FACULTY OF EDUCATION

DEPARTMENT OF MATHEMATICS & SCIENCE EDUCATION

UNIVERSITY OF BOTSWANA STUDENT-TEACHERS' BELIEFS ABOUT THE NATURE, TEACHING AND LEARNING OF SCIENCE

BY

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DECLARATION

The work contained in this dissertation was completed by the author at the University of Botswana between 2016 and 2019. It is an original work except where due reference is made and neither has been nor will be submitted for the award of any other University.

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DEDICATION

In loving memory of my late brother, Pontsho Patrick.

To all student-teachers, teachers, educators, personnel and school children in the science education family. Most of all, to Ludo Jeriko, daughters, Tracy Jeriko and Aphiwe Jeriko, and son Adoh Jeriko.

God be with you all!

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LIST OF ABBREVIATIONS

ABi: Attitudes towards behavior

BASSSQ: Beliefs About Science and School Science Questionnaire

B.Ed.: Bachelor Degree of Education

BGCSE: Botswana General Certificate of Secondary Education

COLI: Conceptions Learning Inventory

D: Dynamic

DMSE: Department of Mathematics and Science Education

EBS: Epistemological Beliefs Scale

GPS: Global Positioning System

HO: Hands-on

IQ: Inquiry Quotient

JC: Junior Certificate

LAD: Learning as a duty

LAU: Learning as understanding

LIK: Learning as an increase in knowledge

LME: Learning as a means to an end

LPF: Learning as personal change

LPT: Learning as a process not bout in time and context

LRR: Learning as remembering and reproducing

LSC: Learning as developing social competency

LSD: Learning as seeing something differently

MBI: Mathematics Beliefs Instrument

NOS: Nature of Science

PCBi: Perceived behavioral control

PTBQ: Prospective Teacher's Beliefs Questionnaire

QUAL: Qualitative

QUAN: Quantitative

RLC: Real-Life Connections

RNCE: Report of the National Commission on Education

R-SPQ-2F: Revised two factor study process questionnaire

SD: Student-directed

SNi: Subjective norm

SP: Science Process

T: Traditional

TALIS: Teaching and Learning International Survey

TAPPI: Teachers Pedagogical Philosophical Interview

TATI: Teaching activities with technology integration

TATU: Teaching activities with technology use

TD: Teacher-directed

TP: Teaching Practicum

UB: University of Botswana

VASS: Views About Science Survey

VOSI-4: Views of Science Inquiry

ABSTRACT

This study intercepted science prospective teachers enrolled in teacher training undergraduate method course in the University of Botswana (UB) and examined the repertoire of their belief systems and instructional practices. A qualitative approach was followed and a descriptive cross sectional case study design was used. The focus of the study was to discern the espoused student-teachers' beliefs about 1) the nature of science, 2) teaching of science, 3) learning of science, and 4) to discern the relationship between student-teachers' beliefs and their choices of instructional practices.

A group of three (n=3) student-teachers were selected through convenience sampling from the University of Botswana, mathematics and Science Education Department in the faculty of Education. Qualitative sets of data were mainly captured by means of lesson observation (aided by video), personal statements of teaching/learning philosophy and post-observation interviews.

The study produced evidence consistent with literature. Findings revealed that even at an early stage of their teacher training, student-teachers possessed beliefs about science, teaching and learning. However, these beliefs were different for individuals and they were also mixed on aspects of NOS, and certain elements of teaching, and learning. Student-teachers tended to drift among the teacher-directed and student-directed instructional practices, which was in many respects associated with the nature of their inconsistent espoused beliefs.

CHAPTER 1: GENERAL INTRODUCTION

1.0 Study Overview

Teachers of the 21st century find themselves in an educational landscape in which attention to and demand for reforms aimed at improving the quality of science, teaching and learning are emphasized both locally and elsewhere. Not only are teachers battling with external factors in their classrooms, but they are also engaged in a continuous struggle with the decisions they make towards the instructional phenomenon (Handal, 2003; Liljedahl, 2008; Macugay & Bernardo, 2013; Richardson, 2003; Weldeana & Abraham, 2014). Institutions offering teacher education programs hold in high regard the need for training of teachers who can resolve the basic question of why, what and how to teach.

Needless to say, during one of the researcher's seat-ins in a method course, an interesting conversation between the lecturer and his students took place. What particularly caught my attention was the following dialogue;

Student$_1$: *What if you as the teacher don't know the answer?*

Lecturer: *Tell them the truth that you don't know.*

Students: *Ah! Aee! No! (Whole class mumbles inaudibly, obviously alarmed and in disagreement with the lecturer's suggestion)*

Student$_1$: *If you tell them you don't know, the student who knew the answer will underestimate (meaning undermine) you!*

Student$_2$: *Ba a go thoboga ba ba ithobalela. (They will give up on you and sleep during your lessons).*

Two issues of interest arose from this conversation. First, clearly the lecturer's argument was an attempt to advance contemporary pedagogical paradigm which have been the center of modernism in the last decades (Tabulawa, 1997; Tafa, 2012). Secondly, student-teachers' insistence on giving a teacher the conventional authority of knowledge is clear indication that there could be traces of positivism in Botswana's students. I became curious as to why student-teachers were adamant that a teacher should never disclose their own misunderstanding and/or lack of concept comprehension to their learners. Therefore, I set out to review literature on classroom practices and decisions made during instructional processes.

1.1 Introduction

Research on classroom practices has shown that instructional phenomenon or teaching and learning is a difficult and complex process (Kansanen, Tirri, Meri, Krokfors, Husu & Jyrhama, 2000). Teachers make choices, decisions, plans and actions towards instructional phenomenon which are for the most part influenced by attributes of a teacher such as training and experience (Savin & Lam, 2008), attitudes (Krapp & Prenzel, 2011; Osborne, Simon & Collins, 2003), beliefs (Fischler, 1994; Flores, 2015; Garegae, 2001; Johnson & Hall, 2007; Kansanen et al., 2000; Mohamed, 2006; Tafa, 2012) and many other factors.

In Botswana for example, it was traditionally believed that a good teacher is expected not only to show good command of content, but s/he should be able to effectively select, plan and teach or make content equally accessible and meaningful to all learners. This meant that a teacher as the authority figure was the 'guru' in matters of content and power relations favored him or her to make choices for students. In this tradition, a teacher would not be ready to disclose his or her limitations or lack of understanding mainly because it would damage the trust and respect learners had for him or her as a reputable authority figure. These cultural beliefs are transferred from generation to generation orally through socialization in the society as well as in schools.

This cultural perspective was somehow expected to have loosened its influence following recommendations for a paradigm shift and the emphasis placed on learner-centered pedagogies by the Education System of Botswana since the 1977 National Policy on Education and its revised version of 1994 (Republic of Botswana, 1993). Since then, the philosophy of education changed and the agenda of modernism was advanced through the curriculum of science at both junior and senior secondary levels. These advancements provided Botswana with comprehensive approaches to achieving universal science education (Tabulawa, 1997).

Science education has since been transformed to adopt such philosophies and literature highlights that science teachers are attempting to use authentic tasks through the hands-on approach (Doppelt, Mehalik, Schunn, Silk & Krysinski, 2008; Edelson, 1997; Gilbert, 2004; Lembardi, 2007), situating learning (Sherman, 2004) and draw from out-of-school experiences (Koosimile, 2004) in order to shift responsibility and power in the learning process to students. Whichever way science teachers go about the process of selecting and integrating their knowledge constructs for creating such equal opportunities (or not), is believed to entirely depend on subjective judgments. These judgments are based on and or justified by the teacher’s beliefs of what is appropriate over the other at that particular context (Handal, 2003; Ribeiro & Carrillo, 2011; Yesil-Dagli, Lake & Jones, 2010). Most research on teacher beliefs suggests that beliefs may be at the forefront of teachers’ work by serving as filters, frames, and guides for teacher practice including engagement in professional learning experiences, instructional planning and classroom interactions (Fives & Buchl, 2012; Gess-Newsome, 1999).

1.2 Statement of the Problem

Student-teachers' espoused beliefs about nature of science (NOS), teaching and learning have been extensively researched at international level for decades of years, for example; Australia (Hassan, 2011), USA (Akerson & Donnedly, 2008; Cakmakci, 2012; Moss et al., 2001; Savasci & Berlin, 2012), China (Chan, 2004; Tsai 2002), Ethiopia (Weldeana & Abraham, 2014), Trinidad and Tobago (Cain, 2012) and Lebanon (Faour, 2003; Halloun, 2001). Some of these studies have influenced a wave of reforms and paradigm shift in Botswana education system and science education in general.

Almost 40 years of emphasizing and advocating for practices underpinned by modernism in the classroom, it seems like there are still traces of traditional perspectives in student-teachers as seen in the excerpt above. Every year, a cohort of student-teachers enters the science education program at the University of Botswana, with beliefs about NOS, teaching and learning which they may be unaware of and may also be unknown to their lecturers. This could pose a challenge on how student-teachers approach learning to teach science as well as how they further build-on their philosophies of science, teaching and learning. This is worrisome and problematic because research has already shown that the ways in which pre-service teachers perceive NOS (Gesss-Newsome & Lederman, 1995; Lederman & Zeidler, 1987), their conception of what is teaching and learning (Hancock & Gallard, 2004; Levitt, 2002; Lumpe, Haney & Czerniak, 2000; Tsai, 2002), may play a role on how science student-teachers execute their instructional practices. If there is a dichotomy of cultural practices and traditions versus modernism in play, then there is a need to understand just how deeply engraved student-teachers' beliefs about NOS, teaching and learning of science are before they can even enter the classroom. Although similar studies are in abundance, this investigation is however necessary since findings from other studies may also not be applicable in the context of Botswana science education. It is likely that over the years, the development of student-teachers' pedagogical and NOS beliefs in Botswana may have been influenced by cultural dimensions (Youn, 2008) and situational constraints (Tafa, 2012) which are unique to Botswana only.

1.3 Purpose of the Study

This study set out to enquire about and examine the repertoire of University of Botswana undergraduate prospective science teachers' pedagogical and NOS beliefs in order to illuminate on their depth and also determine their influence on their choice of instructional practices. The objectives which were addressed are;

- To probe, detect and make sense of pre-service teachers' beliefs about the nature of science (NOS).
- To probe, detect and make sense of pre-service teachers' beliefs about teaching of science.
- To probe, detect and make sense of pre-service teachers' beliefs about learning of science.
- To draw an insight onto their teaching stances or perspectives, and how they stood to impact instructional practice.

1.4 Research Questions

The objectives of this study were guided by the following set of questions;

1. What are the espoused student-teachers' beliefs about the nature of science?
2. What are the espoused student-teachers' beliefs about teaching of science?
3. What are the espoused student-teachers' beliefs about learning of science?
4. How are the student-teachers' beliefs about the nature, teaching and learning of science associated with their instructional practices?

1.5 Significance of Study

It was hoped that the completion of this study will help to illuminate on educational beliefs about science, teaching and learning as held by pre-service teachers. These findings were anticipated to contribute and create opportunities for;

1. a more contextualized knowledge base on science teachers' beliefs,
2. providing teacher educators with baseline information on which they can induce and inform change or to challenge their students' belief system towards a more desirable and enhancing attitudes, and
3. raising novice teachers' awareness of their values, beliefs and how they think of and about science, its teaching and learning.

1.6 Limitations of Study

One of the limitations that faced the researcher was the problem of the study. The problem of student-teacher beliefs and classroom pedagogical practices chosen for investigation had multiple factors which can be influential. Although the researcher has chosen to look at how beliefs influence practice, other conditions were not controlled, which means that they might also have had an impact on the outcome or findings of the study.

An additional limitation to the study was personal bias. The challenge was that the study also relied on the researcher's personal background, history and constructions. Interpretation of data as well as data analysis of transcripts and videos was the sole responsibility of the researcher, which meant that the researcher's own prior understandings and philosophy were fundamental in the process of representing student-teachers' espoused beliefs about NOS, teaching and learning.

The researcher had no prior experience and skills in conducting research, more especially qualitative research. As a novel researcher, lack of skills and experience placed limitations on decisions like which methodology to use, how best to analyze data and how to deal with extensive amount of data generated by the study.

The researcher's choice to use convenience sampling technique and a subsequent small sample meant that the findings could not be generalized to a larger population. Working with small samples such as 3, presents a challenge of representation of the population.

Finally, other limitations were time and availability of resources. The researcher worked under the pressure of time; not enough time for interactive interviews with participants, deadlines for submission as well as the constraint of the researcher's academic tenure. Other than time, the researcher was not well financed to conduct a large scale or a longitudinal study. There were no funds to engage research assistants.

1.7 Delimitations of Study

The researcher narrowed the problem by devising a research purpose which focused the study on four aspect; NOS beliefs, teaching beliefs, learning beliefs and influence on classroom practice. Narrowing the problem was also attempted through the help of research questions which directed the actions and exploration of the researcher.

Qualitative research predisposes the research process to the risk of human bias. On the other hand, it is this subjectivity which is essential in qualitative research because it helps to draw out rich and in-depth perceptions of individual participants. The researcher attempted to minimize the influence of his philosophical stance by regularly discussing his thoughts with his supervisor. A personal journal was also kept to give a reflection of the researcher's position on the problem.

Although the researcher lacked experience and skills in conducting qualitative research, he constantly engaged the assistance of his supervisor and other expert researchers in the university. The researcher also consulted archived dissertations and journal articles to broaden his understanding of the bolts and nuts of conducting a qualitative study.

Although data from a convenience sample or small sample is not generalizable, the researcher triangulated data collection in order to collect adequate data which could provide in-depth insight into the problem investigated. The sample dealt with was actually experiencing the phenomenon, which means that they could provide relevant information needed. Instead of seeking to generalize findings, this study sought to generate rich descriptions and details from the information provided by participants to allow for transferability.

Working under the constraint of time led to selection of a small sample size of 3 participants. However, this did not limit the study in any way because the use of varied data collection instruments and methods yielded enormous amount of data. Searching for data went as far as looking at secondary data and this saved a lot of time and resources. Using a small sample also eliminated the need to engage research assistants, giving the researcher more contact and experience with the research process and the study.

