesson. I want to see how the lecturer does it then I can learn and may do a presentation thereafter. And we need to get more exposure to the policy document; it was hard to work with. The CAPS doc was hard and it is not clear. The change of curriculum was also a challenge, we had to adapt and learn another curriculum. First we were trained with NCS, now CAPS. It is all hard. Teacher education was also not enough, we were not provided with much on IK and how to teach it. We need more training. I need strategies and examples of lessons or maybe outside teachers presenting a good lesson. We can learn from this and plan our own lessons. We are still left with a challenge with what IK to include and how to actually include it in a lesson.

Raeesa – Are there any teaching methodologies that teacher trainers (lecturers) should be using to teach pre-service teachers, that you think are useful?

Interviewee – We must be given content and taught that content. Activities and case studies and lesson plans. We must be taught how to use policy document. Practical activities. We will use it in our future teaching. A short case study and some questions to answer.

Raeesa – Can you suggest how this lack of teacher education (specifically content and how to teach it) influences your learning to teach IKS?

Interviewee – Training is important. Without being trained in the content and how to teach IKS I will not know where to start and how to teach it. I will just ignore IKS, like it is being done in schools. I don't think teachers teach IKS, they don't use IKS because they have not been trained to teach it. So training is very important. The correct training is needed for us to successfully incorporate IKS in lessons. Once I am trained well then I can confidently teach it. Right now training was not enough. When you don't know about IKS, one is hesitant to teach it

Raeesa – How would like to be trained to teach IKS?

Interviewee – The lecturer must train us, but they can bring in outsiders and community members to assist us with our learning. For example, if we are doing anaerobic respiration then fermentation can come into the lesson. Like how people perform fermentation to prepare the African beer. We can make that same example in our own practice. IKS content must be included in every module so we become exposed to it and get familiar with it. More notes and worksheets should be provided to us about ways to include IK in lessons. We need to know what IK to include in a western science lesson. I need more training on the CAPS document; it is hard to change at this late stage.

Raeesa – In this module, whilst learning to teach IKS, explain to me how you were taught to include IKS in science teaching.

Interviewee – We were not taught. We were not shown how to teach it. We had to learn on our own. We were only shown the importance. We prefer to be shown how to teach it in a lesson. A method module must teach it to us. IK must be included in all NS modules, like this is an IK concept and how to include both IK and western science together.

Raeesa – Was it helpful?

Interviewee – No, not effective. But what was helpful was that I became aware of IKS. I came to know its importance and its place in the curriculum. It broadened my knowledge on what is IKS but it did not equip me with how to teach a lesson on it.

Raeesa – What methods or strategies would you prefer to help you learn better?

Interviewee – We must be given content and taught that content. Activities and case studies and lesson plans. We must be taught how to use policy document. Practical activities. We will use it in our future teaching. A short case study and some questions to answer.

Bring in past year students to present their lessons and we get an idea from them. We need to be taught all the different ways IKS can be included in a western science lessons.

Raeesa – Your group and your reflections stated that IKS is valuable and important. Can you elaborate on this? Tell me a little bit more.

Interviewee – Because IKS is knowledge that is relevant and experienced by learners. It is knowledge that learners relate to, they may experience it daily or on a one of occasion. This knowledge helps to understand science concepts and thus produce better results in science. Learners actively engage in lessons when IKS is incorporated in lessons. When you teach only from a western science perspective learners are lost and experience difficulty. When you teach using IKS learners can guide their own learning and perform and understand better.

Raeesa – Linking the home of the child and the science classroom was highlighted as important in your focus group interview. Can you tell me how this can benefit the learner?

Interviewee – It will be good for the learner. They will understand science better. They will feel free to share and ask questions. IKS can be a foundation for new knowledge to be taught.

Raeesa – Do you think teachers need to be sensitive to learners' culture (IKS) in the science classroom?

Interviewee – Yes they should be.

Raeesa – Why?

Interviewee – Learners will feel comfortable and recognised.

Raeesa – If you receive the relevant teacher education; resources; and guidance to teach IKS in the science classroom, how successful do you think you will be in ensuring learners perform well in science?

Interviewee – I will be very successful. When I am trained properly I will teach well and I can achieve specific aim 3. If I am trained well then teaching IKS will be easier and I will be confident. I will not be so hesitant to teach IKS. If I am trained well my lesson will not be a disaster. Training is very important for one to successfully teach IKS. It is a new topic and textbooks don't have any information so we rely on the university to provide the proper training.

Raeesa – Do you think the inclusion of IKS in science education will improve the results of South African learners in science?

Interviewee – Yes, it will definitely because it is relevant knowledge. It will assist in new learning. Tests and exams will include IKS so it will improve results. IKS is prior knowledge that is used to build on new science concepts.

Raeesa – It was mentioned by many groups that an IKS Resource Centre should be established at the university. How would this influence your learning to teach culturally inclusive science (IKS)?

Interviewee – It will be good, learning will be easier. I will have more resources. This will help me learn better. It would be easy and result in better learning.

Raeesa – Is there anything else you would like to share with me?

Interviewee – I definitely need more training on IKS. Right now the module is over and I don't feel prepared or equipped to successfully teach IKS. The group presentations were helpful but the lecturer needs to teach and expand on the lessons that were presented. We need to know more about how it links with western science.

Raeesa – Thank you so much.

APPENDIX 14

Exclamation Translations

To whom it may concern,

The dissertation entitled “Pre-service Teachers’ Experiences of Learning to Teach Culturally Inclusive Science” was thoroughly edited and proofread on 19 October 2013. I verify that it is ready for publication and/or public viewing as it is up to the expected standard.

Kind regards,

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