1.8 Summary

Chapter 1 provided the introductory overview of the problem as well as guiding questions. The chapter ends with an illumination of possible factors which acted to limit the scope and quality of the study. Chapter 2 follows with an attempt of conceptualizing student-teachers' beliefs as used in the study, while Chapter 3 details the methodological approach of the study. The finding are discussed in Chapter 4, and finally the study's recommendations in Chapter 5.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

In this chapter, literature bearing some empirical evidence on teacher beliefs about the nature, teaching and learning of science was discussed. Nonetheless, the review of literature discussed different conceptions of belief and also addressed the extrapolation of beliefs about the nature of science, beliefs about learning and teaching, and the underlying implications that these beliefs may have on the teachers' instructional practice.

2.1 What are Beliefs?

There is no consensus on what a belief is, mainly because of the difficulty in distinguishing between beliefs, attitudes and knowledge (Kansanen et al., 2000; Richardson, 2003; Underwood, 2002).

For the purpose of this study, beliefs are conceptualized as a subjectively or socially held notion, preposition or understanding which does not require epistemic warrant or truth condition (Dunkin, 2002; Handal, 2003; Kansanen et al., 2000; Liljedal, 2008; Murrell & Foster, 2003; Osterholm, 2010; Polly et al., 2013; Ribeiro & Carrillo, 2011; Richardson, 2003; Underwood, 2002). Thus a belief conceptually differs from knowledge because it is tested against and must satisfy a "socially shared criteria" of truth (Liljedahl, 2008, p. 2). The distinction between features of beliefs and knowledge and how they are different from each other are summarised in Table 2.1 below.

Table 2.1

Differences between beliefs and knowledge based on literature (adopted from Savasci-Acikalin, 2009, p. 4).

Beliefs	**Knowledge**
Refer to suppositions, commitments, and ideologies	Refers to factual propositions and the understandings that inform skilful action
Do not require a truth condition	Must satisfy “truth condition”
Based on evaluation judgement	Based on objective fact
Cannot be evaluated	Can be evaluated or judged
Episodically-stored material influenced by personal experiences or cultural and institutional sources	Stored in semantic networks
Static	Often changes

2.2 Beliefs about Nature of Science

Amongst products of science is scientific knowledge, which is taught in school science as Biology, Physics and Chemistry. Scientists, science educators and science teachers have epistemological understandings resident in their minds concerning how scientific knowledge is generated, validated and used (Abd-El-Khalick, 2012; Adedoyin, 2011; Aldridge, Taylor & Chen, 1997; Cakmakci, 2012; Cogill, 2008; Kansanen et al., 2000). The epistemology of scientific knowledge is also commonly known as the nature of science and there is a consensus on at least seven (7) aspects of NOS (see, Abd-El-Khalick & Lederman, 2000; Akerson & Donnedly, 2008; Cakmakci, 2012).

While literature has consistently shown that indeed teachers posses some views on NOS, a majority of studies point towards naïve views (Abd-El-Khalick & Lederman, 2000; Aldridge et al., 1997; Khishfe & Lederman, 2006; Pomeroy, 1993) compared to those with contemporary interpretations of NOS (Cakmakci, 2012; Moss et al., 2001; Tsai, 2002). However, research has also evidenced that teachers' NOS views do not exactly polarize in one view or another (Akerson & Donnedly, 2008; Halloun, 2001; Songer & Linn, 1991). These variations in teachers' NOS views seem to support Henke and Hottecke (2014), who are of the opinion that science is constantly changing with time and as such, it is not surprising that literature should present varying teachers' beliefs about the nature of science. Their sentiments are reflected in the following excerpt;

> Students may hold a variety of possibly [*conflicting*] views about aspects of NOS depending on the context in which these aspects appear….It is therefore plausible for them to also think differently about NOS depending on the time frame in question. As NOS is far from being a fixed set of features independent of time and context, students' ideas about science cannot be expected to lack a diachronic dimension either (p. 329).

In a close review of literature dealing with nature of science, it is noted that there is no standardized classification or categorization of orientations towards NOS aspects. Some studies used two (2) categories (Aldridge et al., 1997; Cakmakci, 2012; Moss et al., 2001) while others used three (3) categories (Abd-El-Khalick & Lederman, 2000; Akerson & Donnedly, 2008; Halloun, 2001; Khishfe & Lederman, 2006; Songer & Linn, 1991; Tsai, 2002). Different labels were attached to these categories, for instance, naïve, inadequate, traditional, expert, incomplete, static and objectivist, all corresponding to the positivist philosophy of science. On another hand, categories labeled not naïve, informed, constructivist, post-modern, non-traditional, dynamic, complete and folk-view corresponded to the contemporary (constructivist) philosophy of science. In this study, two categories were used to characterize the orientation of student-teachers' beliefs about NOS aspects; traditional (T) for views aligned with the positivist philosophy of science and dynamic (D) for all views showing a transition towards the constructivist philosophy of science (see Table 2.2 below). While other studies used a third category (mixed, connectionist, process, adequate, developing, transition and dynamic) for intertwined views of NOS, the researcher chose to group together student-teachers with extreme constructivist views and those with mixed or intertwined views to form one category (dynamic) (Tsai, 2002).

Table 2.2

A framework for NOS categories and descriptors (adopted from Tsai, 2002, p. 776).

Category	Perspective and descriptors
Traditional	*Science provides correct answers, or science represents the truth. Scientific knowledge is discovered through 'the' scientific method or by following codified procedures.* ***Descriptors:*** accurate description; neutral or objective observations; objective interpretations; truths, 'the' scientific method; codified procedures; process of discovery; following scientific rules.
Dynamic	*Science is a way of knowing, and it is invented through scientists' agreed conventions and paradigms.* ***Descriptors*:** invented reality; imaginative acts; theory-laden observations; constructed through social negotiations.

This framework was used to guide data analysis and discussion of student-teachers' belief orientations on aspects of NOS and NOS generally.

2.3 Beliefs about Teaching

Many scholars have documented a broad variety of teacher beliefs about teaching. Nonetheless, all debates related to teaching beliefs culminate in perspectives or orientations opined by traditional and contemporary teaching theories (Ampadu, 2012; Boiadjieva, Tafrova-Grigorova, Hollenbeck & Kirova, 2009; Cain, 2012; Lim & Chai, 2008; Liu, 2011; Macugay & Bernardo, 2013; Peabody, 2011; Talanquer, Novodvorsky & Tomanek, 2010; Yesil-Dagli, Lake & Jones, 2010).

Although studies only focused on the exploration of teachers' beliefs about teaching science do not exist, beliefs consistent with constructivism dominated (Boiadjieva et al., 2009; Cain, 2002; Lim & Chai, 2008; Liu, 2011; Macugay & Bernardo, 2013; Peabody, 2011; Savasci & Berlin, 2012; Talanquer et al., 2010; Yesil-Dagli et al., 2010). Despite the dominance of constructivist orientated teacher beliefs, some findings revealed a gravitation towards the traditional or behaviorist philosophy (Ampadu, 2012; Peabody, 2011).

Constructivism is generally considered a sound theory to assist educators and teachers to explicate how to teach (Savasci & Berlin, 2012; Tsai, 2002). Although there are various tenants of constructivism and forms, this study only looked at constructivism as a broader philosophical stance of learning and teaching science. For the purpose of this study, the Constructivist teaching and learning continuum (see Savasci & Berlin, 2012) and Tsai's (2002) Framework of categorizing teachers' beliefs of teaching science, were modified and used for anchoring data analysis, presentation and discussion (see Table 2.3 below). Instead of looking at pedagogical beliefs of teachers against traditional and constructivist models, it was deemed relevant to group all constructivist continuum by Savasci and Berlin (2012) into 'dynamic', which would account for transitional, emerging, progressing and expert constructivism.

Table 2.3

Categories and descriptors for teachers' beliefs about teaching science.

Category	Descriptions
Traditional	*Science is best taught by transferring knowledge from teacher to students, maintaining a quiet, classroom, and following the curriculum and guidelines.* ***Descriptors*:** transferring of knowledge; giving firm answers; providing clear definition; giving accurate explanations; practicing tutorial problems; presenting the scientific truths or facts.
Dynamic	*Beliefs include a balance of traditional and constructivist beliefs about teaching and learning. Science is best taught by helping students construct knowledge.* ***Descriptors:*** helping students make interpretations; providing authentic experiences; interacting with students; encouraging discussion and cooperative learning; paying attentions to students' prior knowledge or misconceptions.

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2.4 Beliefs about Learning

Teachers hold perceptions about learning which underlie what they think learning is, what it entails, the roles specific to a learner and what is expected of a good learner (Chan, 2003; Siddiquee & Ikeda, 2013; Song & Koh, 2010; Tsai, 2002; Weldeana & Abraham, 2014).

One of the questions addressed by Song and Koh (2010) in their study was, what are teachers' beliefs about students' learning? Song and Koh (2010) found that a majority of participants aligned themselves with the notion that a learning process characterized by "dialogue for conceptual clarification, focus on student talk, [*and*] rich questioning for student thinking" (p. 5). These findings were consistent with other studies (Chan, 2003; Siddiquee & Ikeda, 2013; Weldeana & Abraham, 2014), exceptions of traditionally oriented beliefs where found by Tsai (2002) and more persistent in females (Chan, 2003). Most studies formulated unique dimensions to investigate teachers' beliefs about learning science, for example Chan's (2003) questionnaire described learning as an increase in knowledge (LIK), learning as remembering and reproducing (LRR), and so on.

However, this study adopted a Tsai's (2002) framework and categorized conceptions of learning into two, traditional and dynamic. The dynamic view was considered to holistically encompass both 'process' and 'constructivist' categories by Tsai (2002), see Table 2.4 below).

Table 2.4

Categories and descriptors for teachers' beliefs about learning science.

Category	Descriptions
Traditional	*Learning science is acquiring or 'reproducing' knowledge from credible sources.* ***Descriptors:*** transferring of knowledge; memorizing formula, definition, keywords and scientific facts; copying what teachers do; hard work on practicing tutorial problems; passive listening; finding the right answer; accurate calculation.
Dynamic	*Learning science is constructing personal understanding.* ***Descriptors:*** making interpretations; exploring or coping with authentic experiences; discussing with peers and teacher; relating to prior knowledge or (personal or daily) experiences.

2.5 Science Classroom Practices

Most studies on teacher beliefs have given attention to the relationship between beliefs and classroom practices in science education (Aldridge, Taylor & Chen, 1997; Anderson & Holt-Reynolds, 1995; Czerniak, Lumpe, Haney & Beck, 1999; Khader, 2012; Janesick, 1982; Pajares, 1992; Ribeiro & Carrillo, 2011; Saad & Boujaoude, 2012; Savasci-Acikalin, 2009; Song & Koh, 2010; Waters-Adams, 2006; Wilkins & Brand, 2004).

Studies examining links between teachers' beliefs and instructional practices in revealed that there is no significant correlation between teacher's pedagogical beliefs and their actual classroom practices (Khader, 2012; Saad & Boujaoude, 2012; Waters-

Adams, 2006). Although similar beliefs about science and science teaching may or can be linked with different forms of practices (Polly et al., 2013; Savasci & Berlin, 2012; Tsai, 2002), it is apparently not always safe to generalize that a teacher's beliefs translate into their pedagogical practices. Although it is not clear why, Pajares (1992) offered an explanation that an individual may possess peripheral and central beliefs about an object, one remaining tacit while the other is espoused in practice. And hence resulting in the observed anomaly between espoused beliefs and classroom practices.

In this study, two categories were used to guide data collection, analysis, presentation and discussion; 'teacher-directed' and 'student-directed' approaches (see Table 2.5 below). Descriptors were derived from the Constructivist teaching and learning continuum (Savasci & Berlin, 2012).

Table 2.5

Categories and descriptors for teachers' instructional practices in science.

Category	**Descriptors**
Teacher-directed (TD)	Activities are based on low-level questioning, teacher control, lectures, worksheets, textbooks, and quizzes and tests
Student-directed (SD)	providing an environment for students to use prior knowledge and experiences to construct meaning, high-level questioning, student engagement and involvement through relevant and meaningful problems to understand the nature of science, student inquiry, group work and discussions, hands-on activities, and the use of alternative and authentic assessments

A reflexive or reciprocal link was envisioned to exist between teachers' pedagogical beliefs and classroom instructional practices (Ashton & Gregoire-Gill, 2003).

Two approaches also prevalent in literature, suggesting that teachers' instructional practice can either take a teacher-directed approach (TD) or student-directed approach (SD).

2.6 Summary

This chapter outlined a thorough literature review on aspects of teacher beliefs. The construct 'belief' was conceptualised to the context of this study. The literature reviewed showed some consistencies on certain aspects of student-teacher beliefs, while other studies also showed some inconsistencies. Chapter 2 attempted to build a conceptual understating of the problem of science student-teachers' beliefs as well as develop a point of reference for the collection and analysis of data.

CHAPTER 3: METHODOLOGY

3.0 Introduction

This chapter outlines overall methodological approach used to help in discerning student-teachers' beliefs. Procedures of sampling, data collection, data analysis as well as details on how the study ensured quality of findings are also elaborated. These procedures were intended to help in gathering and processing evidence for the study.

3.1 Philosophical Assumptions

This study was underpinned by Pablo Picasso's quotation which read, "if there were only one truth, you couldn't paint a hundred canvases on the same theme" (Zhang and Wildemuth, 2009, p. 1). Picasso's words resonate well with Edmund's philosophy.

Edmund's philosophy of phenomenology describes the pluralistic nature of reality, its subjectivity or how it is dependent on an individual's mind (Chilisa & Preece, 2005; Patton, 1990). Reality is denoted a human construct, such that when people are presented with same situation (Picasso's theme), they will perceive it in different ways. This is because humans utilize their minds or engage in thought processes to describe and understand these situations (Denzin & Lincoln, 1994; Ellen, 1984; Guba, 1981; Lincoln & Guba, 1985; Patton, 1990), which draws from their unique experiences and conceptions of those experiences. However, these realities can also be a result of social constructions, where a group of people bound by time, space and context can have a 'consensus' on the nature of reality. A social phenomenon, will therefore, evoke multiple interpretations as there are many people (Lincoln & Guba, 1985).

Hence, individuals experiencing teaching or learning are considered to be involved in the process of constructing their own realities about science, teaching or learning. In Picasso's words, they are painting hundred canvases of the same experience. Pre-service teachers will experience science, teaching and learning in their own peculiar ways and make sense of it in their own conscious, differently from others (Alexandersson, 1994).

This study was therefore, interested in these multiple conscious (or canvases) which are held by prospective teachers about teaching or learning experiences and what is being taught. And because the study was interested in their constructs, which lie within their actions and minds or experiences, the researcher adopted methods which cultivated contact with the owners of those independent realities.

3.2 Research Method

A qualitative research method was used primarily because student-teachers' beliefs are cognitive constructs which reside in human actions and experiences. Therefore, a qualitative approach was best suited for this study because it enshrined strategies and techniques which served a better job of exploring, identifying and describing student-teachers' beliefs and experiences (Cameron, 2011; Creswell, 2003; Johnson & Onwuegbuzie, 2004; Johnson, Onwuegbuzie & Turner, 2007; Leech & Onwuegbuzie, 2006; Mayoh & Onwuegbuzie, 2013). Furthermore, qualitative techniques are known for providing in-depth investigation compared to quantitative techniques (Ivankova et al., 2006; Johnson & Onwuegbuzie, 2004; Leech & Onwuegbuzie, 2006; Patton, 1988).

3.3 Study Design

A cross-sectional case study design was used in the assessment and description of student-teachers' beliefs makeup about the nature of science, teaching of science, and learning of science. A cross sectional study design intercepts an ongoing phenomenon at one point (Lincoln & Guba, 1985), in this case, to interrogate student-teachers' beliefs and instructional practices at that specific time and stage in their teacher training program. A case study design was chosen entirely based on its flexibility to lay “claim [to] any particular methods for data collection or data analysis” (Merriam, 2009, p. 42) as well as studying a small unit of student-teachers in-depth.

A case study design has potential for in-depth and holist understanding and depiction of student-teachers’ beliefs (Creswell, 1998; Lincoln & Guba, 1985; Merriam, 2009; Moustakas, 1990). The descriptive nature of the study was aimed at detailing the picture of student-teachers’ belief systems at the point when they were involved in microteaching during their teacher training experiences.

3.4 Setting

The study comprised of University of Botswana student-teachers enrolled in a four-year Bachelor of Education in Science, with specialization in either Chemistry, Biology and or Physics. Trainees admitted into a four years Bachelors degree of education (B.Ed. science) program to train as secondary school science teachers, do so under two faculties; faculty of Science and faculty Education. B.Ed. science is a program coordinated by the Department of Mathematics and Science Education (DMSE) in the faculty of Education. Science student-teachers are all first introduced into methods courses (education related) in their second year of study (year 2) up until they complete the program at the fourth year. Consequently, the population of the study excluded 1st year student-teachers and was only limited to those in their 2nd, 3rd and 4th year of studies. Methods courses cover aspects of teacher training such as theories of learning, teaching practices, history and philosophy of education, education psychology, history and nature of science, contemporary issues in science education and so many other courses which are directed towards the development of good pedagogical skills, competencies and attitudes in teacher trainees.

In the second semesters of both year 2, 3 and 4, student-teachers engage in a practicum course which involves microteaching exercises, where they ‘teach’ assigned topics with their peers acting as students. On long winter vacation, between May and July, cohorts of year 2 and 3 are usually immersed in Teaching Practicum (TP), where they experience first-hand teaching in a real school context. TP usually lasts for about seven (7) weeks, and the student-teachers undertake teaching in real school settings with the help of mentors and supervisors.

3.5 Sampling

A non-probabilistic convenience sampling technique was used to select three participants (n=3) Amo, Boiki and Katlo. Convenience sampling allowed the researcher to choose these participants because they were part of a population of student-teachers submerged in teacher training experiences and hence the most can be learned from them (Creswell, 1998; Lincoln & Guba, 1985; Patton, 1990; Patton, 1988). One other reason was the that the participants were conveniently accessible and in good rapport with the researcher (Alexandersson, 1994; Chilisa & Preece, 2005; Creswell, 1998; Guba & Lincoln, 1988; Lincoln & Guba, 1985; Patton, 1988; Morse, 1998).

The study sought out participants for their obvious relevance to the research purpose (Merriam, 2009) in order to “achieve richer, more profound, and more varied meanings” (Moustakas, 1990, p. 47). Although 3 is arguably a small number, the researcher decided to work with such as small sample for three reasons. First, a case study design naturally deals with small units or cases. Which means that coosing a sample of 3 participants was within the parameters of the design (Yin, 2009). Second, the researcher anticipated enormous amounts of data from triangulated sources. Data collections methods used such as interviews, yield enormous amount of data. Being a novice researcher, lacking research experience, dictated that the amount of data be reasonable so that while the researcher is learning to process data, he also had manageable data to work with and learn from. Third, sampling was data driven leading "the investigator to…the next person" (Merriam, 2009, p. 80). Simply put, the researcher decided on the participants after reviewing their microteaching portfolios and noticed that their thoughts were somehow divergent or extreme from the rest of those who consented for the study-calling for further exploration. These participants were selected because they met and satisfied the following criteria;

i. Participant was a University of Botswana student-teacher
ii. Student-teachers who were enrolled for science method courses.
iii. Student-teachers who were willing to participate
iv. Student-teachers who have signed consent form
v. Student-teachers who have participated in microteaching
vi. Student-teachers who have copies of their microteaching portfolio and video.

Boiki was a 21 year old young man. He hailed from a small village near Sebina in the Central district of Botswana. He has completed his high school (form 5) in 2007 and was admitted to study for B.Ed. (science). Boiki is the third son after two elderly brothers and a sister. He has only one younger sister. In Boiki's family, all the children have gone to various tertiary institutions, and so higher education is something valued by the family. At the time of the study, he was a second year student-teacher in UB studying for B.Ed. (science), for Biology teaching.

Katlo was a single mother in her late 20s. She stayed with her daughter off campus and her boyfriend, which meant she had to commute everyday from her house to the university. Unlike Boiki and Amo, she has had a bumpy road with her academic life, retaking several courses in her first year and eventually failing to satisfy the academic requirements for progression to the next semester. After her discontinued study, she returned to the university a determined mother and student-teacher.

Amo on the other hand, was an outspoken young lady from a village due north of Molepolole. She stayed in the university hostels, but at home, she came from a family which still upheld the extended family traditions. She lived with her mother, one brother and a sister, and about eight cousins and their parents. Her father was deceased. However, she remembered very a little of him because he died while she was young. Living in the extended family has somehow masked her loss and she admits that her relatives, more especially her uncles, are more of her fathers.

3.6 Ethical Considerations

Stake (1998) reminds researchers that they "are guests in the private spaces of …[*participants*]. [*Therefore*] their manners should be good and their code of ethics [*should be*] strict" (p. 103). In its nature, this inquiry was interested in personally lived experiences and beliefs. intrusion into the student-teachers' life, routines, or privacy was inevitable. Therefore, to reconcile the tension that arose between the researcher's interests and participants' rights in the duration of this intrusion (Davison, 2002; Orb, Eisenhauer & Wynaden, 2001; Scales, 2012; Stake, 1998), the student-teachers were informed of their right to stop participation at any time.

To avoid causing harm and embarrassment to informants, a thorough discussion of ethical issues of privacy, harmfulness or benefits or reward for participation, permission, anonymity, confidentiality, voluntary participation and others, were of concern and they were upheld in respect of participants and everyone who was directly or indirectly affected by this study (Ellen, 1984; Stake, 1998). .

Firstly, permission was sought from the University of Botswana DMSE lecturers who were the ‘foster parents’ to student-teachers in their respective Methods courses in DMSE. Lecturers assisted in gaining access to the site and abating any conflict which might have resulted from the researchers’ intrusion into the site (Orb et al., 2001; Scales, 2012). In accordance with Creswell (1998) and Ellen (1984), lecturers were acting as ‘gatekeepers’, which implies that because of their familiarity with the student-teachers in their courses, they were better mediators of the interaction between the researcher and participants. However, the ‘gatekeepers’ role was to ease the researcher’s entrance into the site, thereafter, the assistance of gatekeepers was minimised in order to increase personal contact and create conducive working relationship with the participants.

Student-teachers, as sources of data, were not coaxed into participating in or submitting their documents for the study. Ellen (1984) puts emphasis on this by stating that we should be aware of “the rights of citizens….not to be studied” (p. 138). Thus, their consent was obtained and each student-teacher showed his or her will to participate by signing the consent form (see Appendix B). Prior to signing the consent form, the study was fully explained to the participants and they were always constantly reminded of their right to withdraw from participation whenever they felt threatened, uncomfortable or for whatever reason (Davison, 2002; Orb et al., 2001; Scales, 2012).

The confidentiality and privacy of participants was assured at all times. For instance, pseudo-names were used for the protection of participants’ identities and prevention of exposure. Secondly, their documents and transcribed interview data or any notes from the field, were kept at the researcher’s place in a safe under lock and key.

Any material in the researcher's computer that could be linked to the participant was also protected by a password known only to him (Ellen, 1984).

The researcher always thrived to represent the participants truthfully at all times. Their views were not altered in anyway, instead, the participants were asked to confirm the transcribed data as true representation of their responses and they were also allowed a chance to change or accept the data before it can be utilised for the research study. Since this research study was aimed at fulfilling requirements for academic studies, the study may not be available for publication and hence the participants were promised a copy of the abstract in order to have a feel of how their perceptions have been reported. Ellen (1984) also agrees with this notion, cautioning that the informants need "to be informed about the methods and aims of the study…. [and] to be given feedback on the results" (p. 138).

To sustain the rapport and relationship established during the study, the researcher continued to work with participants, offering assistance to their academic challenges as a token of appreciation for their participation. However, this was only offered after the study, or data collection to avoid indirect coercion or influence to participate (Ellen, 1984; Orb et al., 2001). Student-teachers were not, at any time, made to feel that they had to participate in the study as a favour or obligation to the researcher. Maybe it is also worth acknowledging that it was possible that the multiple roles of the researcher might have influenced student-teachers' willingness to participate. For instance, his role as a laboratory Demonstrator and as a microteaching assessor or supervisor, might have indirectly influenced participation in the study (see Appendix C for the researcher's personal reflection).

3.7 Data Collection

Triangulated data sources were used to extensively trace and gain in-depth understandings of patterns of student-teachers' beliefs and how they relate to their enshrined instructional practices. Four qualitative data sources were solicited in this study and they were;

a) Personal statements of science teaching/learning philosophies

Student-teachers were required by the course instructor or lecturer to compile a microteaching portfolio detailing their experiences. The participants' portfolio contained several documents which basically reflected their journey during the course of their microteaching exercise. One such document was an essay on their stances or how they thought science is best taught and learned. This document was supposed to elaborate on their personal opinions about teaching and learning, with supporting reasons. To make these views/opinions more personal, student-teachers were advised by their instructor not to consult any literature. This essay was not developed for this study, however, the researcher choose it as a source of student-teachers' conception of teaching and learning (Merriam, 2009; Weitzman, 2000). The essays were what Glaser and Strauss (1967) in Merriam (2009), described as "voices begging to be heard" (p. 150).

b) Lesson observations

During the course of microteaching, student-teachers' lessons were captured on video tape. The lessons were recorded so that student-teachers could later watch their videos and reflect on their teaching and self evaluate. These were the same lessons in which the researcher participated as an assessor for the purposes of grading and giving feedback to student-teachers. Hence this limited the researcher's ability to make observations inclined towards the study during the lessons. Participants' videos were collected and watched in order to discern instructional practices which were enacted in the lessons. It was the observation of these video recorded lesson that provided data on whether student-teachers' instructional practices were student-directed or teacher-directed.

Although these materials held so much relevance to the study, the researcher was aware of the possible limitations which may be inherent to documents as a source of data, for example, Merriam (2009) feared that;

- Missing texts may result in misrepresentation or lack of continuity of unfolding events, for instance, the videos were edited by the technician.
- Information may be produced in a format which is not directly useful because it was not intended for the research in question,
- Personal documents (personal statements of philosophies) may contain embedded biases due to purposeful or non-purposeful deception, in this case, student-teachers deceiving supervisors during microteaching and writing.

c) Interviews.

The researcher was compelled to engage in 'talk' with student-teachers in order to gain access to their beliefs and also get them to speak openly using an interview schedule developed by adapting a set of questions from literature (Aldridge et al., 1997; Lederman et al., 2002; Halloun, 2001; Polly et al., 2013; Tatto et al., 2008; Trigwell & Prosser, 2004). There were four components, viz. (a) Demographics, (b) Beliefs about NOS, (c) Beliefs about Teaching, and (d) Beliefs about learning. Parts B consisted of 5 modified questions aimed at soliciting talk about NOS aspects and they were adapted from Views of the Nature of Science Questionnaire Form C (VNOS-C which was developed by Lederman et al. (2002). For example, (*After scientists have developed theories, do you think they do not ever change or they can change? Defend your answer.)* Possible responses could reveal participants' conception of the tentative nature of scientific theories and their justifications can also reveal influences on this tentativeness, such as subjectivity, creativity, sociocultural dependence on people doing science. In part B and C assessed for student-teachers' pedagogical assumptions about learning and or teaching respectively. For example, (3) questions in C like '*What role (responsibilities) do students have to play when learning of science?*' sought out views on student participation, students' prior knowledge in learning science. Part C had five (5) questions like '*How would you describe outstanding teaching of science?'.* Such a question assessed participants' views on strategies.

Before the interview schedule was used, the researcher was established content validity through the help of two Masters degree students, one Doctorate candidate and an expert researcher (lecturer). This team examined questions constructed, their clarity, relevance, suitability for exploring student-teachers' beliefs. Based on this team's recommendation, the wording of some questions was altered, and some questions were removed (Foddy, 1993).

During the 30 minutes long interviews, questions were posed in response to the interviewee's own answers and observed behaviour patterns in their videos (Turner, 2010). One of the major goals of the interviews was to validate and extend the findings obtained from the analysis of participants' beliefs and orientations from their philosophy statements and their instructional practices observed from their videos (Talanquer, Novodvorsky & Tomanek, 2010).

3.8 Assuring Quality and Rigor of Study

A qualitative study can be made objective by increasing rigor of processes, reducing biases and effects of the researcher's subjectivity during design selection, sampling, data collection and analysis (Shenton, 2004) . For instance, during data collection by means of an interview, "we cannot be sure that a case telling its own story will tell all or tell [it] well" (Stake, 1998, p. 93). Hence it rested on the researcher to determine ways of enhancing the criteria for extracting and representing the case's story.

3.8.1 Triangulation

The underlying principle of this case study's sample was based on selecting only participants who were submerged in the phenomenon, this way data were considered credible because it truthfully reflected the phenomenon in its naturalistic context (Firestone & Dawson, 1988; Krefting, 1991; Long & Johnson, 2000; Patton, 1990). Therefore, data were collected from a variety of triangulated sources, e.g., interviews, video recorded lessons and participants' document on personal philosophies.

3.8.2 Reducing participants' reactivity

During the interview sessions, the researcher varied the way questions were asked for three reasons; to reveal any ploy to lie (Shenton, 2004) or reduce reactivity effect (Lincoln & Guba, 1985) and to increase credibility (Krefting, 1991). Credibility was enhanced further by repeating questions, reframing questions and expanding on questions in order to solicit in-depth self-assertions and avoid eluding or confusing the participant as to the aim of the question. While phrasing interview questions so that they do not confuse participants; rather they must elicit more talk (Guba, 1981), the researcher battled with eliciting authentic responses from participants. However, other data sources (documents and video recorded lessons) had minimal or no reactivity effect because the data were not initially generated for this study and yet they were relevant.

3.8.3 Member checks

Participants were always asked to confirm whether their responses have been captured truthfully or represent their views. This was done after every question, at the end of the interview session, and as well as after the transcription of captured data. The objective of this member checks was to give both the researcher and participant a chance to revisit their conversations and reconstruct it if need be until the participant was happy that they have been accurately represented. The researcher also used those moments to eliminate reactivity effect and to detect and redress any contradictions. This was also an ethical issue which guarded against misrepresentation of participants (Creswell, 1998; Janesick, 1998; Krefting, 1991; Lincoln & Guba, 1985; Long & Johnson, 2000; Morse, 1998; Patton, 1990; Shenton, 2004).

3.8.4 Authenticating documents

Components of student-teachers' portfolio which they willingly submitted for use as data sources in the study were looked into and authenticated (Merriam, 2009). Particular attention was paid to the circumstances under which the materials (in this case; the statement of teaching philosophy and video) were produced and the purpose for which they were produced. This helped the researcher to reflect reasonably on the state of data. For example, the video tapes contained recorded lessons which were made for student-teachers' own reflection. Therefore, the participants were supposedly comfortable compared to when they knew the video was going to be scrutinised by a third party. The instructor or lecturer also made it known that the statement of teaching/learning philosophy was not going to be marked or graded because it was their personal beliefs or opinions about teaching and learning. This authenticated their statements because there was no fear of not conforming to the right or correct answer. Student-teachers wrote openly how they thought science should be best taught and learnt.

3.8.5 Researcher's roles

The multiple roles the researcher assumed before and during this study could also have some considerable effect on the credibility and general trustworthiness of data or the study. The researcher was also an instrument of data collection, data analysis and hence personal reflections are also crucial in authenticating this study (see Appendix C).

A qualitative study deliberately dictated that the researcher be conscious and cautious of how vigour and rigor were ensured throughout the course of the study, without infringing on the rights of participants.

3.9 Data Analysis

Data were drawn from student-teachers (n=3) through semi-structured interviews, personal statements of teaching/learning philosophies and observation of video recorded lessons. These large volumes of data were reduced to small manageable units for data analysis (Hutch, 2002). Interview data and personal statements of teaching/learning philosophies data were analyzed using the constant comparison approach (Strauss, 1987; Strauss & Corbin, 1998), while video recorded lessons were analyzed using content analysis (Firestone & Dawson, 1988).

3.9.1 Interview data and document data

Firstly, audio recorded interviews were listened to several times and transcribed into text. Transcripts were carefully read and compared to their corresponding audios. Secondly, each transcript and document of personal statements of teaching/learning philosophy were read several times to gain sense of what is expressed. Student-teachers' interview responses to Part B (about NOS) were examined and 'incidents' identified were coded using an adopted coding scheme from Lederman et al. (2002), see Table 3.1 below.

Table 3.1

NOS aspects and descriptions that serve as a basis for evaluation of responses (adapted from Lederman et al., 2000).

Aspect	Description
Tentativeness	*Scientific knowledge is subject to change with new observations and with the reinterpretations of existing observations. All other aspects of NOS provide rationale for the tentativeness of scientific knowledge.*
Empirical basis	*Scientific knowledge is based on and/or derived from observations of the natural world.*
Subjectivity	*Science is influenced and driven by the presently accepted scientific theories and laws. The development of questions, investigations, and interpretations of data are filtered through the lens of current theory. This is an unavoidable subjectivity that allows science to progress and remain consistent, yet also contributes to change in science when previous evidence is examined from the perspective of new knowledge. Personal subjectivity is also unavoidable. Personal values, agendas, and prior experiences.*
Creativity	*Scientific knowledge is created from human imaginations and logical reasoning. This creation is based on observations and inferences of the natural world.*
Social/cultural embeddedness	*Science is a human endeavor and, as such, is influenced by the society and culture in which it is practiced. The values and expectations of the culture determine what and how science is conducted, interpreted, and accepted.*
Observations and Inferences	*Science is based on both observations and inferences. Observations are gathered through human senses or extensions of those senses. Inferences are interpretations of those observations. Perspectives of current science and the scientist guide both observations and inferences. Multiple perspectives contribute to valid multiple interpretations of observations.*
Theories and Laws	*Theories and laws are different kinds of scientific knowledge. Laws describe relationships, observed or perceived, of phenomena in nature. Theories are inferred explanations for natural phenomena and mechanisms for relationships among natural phenomena. Hypotheses in science may lead to either theories or laws with the accumulation of substantial supporting evidence and acceptance in the scientific community. Theories and laws do not progress into one and another, in the hierarchical sense, for they are distinctly and functionally different types of knowledge.*

Categories of responses were identified and tabulated as either ‘Traditional’ or ‘Dynamic’ views of NOS. See Table 2.2 for a framework used for this study. Student-teachers’ views about NOS were then interpreted to address the first research question.

Secondly, data from statements of teaching/learning philosophy document were separated into two groups, learning and teaching. These two groups were subsequently coupled with Part C (*learning*) and Part D (*teaching*) respectively from the interview, to profile student-teachers’ beliefs about teaching. Data in each group was coded and categorized as ‘traditional’ or ‘dynamic’. For example, the ‘traditional’ category perceives learning and teaching science within the philosophy of behaviorism. On the other hand, ‘dynamic’ category perceives learning and teaching science within the broader philosophy of constructivism. A framework (see Table 2.3 and 2.4) describing these two categories was modified by connecting and clustering descriptors and categories from separate works of Savasci and Berlin (2012) and Tsai (2002).

3.9.2 Video recorded lesson data

Video recorded lessons were watched several times, with regular pauses, re-windings and replays. A thorough observation of these lessons identified incidents of behaviors, activities, voices and interactions taking place in the classroom. These were then categorized as ‘student-directed’ (SD) when the student is active and responsible for learning or ‘teacher-directed’ (TD) when the teacher has is responsible for controlling what is learnt and how it is learnt (see Table 2.5). The frequency with which a particular category occurred was computed (Lincoln & Guba, 1985) and this was interpreted as the student-teachers’ enacted instructional practices. Student-teachers’ beliefs about learning and teaching were compared to their classroom practices in order to offer an understanding of relationship between beliefs and instructional practices, hence addressing research question 4.

Student-teachers' beliefs about NOS, learning of science, the teaching of science and the relationship between their beliefs and instructional practices were also analysed for individuals and between individuals. Quotes, actions and voices from data were used as evidence to support the discussion.

3.10 Summary

Chapter 3 presented the philosophy underpinning the investigation as well as the methodological framework guiding the research. Research design, sampling techniques, data collection methods and tools, data analysis and ethical guidelines were comprehensively described. The next chapter presents findings as they emerge from analysis of data.

CHAPTER 4: RESULTS AND DISCUSSION

4.0 Introduction

A deliberate move to triangulate data presentation and discussion was assumed. This way, 3 participants' actions, opinions, thoughts, feelings, and perspectives about how learning and teaching in science classrooms were reported and discussed in one chapter. Findings were presented and reported according to the research questions they address.

4.1 Research Question 1

What are the espoused student-teachers' beliefs about the nature of science?

Student-teachers' views on aspects of NOS could be inferred from their assertions. Boiki and Katlo held inconsistent beliefs on aspects of nature of science, while Amo was consistently oriented towards the traditional perspective in most of her responses. Table 4.1 shows individual student-teachers' expressed views categorized as either traditional or dynamic, by using (x) to indicate the presence of a view and a dash (-) to represent absence. By comparing each participants' traditional views and dynamic views, student-teachers' general belief orientation towards NOS was represented.

Table 4.1

Student-teachers' views on aspects of NOS.

NOS Aspects	Katlo		Amo		Boiki	
	Traditional	Dynamic	Traditional	Dynamic	Traditional	Dynamic
Tentative NOS	-	x	x	-	x	-
Empirical NOS	x	-	-	x	x	-
Theories and laws	x	-	x	-	x	-
Observations versus inferences	x	-	x	-	x	-
Subjective (theory laden)	-	x	x	-	x	-
Creative and imaginative NOS	-	x	x	-	-	x
Social and cultural influences	-	x	x	-	x	-
	3	4	6	1	6	1
General NOS View	***Dynamic***		***Traditional***		***Traditional***	

The analysis of participants' interview transcriptions have revealed that student-teachers (n=3) hold views on aspects of NOS which are inconsistent and seemingly immature. Variations student-teachers' orientations such as with regard to the tentativeness of NOS and subjective or creative and imaginative NOS aspects showed that participants failed to establish interconnections that are in existence between the aspects (Moss et al., 2001). For example, while Boiki was of the opinion that scientific knowledge is not tentative, that is, it cannot change, he however pointed towards the relevance of individuals' creativity and imagination in science.

Student-teachers do not link aspects of nature of scientific knowledge. If they did, they would have realized that some aspects such as creativity and new ideas which lead to change in science and science education are a result of people's involvement of their thought, practices, errors and biases. Songer and Linn (1991) have suggested that sometimes students memorize what they are taught, which can also be a factor at play in this instance. If student-teachers are working on memorized facts and or knowledge they encountered in their early science and method courses, then it would not be surprising that they cannot see and establish relationships in aspects of NOS. Establishing relationships involves the attainment of science process skills which student-teachers should possess to enable them to appreciate, learn and teach science topics as a whole instead of fragmented episodes which are not complementary (Koosimile, 2004).

Katlo acknowledged that science processes are tentative and can be changed. On the other hand she maintained that science is factual or was a certain knowledge which cannot be changed, this was inconsistent with her general support for tentativeness views of NOS. An example is Katlo's views about science which are reflected in an extract of her interview;

> *Science is the intellectual and practical activity including the systematic study of the structure and behaviour of the physical and natural world through observation and experiment.*

The above extract shows that Katlo thinks of science as '*systematic'* which may suggest that there are specific procedural techniques or methods to be followed in an orderly fashion. This idea resonates with Traditionalistic assumptions (Moss et al., 2001; Songer & Linn, 1991). Although Katlo has disregard for an individual's ability engaging his or her intellect, creativity and ideas in a haphazard manner to make sense of the world. She however, implicitly point out the embedded-ness of human values by reference to '*intellectual*'. This may suggests that to Katlo, subjectivity is not entirely separated from science after all. She further pointed out that;

To me science is more interesting, it is very unique and totally different from other subjects because you learn from interaction with the natural world and also you discover hidden and new information or concepts. One gets to understand nature or the world around him or her better.

Although in the excerpt, Katlo has expressed her belief that NOS changes or it is tentative and that new ideas or knowledge have a place in science. She however, may harbor a traditional belief when considering her reference to '*hidden*' information or concepts. This may imply that scientific knowledge is already out there and it only waits to be discovered, a notion which is associated with positivist epistemology (Tafa, 2012).

The other student-teachers, Boiki in particular, shared the same views with Katlo except that he did not necessarily acknowledge that science is tentative and can change. He agreed that most of the technologies we use every day are creations of science, his sentiments were that;

Science cannot be changed, look at cell phones. They are not inventing anything new but they are taking existing ideas like watches, torches, GPS and putting them in one gadget. It is rare to see something totally new, like the times when atoms were discovered and maybe cars.

Boiki saw no place of new ideas or creativity in science. His view about these two aspects was very strong and traditionally oriented. Boiki's views (Cakmakci, 2012) on issues of creativity, new ideas and their input to science. He regarded science as predetermined and set by the 'gurus' in the early years of scientific revolution. But he concurred that science has contributed to making life easy and that it continues to fulfill the same relevance to date.

Amo strongly portrayed beliefs clearly consistent with traditional perspectives. She explained that science does not change and will remain the same forever. She used both religious and cultural perspectives to elaborate her belief about NOS. In the interview, she said;

> *God created the world and now things are just falling in place. Everything you see happening around us, has been foretold and what we use has been already made. Even the law of conservation states that matter cannot be created or destroyed…when I teach a practical lesson, I know what students will get from their experiments. They follow the same methods which have been set for that practical.*

Although Amo believed that scientific or empirical inquiry is part of science, she placed high emphasis on following set methods and rules. Her view is that science does not change and will never change. Her strong belief is noticeable in her interpretation of the law of conservation of matter, which she suggested it had implications on evolution of new ideas or knowledge. Amos also considered science as strictly void of human interference and creativity. She attested that rules and methods must be followed, and that life and things of this world have been '*created*' and we are just reliving or science is bringing them to life. Throughout the conversation with Amo, it was also apparent that she believed that science is something out there, with origins in the western states and it has been brought to Africans to follow and use.

These findings were clearly depicting a conflicting (Henke & Hottecke, 2014) and ambiguous polarization towards scientific philosophies (Halloun, 2001). Several meanings could be read from these undefined beliefs about science. Student-teachers do not see themselves as partners in science knowledge construction. For instance, anyone harboring beliefs like those of Amo, that science is from the west and it is being imposed on them, will surely tend to isolate themselves or not consider themselves as being part of the scientific process and its products.

On a different note, one could also perhaps hope that the inconsistencies observed demonstrate that their belief system is undergoing rigorous change or transformation due their experience of science. Having been engaged in almost 7 years (from JC to 2nd year, in the case of the three participants) of school science, student-teachers might be beginning to adopt some of the contemporary aspects which are constantly being advocated for by many educators and even the Botswana education system. In this case, it would be good a sign that eventually Botswana teachers or even students do appreciate the relevance of science and science education in innovations and the well-being of humanity.

4.2 Research Question 2

What are the espoused student-teachers' beliefs about teaching of science

When asked to describe teaching or best teaching practices in science, the three participants contributed different descriptions which were comprised of mixed attributes of both traditional and dynamic orientations. However, Amo was more inclined towards traditionally oriented teaching perspectives while Katlo and Boiki showed more dynamic teaching beliefs (see Table 4.2)

Table 4.2

Student-teachers' beliefs about teaching science.

	Pedagogical view of teaching science	
Participant(s)	Traditional (T)	Dynamic (D)
Amo	*x*	-
Boiki	-	*x*
Katlo	-	*x*

Key
x means present *-means absent*

Amo's traditional views of teaching science were deeply rooted in behaviourist philosophy such that her descriptions of science teaching was dominated by descriptors such as 'listen', 'note taking', 'knowledge transfer' (Ampadu, 2012). Her conceptions are best captured in the excerpt below;

> ***Amo**: well, it is difficult to describe teaching. But I think because when we teach, students are listening and taking notes, I will say knowledge has been transferred to them*

This description can be aligned with the traditional perspective in which students are '*listening*' and '*taking notes*' as passive recipients of knowledge from teachers. This student-teacher's opinion of teaching was centred on note-giving and note-taking, teacher-talking and student-listening interactions (Ampadu, 2012). When asked to explain what she meant by students listening and taking notes, Amo explained in a rather questioning or unsure tone;

> *Kante gone fa re ba letlelela go bua thata, rona re tsile go ruta leng?(but if we allow them to discuss most of the time, when are we going to have the time to teach?) A teacher must explain these things so that all students can hear and learn.*

Clearly, Amo felt that teaching involves the transfer of factual knowledge to learners. Her traditionalist views of teaching are so rigid that when one of her peers tried to advise her against 'too much teacher-talk' during a lesson evaluation session immediately after her microteaching, she quickly defended herself;

> *Aaah, nna ke pasitse fela mme re ne re rutwa ka go neelwa dinotes (We were taught through notes taking and I have passed nonetheless). Students waste too much time when they discuss. Sir? (Referring to me) o rutilwe jang? (How were you taught?) Fa o nale notebook, ga o kake wa feila, bao ba ba setseng ke ba ba neng basa kwale fa re rutwa. (You cannot possibly fail if you have a notebook, and those who have failed form 5 did not write notes when we were taught).*

On the other hand, Katlo and Boiki's beliefs about teaching were almost identical. Their conceptions of teaching involved engaging students and also situating learning experiences. These participants believed that teaching is an activity which converges science in the real world with school science (Savasci & Berlin, 2012). This is what Katlo said;

> *Most of the things we teach are already out there and happening (smiles). During my lesson we were just sharing those experiences. Akere o bone le wena sir? (Sir, you have also witnessed that in my teaching, right?)*

Participants mentioned that teaching targets students' interest and thus it has to be exciting (Liu, 2011; Yesil-Dagli et al., 2010). They also suggested that a good lesson can be identified by students' '*noise*'. Katlo added that "*when students are actively engaged in learning…their noise is welcome and of course it means they are constructing something there.*" Although Boiki shared the same views, his metaphors of describing an ideal teacher included '*a facilitator, supervisor and guide'*. His emphasis was on facilitation of critical thinking by engaging students in argumentative discussions. Their views were however oscillating between traditional and dynamic orientation (Boiadjieva et al., 2009), with no coherent inclination towards specific views. For instance, science was considered best learned and taught in situations where students' noise and engagement in arguments or discussion was encouraged (Talanque et al, 2010), knowledge transfer was also emphasized (Tsai, 2002).

Student-teachers had mixed views on students' and teacher's roles, but these were consistent with their beliefs about teaching and learning. For instance, they compared a good teacher to '*police office'*, '*social worker'*, '*nurse*' and a '*parent'*. In their opinion, teachers must offer guidance to students on both academic and social issues. Katlo was also quick to add that a teacher is a '*care-taker'*. The extract below captures her views;

> *A classroom or lesson is like a busy mall. You never know what is going to happen until it does…students arguing…fighting…noise…ill…depressed…it's a turmoil. And you have to handle all that calmly.*

In statement of teaching and learning philosophy, Katlo describes a teacher as a multi-tasked individual who can adjust with emerging situations in his or her classroom. She looks at a teacher as a mentor and a groomer of talent, leadership skills and learning styles. In many ways, Katlo's conceptions mirrored her experience with her primary school teacher. She also wrote;

> *A great teacher is a skilled leader. Different from administrative leaders, effective teachers focus on shared decision-making and teamwork, as well as on community building. This great teacher conveys this sense of leadership to students by providing opportunities for each of them to assume leadership roles. A great teacher can "shift-gears" and is flexible when a lesson isn't working. This*

> *teacher assesses his teaching throughout the lessons and finds new ways to present material to make sure that every student understands the key concepts. A great teacher respects students. In a great teacher's classroom, each person's ideas and opinions are valued. Students feel safe to express their feelings and learn to respect and listen to others. This teacher creates a welcoming learning environment for all students.*

In addition to these roles, Amo believed that a teacher is someone who is strict and a good leader. She added that;

> *Teachers must stamp their feet and show that they are in charge at all times. This way their students will do his or her work… also check notes and punish those who do not write. A friendly teacher can loose control of the students and they will fail in class. I have seen teachers trying to be nice to us, we took advantage of that and didn't do their work.*

Her belief on authority and power of the teacher was also evident in her teaching sessions. During one of her teaching experiences in microteaching, she stood next to a table chatting with her students. When she was told that she can start teaching, Amo moved to the front of the class and stood between the white board and a table (see Figure 4.1). She was clearly positioning herself in power as a leader or maybe assuming the 'teacher' position, '*stamping*' her authority (Tafa, 2012).

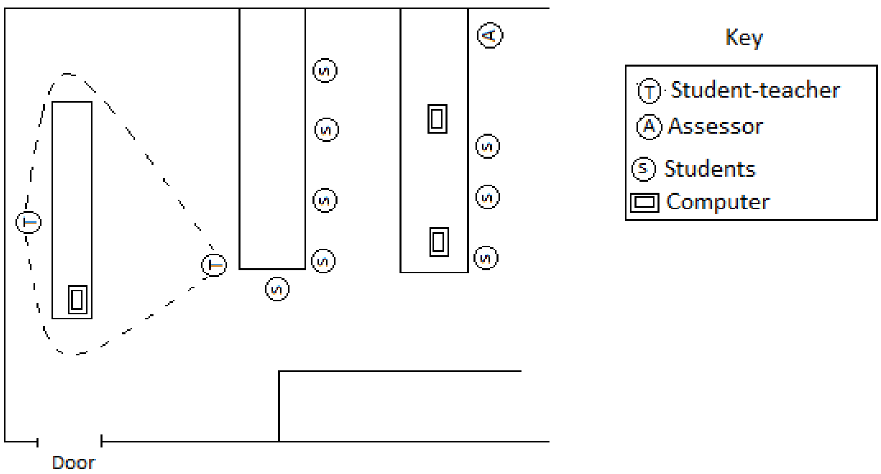

Figure 4.1. Diagrammatic representation of Amo's classroom layout & movements.

Students are however, regarded as core-workers or constructors of knowledge, they are seen as partners in the learning process. Katlo felt that students should also act as children at home and be obedient to their teachers. This obedience was attributed to good teaching and learning. Katlo explained that when students do not misbehave, their teacher will also like and care for them.

4.3 Research Question 3

What are the espoused student-teachers' beliefs about learning of science?

This question was intended to solicit the views that student-teachers held with regard to how science should be taught. Findings are reported in Table 4.3 and they mirror their conceptions of teaching.

Table 4.3

Student-teachers' beliefs about learning science.

	Pedagogical view of learning science	
Participant(s)	Traditional (T)	Dynamic (D)
Amo	*x*	-
Boiki	-	*x*
Katlo	-	*x*

Key

x means present
-means absent

Boiki and Katlo generally held strong dynamic beliefs about learning of science, while Amo is oriented towards the traditional view. It is not surprising that Amo should show traditionally inclined views about learning science since she has already pointed out that in her opinion, teaching science means transferring knowledge from the source to the students. Amo's beliefs about learning are also evident in her choice of language or words she uses. For example, she insists that student should '*pay attention*'. This '*attention*' may have to do with her earlier description of teaching, where she emphasized that students should '*listen*'. According to Amo's view, if students in a science classroom do not pay attention and listen to the source of knowledge, they may miss the knowledge. These findings are consistent with notions that teachers who hold a view on teaching is likely to be inclined in the same direction when it comes to views on learning (Ampadu, 2012; Boiadjieva et al., 2009; Cain, 2012). Boiki and Katlo may have vouched for learning elements which are otherwise traditional in nature, such as the belief that learning of science occurs through imitating the 'guru', they however held strong dynamic beliefs the learning of science.

4.4 Research Question 4

How are the student-teachers' beliefs about the nature, teaching and learning of science associated with their instructional practices?

Planned and taught lessons were divided into two sessions for every individual participant, a non-practical and a practical lesson. Each one of the lessons was allocated only 40 minutes, within which student-teachers presented a scheme of work, planned for and taught their peers. Both student-teachers' instructional plans or lesson plans and the lesson instructions, showed a predominance of traditional teaching and learning perspectives. Nevertheless, some sporadic elements of dynamic orientations were also observed within student-teachers' lessons. Four categories emerged from the data, viz. learning goals or rationale, teaching strategy or approach, assessment approach and knowledge base.

Table 4.4

Frequency of student-teachers' observed instructional practices.

Instructional practice orientation	Amo	Boiki	Katlo
Student-directed (SD)	17%	79%	39%
Teacher-directed (TD)	83%	1%	61%
Overall orientation	**TD**	**SD**	**TD**

Of the three (3) lessons observed, student-teachers' perception of the source of scientific knowledge tended towards the traditional model or orientation. This drift towards the traditional perspectives was evident, despite of the practical nature of some lessons. Participants seemed to put more emphasis on themselves and textbooks as authorities of scientific knowledge. For instance, in Boiki's practical lesson, he gave students experimental activity to produce oxygen gas using hydrogen peroxide (H_2O_2) and yeast. This activity was successfully executed by his students, and during the discussion of the student's observations and results, Boiki asked them to write the equation for the reaction. The following equations were put on the board by two groups (S_1-student 1);

***S_1* wrote**: $H_2O_2 \longrightarrow O_2 + H_2O + yeast$

***S_2* wrote**: $H_2O_2 \xrightarrow{\text{yeast}} O_2 + H_2O$

On his attempt to engage the class in a discursive discourse and maybe make it more student-centered like he has been encouraged by instructors, Boiki asked students' opinions on the first equation. The following excerpt from the video recorded lessons reflects the sequence of events.

Boiki: *Hey guys, is yeast a product?*

Student*s: (whole class echoed) No!*

At that moment, Boiki decided to explain the role of yeast in the reaction or the decomposition of hydrogen peroxide. Boiki explained that the yeast is offering catalytic function to the breakdown of the peroxide and it does not react or take part in the reaction. He even reminded students that they added the yeast to the test tube of reactants, therefore it cannot be possibly one of the products of the reaction. Boiki wrote his version of the equation on the board and told the class;

***Boiki**: So, the reaction producing our oxygen looks like this. (And he wrote)*

$$H_2O_2 + yeast \longrightarrow O_2 + H_2O$$

At this point, one student from the second group raised a question, (*S_A, S_1 or S merely represents a student(s) in class and these will be used interchangeably or in no particular reference to any one student*);

***S_A**: Sir? What is wrong with our equation? (referring to the second equation on the board from group 2).*

Boiki turned towards the board and studied the equation in question for a while, looking a little perplexed. He turned back to his class obviously unsettled by the question and confused by the equations. On noticing the teacher's hesitation to answer the question, one of Boiki's students continued;

***S_A**: I think it is ok, in fact it is the correct one. A kere, you said the yeast is not reacting but just acting as a catalyst…..*

***Boiki**: (interrupting the student to defend his equation) But I found it like this!*

***Students**: (whole class roars with laughter and ask) where?*

***Boiki**: In a textbook (peers continue laughing).*

Evidently Boiki held textbooks in high regard and as knowledge authorities (Lim & Chai, 2008; Tafa, 2012). His inability to critically analyze his equation or the textbook's equation and link it to his explanations was clearly corrupted by his respect for the textbook. He was surprised that even his students doubted the '*textbook'*. A similar incident took place in Katlo's lesson, in the introductory stages. She asked her students to define speed, and after several attempts by her students, she said, "*So, you have given me your ideas. My definition from a certain book goes like this…clear?*" Katlo's disregard for students' creative opinions or ideas in the construction of a meaningful definition of speed was not an option comparable to the information provided by '*certain book*'. She also perceived a textbook as one of the authorities of science knowledge base. In spite of this, student-teachers were aware of the dynamic view of knowledge construction and the regard of knowledge as a social product, because they kept on reminding their students that they should not expect to be 's*poon fed*'. They encouraged the students to interactively construct sensible meanings of the activities they do in class. These assertions were however divergent from the student-teachers' instructional practices, showing inconsistencies and struggles between perception and their action.

Table 4.5

Summarised student-teachers' beliefs about NOS, teaching and learning and their practices.

	Student-teachers' perspectives			
Participant (s)	**NOS**	**Teaching**	**Learning**	**Instructional Practices**
Amo	T	T	T	TD
Boiki	T	D	D	TD
Katlo	D	D	D	SD

Student-teachers' lessons were more dynamic than traditional oriented. Most of their teaching approaches were student-centered and the activities involved in the lessons were more engaging. Students worked collaboratively in groups and they were given experimental exercises which gave the students 'authentic' hands-on experiences with scientific equipment and interrogation of data. In lessons which were not practical, student-teachers used various teaching and learning aids such as video clips, colorful diagrams and worksheets.

Participants clearly were knowledgeable on various teaching strategies or methods, however, their lessons tended to be more teacher-centered when the teachers tried to explain or engage in discussions.

The lessons were centered around learning objectives which reflected the traditional perspective. Although the students were engaged in practical or experimental activities, their hands-on activities were however directed towards discovering the 'true' answer (Tafa, 2012). One such lesson which was driven by traditionally oriented goals, was Amo's lesson where she constantly reminded her students that, "*if you don't pay attention, you will fail my test and the exam*." In one occasion, she also cautioned students when they were discussing the definition of digestion, "*Ok, there is nothing wrong with your definitions. But if you write like that you will only get half a mark that is if you are lucky!"*

The emphasis of examination, tests, or assessment as a reason for students' learning was more dominant. Clearly, student-teachers regarded or equated learning to doing well in assessments. And this notion was made obvious to students.

Lessons were driven by a series of questions which made the lessons seem like a reconstruction of a model answer or teacher's right answer. Katlo's lesson is a typical example in which questions were used for 'reconstruction' of facts or the truthful answer. It was like the students' responses were supposed to eventually rebuild the content of the lesson. For example, students in her class worked in groups to label the parts of a given flower diagram. On completion, they presented their work and she often interrupted with "*is s/he right?*" When students' presentations were over, she continued without discussing or explaining the labels that students were attaching to the parts of the flower, simply because she was satisfied with their responses. This excerpt reflects the Katlo's lesson progression;

***Katlo**: What is the function of the stamen?*

***S**: Fertilization. (The whole class sounding confident about the answer.)*

***Katlo**: Yes, but fertilization of what?*

***S_1:** Stamen fertilizes the ovules.*

***Katlo**: Where is the ovule?*

***S_2**: In the ovary.*

***Katlo**: How does the stamen reach the ovule?*

***S_3**: Through the style?*

***Katlo**: But where does this all start?*

***S_4**: (after a long silence) I think the stamen is blown or carried by insects to the stigma.*

Katlo's lesson was comprised of a sequence of questions and answers. The way she asked students those questions, was intended to be formative in nature and also intended to be engaging. However, Katlo's questioning led students to give short responses and details like 'crumbs' of facts recollected and yet not shaped into any sensible form.

Although the student-teachers were continuously assessing their students for understanding, their approach comprised of more expository questions and questions which were ultimately focused at the solicitation of a 'correct answer'. Recall and expository questions, which checked for memorization seemed to be more dominant than thought provoking ones (Chan, 2003). For example, students would be frequently asked questions like, "*what did I say is speed?*" or "*what did we say happens to food in the stomach?*" The 'model response' syndrome (Lim & Chai, 2008; Tafa, 2012) also made persistent appearances within most of their lessons. An excerpt below is of one such interaction;

> ***Amo**: Good morning class. Can someone tell us what happens to food when we eat?*
>
> ***S_1**: It is chewed.*
>
> ***Amo**: Others?!*
>
> ***S_2**: It goes straight to the stomach.*
>
> ***S_3**: It is digested.*
>
> ***Amo**: (interested by the third student's response) Yes, you said digested! What do you mean digested?*

Other responses were not followed up by the teacher, but when the one response or what was close to the 'model answer' popped up, it caught Amo's attention and she prompted for further explanation from the student (Tafa, 2012). However, the majority of lessons were assessed through a summative strategy, where students were asked question towards or at the end of the lesson. The main aim seemed to be to determine how much of the content they could recall for the lesson that just ended.

4.5 Summary

Findings highlight the diversity of beliefs in a group of three (n=3) teacher trainees and support the notion by Tsai (2002) that there may exist an interplay between student-teachers' beliefs about NOS, teaching, learning and instructional practices in science (also see, Levitt, 2002; Pajares, 1992; Nespor, 1987). Katlo and Amo evidently harbored what Tsai termed as nested beliefs, where a relationship existed between belief and practice orientation (see Figure 4.2). Although linkages existed between student-teachers' beliefs and instructional practices, there was no link between Boiki's NOS and teaching beliefs, and between learning beliefs and instructional practices. Tsai (2002) referred to this disconnect between beliefs and instructional practices as divergent. It is possible that these divergence portrayed by Boiki may be a result of possessing tacit and espoused beliefs (Pajares, 1992). Or it may be that Boiki lacks the skill and experience impacted on his ability to act in accordance with his stated beliefs (Cain, 2012). The implication of the interplay of beliefs on practices is that it could determine the amount of energy a teacher will put into an activity and how s/he will expend the energy (Cain, 2012).

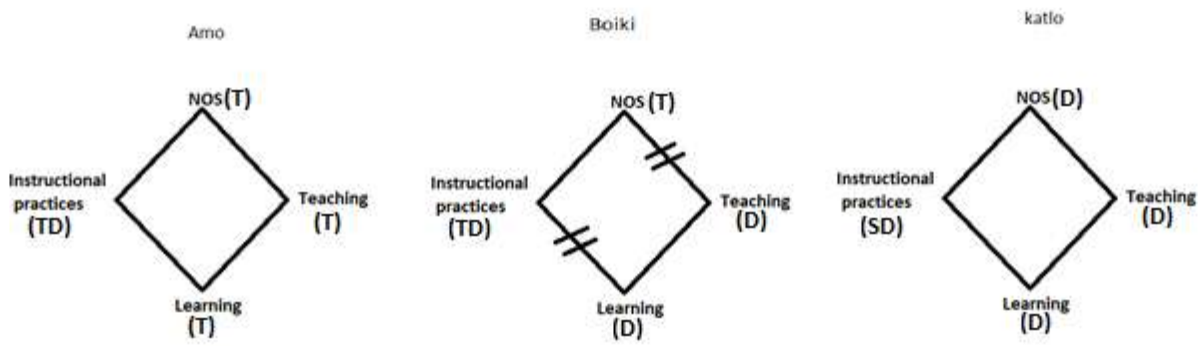

Figure 4.2. Possible linkages between student-teachers' beliefs about NOS, teaching, learning science, and instructional practices

On the other hand, Katlo belief systems and practice showed linkages or nested beliefs. Katlo is a student-teacher who holds dynamic views of NOS, teaching, learning and also enacts student-directed practices in the classroom.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This study was conducted in an attempt to find student-teachers' beliefs about NOS, teaching and learning of science, as well as how these beliefs were enacted in science microteaching lessons. This chapter summaries the study and forwards conclusions and recommendations for consideration.

5.1 Conclusion

Findings of this study show that indeed, student-teachers held some preconceptions or beliefs about NOS, teaching and learning of science, and that they displayed different instructional practices during their micro-teaching assignments. The current study demonstrated that student-teachers' beliefs about NOS are sophisticated, different for individuals due to their own subjectivity. The study also highlight the potential influence of beliefs on instructional practices, though in one case such influence was non-existent.

However, it has come to light that these beliefs are not polarized towards either traditional or dynamic. Even in their enactment of instructional practices, student-teachers' practices were most of the time shifting within the student-directed and the teacher-directed approaches. It can be concluded that individuals have preconceptions of what science is all about, how it should be learned and taught. However, these maze of beliefs have shown that beliefs interact and evolve in classrooms in interesting ways. Some beliefs are sometimes impinging to science teaching and learning, such as the strong faith directed towards textbooks and marginalization of learner input in the construction of scientific knowledge.

5.2 Implications for Teacher development

The wrestling of student-teachers between Dynamic and Traditional beliefs, practices and even their lack of interest in science teaching has underlying implications. Lecturers in science, and more especially in science related method courses should portray dynamic attitudes towards science teaching. This will hopefully inspire students to challenge and dispel their own traditional beliefs and even emulate their teachers and lecturers. Teacher development should encompass rigorous efforts directed towards conceptual change. This should not only occur in the form of study modules or courses. Student-teachers and teachers in science must be involved in regular training and competency development programs which will help in changing their practices and hopefully their beliefs within the contemporary perspectives. Micro-teaching as an opportunity for student-teachers to express, challenge and maybe shape their conceptions, should therefore be more reflexive in nature and continuous. During this time, student-teachers should be engaged in debates with and be given a chance to question their rooted perceptions. Findings also show that by merely assuming that conceptual change can result from offering method courses on NOS, teaching and learning theories is not enough. A complementary means of effecting this change should be devised and should be intensified, where student-teachers can again have opportunities to challenge their conceptions.

5.3 Recommendations for Research;

a) To give more meaningful and rewarding findings, it is suggested that the study can also be conducted in a longitudinal fashion, or through an action or reflective design, working with cohorts throughout their training period so that participants can benefit from the extensive evaluation of their belief systems. This way, exploration of belief systems and their change can be documented while at the same time assisting participants to remodel or shape them in line with their practices.

b) A study ought to be conducted to investigate the nature of divergent beliefs and practices evident in Boiki's case.

c) In order to determine the influential nature of social and cultural context (Botswana's context) on teachers' beliefs, characteristics of teachers' should also be investigated.

d) A study aimed at exploring the underlying predispositions of students like Boiki and Amo to teaching would also come in handy. More especially Amo, who did not like teaching science and yet she did not necessarily despise science (or other science related careers like nursing).

REFERENCES

Abd-El-Khalick, F. (2012). Teaching with and about nature of science, and science teacher knowledge domains. *Science and Education.* doi 10.1007/s11191-012-9520-2.

Abd-El-Khalick, F., & Lederman, N, G. (2000). The influence of history of science courses on students' views on nature of science. *Journal Research in Science Teaching, 37(10),* 1057-1059

Adedoyin, O. O. (2011). The impact of teachers' in-depth pedagogical mathematical content knowledge on academic performance: As perceived by Botswana junior secondary school pupils. *European Journal of Educational Studies, 3*(2), 277-292

Akerson, V. L., & Donnelly, L. A. (2008). Relationships b among learner characteristics and preservice elementary teachers' views of nature of science. *Journal of Elementary Science Education, 20*(1), 45-58

Aldridge, J., Taylor, P., & Chen, C. (1997). Development, validation and use of the beliefs about science and school science questionnaire (BASSSQ). *National Association for Research in Science Teaching, (NARST), Chicago, Illinois.*

Alexandersson, M. (1994). Focusing teacher consciousness: What do teachers direct their consciousness towards during their teaching? In Carlgren, I., Handal, G., & Vaage, S. (Eds.), *Teachers' minds and actions: Research on teachers' thinking and practice*. Washington, D.C: The Falmer Press.

Ali, M., & & Ismail, Z. (2006). Comprehension level of non-technical terms in science: Are we ready for science in English. *Journal Pendidik dan Pandidikan, 21*, 73-83.

Ampadu, E. (2012). Students' perceptions of their teachers' teaching of mathematics: The case of Ghana. *International Online Journal of Educational Sciences, 4*(2), 351-358. From www.iojes.net

Anderson, L. M., & Holt-Reynolds, D. (1995). Prospective teachers' beliefs and teacher education pedagogy: Research based on a teacher educator's practical theory, (Research Report 95-6). *East Lansing, MI: National Center for Research in Teacher Learning,* Michigan State University.

Ashton, P., & Gregoire-Gill, M. (2003). At the heart of teaching: the role of emotion in changing teachers' beliefs. In Raths, J., & McAninch, A. C. (Eds.), *Teacher beliefs and classroom performance: The impact of teacher education*. Greenwich: Information Age Publishers.

Bless, C. & Kathuria, R. (2001). *Fundamentals of social statistics: An African perspective*. Cape Town: Juta & Co. Ltd.

Boiadjieva, E., Tafrova-Grigorova, A., Hollenbeck, J. E., & Kirova, M. (2009). An examination of teacher's pedagogical philosophical beliefs of secondary science teachers in Sofia public schools, Sofia, Bulgaria. *Bulgarian Journal of Science and Education Policy (BJSEP), 3*(1), 39-46.

Cain, M. (2012). Beliefs about classroom practice: A study of primary teacher trainees in Trinidad and Tobago. *International Journal of Humanities and Social Science, 2*(3), 96-105.

Cakmakci, G. (2012). Promoting pre-service teachers' ideas about nature of science through educational research apprenticeship. *Australian Journal of Teacher Education, 37(2),* 114-135

Cameron, R. (2011). Mixed methods research: The five Ps framework. *The Electronic Journal of Business Research Methods, 9*(2), 96-198.

Chan, K. W. (2003). Hong Kong teacher education students' epistemological beliefs and their relations with conceptions of learning and learning strategies. *The Asia Pacific Education Researcher, 16*(2), 199-214.

Chan, K. W. (2004). Preservice teachers' pedagogical beliefs and conceptions about teaching and learning: Cultural implications for research in teacher education. *Australian Journal of Teacher Education, 29*(1), 1-13.

Chilisa, B., & Preece, J. (2005). *African perspectives on adult learning: Research methods for adult educators in Africa*. Cape Town, South Africa: Pearson

Cicourel, A. V. (1964*). Method and measurement in sociology*. New York: Macmillan Publishers

Cil, E., & Cepni, S. (2012). The effectiveness of the conceptual change approach, explicit reflective approach, and course book by the Ministry of Education on the views of the nature of science and conceptual change in light unit. *Educational Sciences: Theory & Practice, 12*(2), 1107-1113

Cogill, J. (2008). *Primary teachers' interactive whiteboard practice across one year: Changes in pedagogy and influencing factors* (Unpublished doctoral dissertation). King's College University of London. From www.juliecogill.com

Creswell, J. W. (1998). *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oaks: Sage Publications.

Creswell, J. W. (2003). *Research designs: qualitative, quantitative and mixed methods approach*. London: Sage Publications.

Czerniak, C. M., Lumpe, A. T., Haney, J. J., & Beck, J. (1999). Teachers' beliefs about using educational technology in the science classroom. *International Journal of Educational Technology, 1*(2), 1-18.

Davison, R. M. (2002). *Ethics and research methods*. Proceedings of the 35th Hawaii International Conference on System Sciences, 3439-3445. IEEF.

Denzin, N., & Lincoln, Y. (1994). *The handbook of qualitative research in education*. Newbury Park, CA: Sage Publications.

Doppelt, Y., Mehalik, M. M., Schunn, C. D., Silk, E., & Krysinski, D, (2008). Engagement and achievement: A case study design based learning in a science context. *Journal of Technology Education, 19*(2), 22-39.

Dunkin, M. J. (2002). Novice and award winning teachers' concepts and beliefs about teaching in higher education: Effectiveness, efficacy and evaluation. In Hativa, N., & Goodyear, P. (Eds.), *Teacher thinking, beliefs and knowledge in higher education*. London: Kluwer Academic Publishers

Edelson, D. C. (1997). Realising authentic science through adaptation of scientific practice. *International Handbook of Science education, 1*, 317-331.

Ellen, R. F. (1984). Ethnographic research: *A guide to general conduct*. London: Academic Press

Ezzy, D. (2002). *Qualitative analysis: Practice and innovation*. London: Routlrdgr , Taylor & Francis Group

Faour, B. (2003). *Early childhood Teachers' in Lebanon: Beliefs and practices*. PhD Thesis, School of Education. University of Leicester. UK.

Firestone, W. A., & Dawson, J. A. (1988). Approaches to qualitative data analysis: Intuitive, procedural, and intersubjective. In Fetterman, D. M. (Ed.), *Qualitative approaches to evaluation research in education: The silent scientific revolution*. New York: Praeger Publishers

Fischler, H. (1994). Concerning the difference between intention and action: Teachers' conceptions and actions in physics teaching. In Carlgren, I., Handal, G., & Vaage, S. (Eds.), *Teachers' minds and actions: Research on teachers' thinking and practice*, Washington, D.C: The Falmer Press

Fives, H., & Buchl, M. M. (2012). Spring cleaning for the “messy” construct of teachers beliefs: What are they? Which have been examined? What can they tell us? In Harris, K. R., Graham, S., & Urdan, T. (Eds), *APA educational psychology handbook: Volume 2 Individual differences and cultural and contextual factors*. Washington: American Psychological Association.

Flores, I. M. (2015). Developing pre-service teachers’ self-efficacy through field-based science teaching practice with elementary students. *Research in Higher Education Journal*, *27*, 1-19.

Foddy, W. (1993). *Constructing questions for interviews and questionnaires: Theory and practice in social research*. Cambridge: Cambridge University Press.

Garegae, K. G. (2001). *Teachers' beliefs about mathematics, its teaching and learning and the communications of these beliefs to students: A case study in Botswana* (Unpublished doctoral dissertation). University of Manitoba.

Gencturk, Y. C. (2012). *Teachers' mathematical knowledge for teaching instructional practices , and student outcomes* (Dissertation submitted for doctor of Philosophy in Secondary and Continuing education)

Gess-Newsome, J. (1999). Pedagogical content knowledge: An introduction and orientation. In Gess-Newsome, J., & Lederman, N. G. (Eds.), *Examining pedagogical content knowledge*. Boston: Kluwer Academic Publishers

Gilbert, J. K. (2004). Models and modelling: Routes to more authentic science education. *International Journal of Science and Mathematics Education, 2*, 115-130

Guba, E. G. (1981). *Criteria for assessing the trustworthiness of naturalistic inquiries. Educational Communication and Technology*, *29*(2), 75-91. From http://www.jstor.org/stable/30219811

Guba, E. G., & Lincoln, Y. S. (1988) .Do inquiry paradigms imply inquiry methodologies? In Fetterman, D. M. (Ed), *Qualitative approaches to evaluation research in education: The silent scientific revolution*. New York: Praeger Publishers

Halloun, I. A. (2001). Student views about science: A comparative survey. *Lebanon Educational Research Centre*, Lebanese University.

Handal, B. (2003). Teachers' mathematical beliefs: A review. *The Mathematics Educator, 13*(2), 47-57.

Hannock, E. S., & Gallard, A. J. (2004). Preservice science teachers' beliefs about teaching and learning: The influence of K-12 field experience. *Journal of Science Teacher Education, 13*(4), 281-291.

Hart, L. C. (2002). Preservice teachers' beliefs and practice after participating in an integrated content/method course. *School Science and Mathematics, 102*(1), 4-14.

Hassan, G. (2011). Students' views of science: A comparison between tertiary and secondary school students. *Science Educator, 20*(2),54-61.

Henke, A., & Höttecke, D. (2014). Physics teachers' challenges in using history and philosophy of science in teaching. *Science & Education, 24*(4), 349-385

Ivankova, N. V., Creswell, J. W., & Stick, S. L. (2006). Using mixed methods sequential exploratory design: From theory to practice. *Field Methods, 18*(1), 3-20.

Janesick, V. (1982). Of snakes and circles: Making sense of classroom group processes through a case study. *Curriculum Inquiry, 12*, 126-187.

Janesick, V. J. (1998). The dance of qualitative research design: Metaphor, methodology, and meaning. In Denzin, N. K., & Lincoln, Y. S. (Eds.), *Strategies of qualitative inquiry*. London: Sage Publications

Johnson, M. J.m & Hall, J. L. (2007), Impact of one science teacher's beliefs on his instructional practices. *Journal of Education and Human Development, 1*(1)

Johnson, B. R., & Onwuegbuzie, A. J. (2004). Mixed method research: A research paradigm whose time has come. *Educational Researcher, 33*(7), 14-26. From www.jstor.org/stable/3700093

Johnson, B. R., Onwuegbuzie, A. J., & Turner, L. A. (2007). Towards a definition of mixed methods research. *Journal of Mixed Methods Research, 1*(2), 112-133. doi: 10.117/1558689806298224.

Johnstone, A. H., & Selepeng, D. (2001). A language problem revisited. Chemistry Education: *Research and Practice in Europe, 2*(1), 19-29.

Joniak, L. (2006). *The qualitative paradigm: An overview of some basic concepts, assumptions, and theories of qualitative research*. From http//www.unf.edu/dept/cirt/events/past/joniak.

Kansanen, P., Tirri, K., Meri, M., Krokfors, L., Husu, J., & Jyrhama, R. (2000). *Teachers' pedagogical thinking : Theoretical landscapes, practical challenges*. Oxford: Peter Lang

Keren-Kolb, E. F. (2010). *Stimulating preservice teachers' beliefs about the benefits of everyday technology in their teaching* (doctoral dissertation). University of Michigan.

Khader, F. R. (2012). Teachers' pedagogical beliefs and actual classroom practices in social studies instruction. *American International Journal of Contemporary Research, 2*(1), 73-92.

Khishfe, R., 7 Lederman, N. G. (2006). Teaching nature of science with a controversial topic: Integrated versus nonintegrated. *Journal of Research in Science Teaching, 43(4),* 395-418.

Koosimile, T. A. (2004) , Out-of-school experiences in science classes: Problems, issues and challenges in Botswana. *International Journal of Science Education, 26*(4), 483-496.

Krapp, A., & Prenzel, M. (2011). Research on interest in science: Theories, methods and findings. International Journal of Science education, 33(1), 27-50. DOI 10.1080/09500693.2010.518645

Krefting, L. (1991). Rigor in qualitative research: The assessment of trustworthiness. American *Journal of Occupational Therapy, 45*(3), 214-222.

Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of the nature of science questionnaire: Toward valid and meaningful assessment 0of learner's conceptions of the nature of science. *Journal of research in Science Teaching, 39(6),* 497-521.

Lederman, N. G., & Zeidler, D. L. (1987). Science teachers' conceptions of the nature of science: Do they really influence teaching behavior? *Science Education, 71(5),* 721-734.

Leech, N. L., & Onwuegbuzie, A. J. (2006), A typology of mixed methods research designs. *Quality and Quantity, 43*,(2) 265-275. doi: 10.1007/s11135.007.9105.3

Lembardi, M. M. (2007). Authentic learning for the 21st century : An overview. *Educare Learning Initiative-Advancing Learning through IT Innovation. 1,* 1-12.

Levitt, K. E. (2002). An analysis of elementary teachers' beliefs regarding the teaching and learning of science. *Science education, 86(1),* 1-22.

Liljedahl, P. (2008). *Teachers' beliefs as teachers' knowledge*. Paper presented at the Symposium on the Occasion of the 100th Anniversary of ICMI (Rome, 5-8, March, 2008).

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Beverly Hills, CA: Sage Publications

Lim, C. P., & Chai, C. S. (2008). Teachers' pedagogical beliefs and their planning and conduct of computer-mediated classroom lessons. *British Journal of Educational Technology, 39*(5), 807-828. doi: 10.1111/j.1467-8535.2007.00774.x

Liu, S. (2011). Factors related to pedagogical beliefs of teachers and technology integration. *Computers and Education, 56*, 1012-1022.

Long, T., & Johnson, (2000). Rigour, reliability and validity in qualitative research. *Clinical Effectiveness in Nursing, 4*, 30-37.

Lumpe, A. T., Haney, J. J., & Czerniak, C. M. (2000). Assessing teachers' beliefs about their science teaching context. *Journal of Research in Science Teaching, 37*(3), 275-292

Macugay, E. B., & Bernardo, A. B. (2013). Science coursework and pedagogical beliefs of science teachers: The case of science teachers in the Philippines. *Science Education International, 24*(1), 63-77.

Magnusson, S., Krajcik, M., & Borko, H. (1999). Nature, sources and development of pedagogical content knowledge for science teaching. In Gess-Newsome, J. & Lederman, N. G. (Eds.), *Examining pedagogical content knowledge*. Boston: Kluwer Academic Publishers

Major, T. E., & Tiro, L. (2012). Theory vs practice: The case of primary education in Botswana, *International Journal of scientific Research in Education,5*(1), 63-70.

Mayoh, J., & Onwuegbuzie, A. J. (2013). Towards a conceptualisation of mixed methods phenomenological research. *Journal of Mixed Methods Research*, 1-17. doi: 10.1177/1558689813505358.

McLaury, R. L. (2011). Preservice science teacher beliefs about teaching and the science methods courses: Exploring perceptions of microteaching outcomes. ProQuest LLC.

Merriam, S. B. (1988). *Case study research in education: A qualitative approach*. San Francisco: Jossey-Bass Publishers

Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation, Revised and expanded from qualitative research and case study applications in education*. San Francisco: Jossey-Bass, A Wiley Imprint

Miles, M. B., & Huberman, A. M. (1984). *Qualitative analysis: A sourcebook of new methods*. London: Sage Publications

Mohamed, N. (2006). An exploratory study of the interplay between teachers' beliefs, instructional practices and professional development. A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Language Teaching and Learning, The University of Auckland.

Morse, J. M. (1998). Designing funded qualitative research. In Denzin, N. K., & Lincoln, Y. S. (Eds.), *Strategies of qualitative inquiry*. London: Sage Publications

Moss, D. M., Abrams, E. D., & Robb, J. (2001). Examining student conceptions of the nature of science. *International Journal of Science Education, 23*(8), 771-790. doi: 10,1080/09500690010016030

Moustakas, C. (1990). *Heuristic research: Design, methodology and applications.* London: Sage Publications

Murrell, P. C., & Foster, M. (2003). Teacher beliefs, performance and proficiency in diversity-oriented teacher preparation. In Raths, J. & McAninch, A. C. (Eds.), *Teacher beliefs and classroom performance: The impact of teacher education*. Greenwich: Information Age Publishers

Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies, 19(4),* 317-328.

Nuangchalerm, P. (2009). Preservice teachers perception about nature of science. *The Social Sciences, 4*(5), 463-467.

Orb, A., Eisenhquer, L., & Wynadon, D. (2001). Ethics in qualitative research. *Journal of Nursing Scholarship First Quarter*, 93-96.

Osborne, J., Ratcliffe, M., Collins, S., Millar, R. & Duschl, R. (2003). What 'ideas about science' should be taught in school science? A Delphi study of the 'expert' community. *Journal of Research in Science Teaching, 40(7),* 692-720.

Osterholm, M. (2010). *Beliefs: A theoretically unnecessary construct?* In proceedings of the Sixth Congress of the European Society for Research in Mathematics Education, January 28th-February 1st 2009, Lyon, France, 154-163.

Pajares, M. F. (1992). Teacher's beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*(3), 307-332.

Patton, M. Q. (1988). Paradigms and pragmatism. In Fetterman, D. M. (Ed.), *Qualitative approaches to evaluation research in education: The silent scientific revolution*. New York: Praeger Publishers

Patton, M. Q. (1990). *Qualitative evaluation and research methods*. 2nd ed. London: Sage Publications

Peterson, S., Schreiber, J., & Moss, C. (2011). Changing preservice teachers' beliefs about motivating students. *Teaching Educational Psychology, 7*(1), 27-39.

Peabody, D. (2011). Beliefs and instructional practices among secondary teachers within selected high and low performing high schools. *Florida Journal of Educational Administration & Policy, 4*(2), 181-192.

Pietila, A. (2003). *Fulfilling the criteria for a good mathematics teacher: The case of one student*. Proceedings of European Research on Mathematical Education III. From http://www.dm.unipi.it/clusterpages/didacttica/CERME_3.

Polly, D., McGree, J. R., Wang, C., Lambert, R. G., Pugalee, D. K., & Johnson, S. (2013). The association between teachers' beliefs, enacted practices, and student learning in mathematics. *The Mathematics Educator, 22*(2), 11-30.

Pomeroy, D. (1993). Implications of teachers' beliefs about the nature of science: Comparison of the beliefs of scientists, secondary science teachers, and elementary teachers. *Science Education, 77*(3), 261-278.

Price, C. A., & Lee, H. S. (2013). Changing in participants' scientific attitudes and epistemological beliefs during an Astronomical citizen science project. *Journal of Research in Science Teaching, 50*(7), 773-801.

Raths, J. (2001). Teacher beliefs and teaching beliefs. *Early Childhood Research & Practice, 3*(1)

Reid, N. (2011). Attitude research in science education. In Saleh, I. M & Khine, M. S. (Eds.), *Attitude research in science education: Classic and contemporary measurements*. Charlotte, NC: Information Age Publishing Inc.

Republic of Botswana, Ministry of Education & Skills Development. (1993). *Report of the National Commission on Education*. Gaborone: Government Printers.

Ribeiro, C. M., & Carrillo, J. (2011). The role of beliefs and knowledge in practice. *Current State of Research on Mathematical Beliefs XVII-MAVI*, 17.

Richardson, V. (2003). Preservice teachers' beliefs. In Raths, J. & McAninch, A. C. (Eds.), *Teacher beliefs and classroom performance: The impact of teacher education*. Greenwich: Information Age Publishers

Riessman, C. K. (1993). *Narrative analysis.* London: Sage Publications.

Rolfe, G. (2006). Validity, trustworthiness and rigour: Quality and the idea of qualitative research. *Methodological Issues in Nursing Research, 53*(3), 304-310.

Saad, R., & Boujaoude, S. (2012). The relationship between teachers' knowledge and beliefs about science and inquiry and their classroom practices. *Eurasia Journal of Mathematics, Science and Technology Education, 8*(2), 113-128

Sandt, S. (2007). Research framework on mathematics teacher behaviour : Kochler and Grouws' framework revised. *Eurasia Journal of Mathematics, Science and Technology Education, 3*(4), 343-350

Savasci-Acikalin, F. (2009). Teacher beliefs and practice in science education. *Asia-Pacific Forum on Science Learning and Teaching, 10*(1), 1-14.

Savasci-Ackikalin, F., & Berlin, D. F. (2012). Science teacher beliefs and classroom practice related to constructivism in different school settings. Journal of Science Teacher education, 23, 65-86.

Savin, A., & Lam, R. S. Y. (2008).,,Enhancing student-teachers' learning and teaching through guided reflection. *Studies on Teaching and Learning*. Hong Kong: Hong Kong Baptist University, 17-28.

Scales, K. (2012). *Ethics in practice: Considering ongoing ethical issues in qualitative research.* Paper presented at Collaboration for Leadership in Applied Health Research and Care for Nottinghamishire, Derbyshire, and Lincolnshire (CLAHRC-NDL).

Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information, 22*, 63-75.

Sherman, W. (2004). Science studies, situated-ness, and instructional design in science education: A summary and critique of the promise. *Canadian Journal of Science, Mathematics, and Technological Education, 4*(4), 443-465.

Shin, N., Deniz, S., & Gorgen, I. (2006). Student teachers' attitudes concerning understanding the nature of science in Turkey. *International Education Journal, 7*(1), 51-55.

Siddiquee, M. N., & Ikeda, H. (2013). Science teachers' beliefs on teaching and learning at secondary schools in Bangladesh. *GSE Journal of Education,* ISSN 2289-3970. Wolrdconference.net

Song, E., & Koh, K. (2010). *Assessment for learning: Understanding teachers' beliefs and practices*. 36th Annual Conference of the International Association for Educational Assessment (IAEA) Bangkok, Thailand. From http://www.iaea2010.com/fullpaper/104.pdf.2010

Songer, N. B., & Linn, M. C. (1991). How do students' views of science influence knowledge integration? *Journal of Research in Science Teaching, 28*(9), 761-784

Stake, R. E. (1998). Case studies. In Denzin, N. K., & Lincoln, Y. S. (Eds.), *Strategies of qualitative inquiry*. London: Sage Publications

Strauss, A. (1987). *Qualitative analysis for social scientists*. New York: Cambridge University Press.

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Grounded theory procedures and techniques*. Newbury Park, CA: Sage Publication.

Swan, M. (2007). The impact of task-based professional development on teachers' practices and beliefs: A design research study. *Journal of Mathematics Teacher Education, 10*, (4-6), 217-237. doi:10.1007/s10857-007-9038-8.

Tabulawa, R. (1997). Pedagogical classroom practice and the social context: The case of Botswana. International Journal of Educational Development, 17(2), 189-204.

Tafa, E. M. (2012). Authoritarian teaching methods in Botswana schools: Which philosophies underpinned them? *Mosenodi Journal, 17*(2), 3-27.

Talanquer, V., Novodvorsky, I., & Tomanek, D. (2010). Factors influencing entering teacher candidates' preferences for instructional activities: A glimpse into their orientations towards teaching. *International Journal of Science Education, 32*(10), 1389-1406.

Tarman, B. (2012). Prospective teachers' beliefs and perceptions about teaching as a profession. *Educational Sciences Theory and Practice, 12*(3), 1964-1973.

Tatto, M. T., Peck, R., Schwille, J., Bankov, K., Rodriguez, M., … & Rowley, G. (2008). Policy, practice, and readiness to teach primary and secondary mathematics in 17 countries: Findings from the IEA Teacher Education and Development Study in Mathematics (TEDS-M). International Association for the Evaluation of Educational Achievement. Herengracht 487, Amsterdam, 1017 BT, The Netherlands.

Trigwell, K., & Prosser, M. (2004). Development and use of the Approaches too Teaching Inventory. *Educational Psychology Review, 16*(4), 409-424.

Tsai, C. C. (2002). Nested epistemologies: science teachers' beliefs of teaching, learning and science. *International Journal of Science Education, 24*(8), 771-783

Turner, D. W. (2010). Qualitative interview design: A practical guide for novice investigators. *The Qualitative Report, 15*(3), 754-760. From http://www.nova.edu/ssss/QR/QR15-3/qid.pdf

Underwood, C. (2002). *Beliefs and attitude change in the context of human development*. Sustainable Human Development in the Twenty-First Century. From Encyclopedia of Life Support Systems, (EOLSS). Developed under the Auspices of UNESCO, Oxford, UK: Eolss Publishers.

Uusimaki, L., & Nason, R. (2004). *Causes underlying pre-service teachers' negative beliefs and anxieties about mathematics*. Paper presented at Proceedings of the 28th Conference of the International Group for the Psychology of Mathematics Education, 4, 369-376.

Waters-Adams, S, (2006). The relationship between understanding of the nature of science and practice: The influence of teachers' beliefs about education, teaching and learning. *International Journal of Science Education, 28*(8), 919-944.

Weitzman, E. A. (2000). Software and qualitative research. In Denzin, N. K. & Lincoln, Y. S. (Eds.), *Handbook of qualitative research*. 2nd ed. London: Sage Publications, Inc.

Weldeana, N. H., & Abraham, S. T. (2014). The effects of an historical perspective on prospective teachers' beliefs in learning mathematics. *Journal of Mathematics Teacher Education,17*, 303-330. doi: 10.1007/s10857-013-9266-z

Wilkins, J. L. M., & Brand, B. R. (2004). Change in preservice teachers' beliefs: An evaluation of a mathematics methods course. *School Science and Mathematics, 104*(5), 226-232.

Yasri, P., & Mancy, R. (2012). Understanding student approaches to learning evolution in the context of their perceptions of the relationship between science and religion. *International Journal of Science Education,* 1-22, doi: 10.1080/09500693.2012.715315.

Yesil-Dagli, U., Lake, V. E., & Jones, I. (2010). Preservice teachers' beliefs about mathematics and science content and teaching. *Journal of Research in Education, 21*(2), 32-48.

Youn, I. (2008). The cultural specificity of epistemological beliefs about learning. *Asian Journal of Social Psychology, 3*(1), 87-105.

Zhang, Y., & Wildemuth, B. M. (2009). Qualitative analysis of content. *Application of social research methods to questions in information and library science,* 308-319

Appendix A: INTERVIEW SCHEDULE FOR PRE-SERVICE TEACHER BELIEFS

BREAKING THE ICE

Hello, my name is Kago Confidence Patrick. I am doing my Master's degree of Education in Science here in the University of Botswana and I will appreciate your participation in an interview.

The purpose of this study is to find out the nature of student teachers' pre-conceived beliefs about science education, teaching and learning of science. Therefore, I would like to ask you some questions, which might also be personal, about your views and experiences concerning teaching, learning and science. Do not worry, information generated from our conversation will remain strictly confidential and it will be used only for the purpose of this study.

Part A : Can you please tell me about yourself.

Code name :_________________ Place :________________ Time :_______________

Part B: I am interested in understanding your views about science.

1. *If someone asks you 'what is science?', what will you tell him or her?*
2. *What makes science different from other disciplines of inquiry? Explain.*
3. *After scientists have developed theories, do you think they do not ever change or can change? Defend your answer.*
4. *Is it possible for scientists to arrive at different conclusions from same set of data? Explain how that is possible.*
5. *Can science be affected by social, political, cultural values and norms of people practicing it? Explain why and how.*

Part C : Let us talk about learning.

1. *In your view, science is learnt by which ways?*
2. *What role (responsibilities) do students have to play when learning of science?*
3. *In your opinion, what is the most determinant for the success of learning science? Why?*

Part D : Now, I wish to explore your opinions about teaching.

1. *How would you describe outstanding or good teaching of science?*
2. *On what strategy or method(s) or approach do you think science should be taught?*
3. *In your opinion, what should be the main focus of a teacher during teaching of science?*
4. *Please, describe your ideal science lesson?*

Appendix B: Consent Form

Dear student

I am conducting a study titled;

Probing for pre-service teachers beliefs about teaching and learning of science

What is the purpose of this consent?-I am doing s study in the University of Botswana about prospective teachers and their beliefs on teaching and learning. This study is intended to shed light on the influence that these beliefs may have on teachers' instructional patterns and behaviors in class. It is hoped that by capturing these beliefs at an early stage will help in molding teachers' perspectives for better practices in the field.

You have been considered for this study because you are nearing the completion of your studies and preparing to enter the world of professional teaching. But this does NOT mean you have to participate in the study.

What happens when you sign this consent form?- By signing this form, you agree to participate in the study. This gives the researcher the permission to access your teaching practicum portfolio, and permission to interview you. You are also agreeing to completing a questionnaire administered for the study. Nevertheless, your signature does not mean you are obliged to participate. You may choose to participate or withdraw your participation at any time.

What happens when you do not sign this consent form?-By not signing this form, you choose not to participate in the study. This is a voluntary choice which will not affect your present relationship with the researcher. You will not be penalized or denied of any benefits of your position as a student in the University of Botswana.

Are there any risks to your signing this form?-This is a strictly pen and paper study, which poses no physical harm at all. However, you may experience a certain degree of loss to your privacy. But you are assured that your records will be kept confidential in a secure place where access to them will be limited to the researcher only. Your records will be secured until the end of the study whereupon they will be destroyed with your permission. Your contact details or information will not be shared and your permission will be continuously sought.

Are there any financial considerations?-There will be no cost or payment to you if you consent or sign this form. Participation in this study will not attract any financial rewards, except maybe the benefit of knowledge.

What do you do if you have questions?-In the event that you may have any question concerning the study, you can contact either Kago C Patrick (investigator) at 74069493, kagcon@yahoo.com or Dr. Tawana (supervisor) at 71480789 or tawana@mopipi.ub.bw. But if you wish to make known of your grievances or unfair treatment during the study, you can contact the;

Office of Research and Development , University of Botswana

Tel: 355-2990 Fax: 395-7573 research@mopipi.ub.bw

What do you do to consent?-If you agree to participate in this study, please indicate by signing below. Also include your preferred contact method. Keep a copy of this consent form.

Cell:_________________ Phone:__________________ e mail :________________________

______________________ ________________

Signature (participant) Date

_______________________ _________________

Signature (Researcher) Date

________________________ __________________

Signature (Supervisor) Date

Appendix C: Self Report

My role as a Laboratory Demonstrator

While I was struggling with finding an interesting problem for research purpose, I was offered a temporary position with the university as a Laboratory Demonstrator in the same department (DMSE) I was pursuing my masters. This job influenced this study in that the interest in the topic of teacher belief was elicited by comments I came across when marking students' scripts. My duties included preparing, supervising, facilitating student-teachers' practical work, as well as marking their laboratory reports, lesson plans, test scripts, and assessed their peer teaching or microteaching activities. I also acted as teaching assistant in method courses and this sort of expanded my roles;

> ***Assessor***, I was engaged in helping students to prepare their lesson plans and other relevant materials for peer teaching exercises. In fact, I graded the lesson plans, observed their teaching exercise and evaluated their experiences.
>
> ***Friend***, Because I worked with students so closely on daily basis. I often assisted them on matters of their studies including their other courses taken out of the Faculty of Education. I was also available to attending their personal issues.

My role as a Masters Degree candidate

As a student, I must say, the concepts of NOS and philosophy were rather new to me. This is despite having done them in my undergraduate years. This time though, I was pretty much excited about them. By being a student meant certain demands were put on me, and I had to accomplish them in order to pass. I was learning and at the same time I was expected to behave like I was competent on these issues. Therefore, this study was a learning process in which I was exercising theoretical aspects of research methods and education in more realistic environment.

My role as a researcher

Being the researcher meant that I had to draw boundaries during the times when I held anything to do with this study. But that is the problem, every minute seemed to be about this study. I had to be conscious about small details in the lesson or scripts which were submitted for marking. I was always looking for 'something' anywhere and anytime. My role was intertwined and inseparable from my life. I was new to the field of research, experiencing the application of research methods for the first time. Sometimes I felt constrained by the research ethics on things I can do or say.

My teaching experiences

I have completed my Bachelor degree of Education (Science) with specialization in Biology (Bed, science) a long time back (2005). But before then, I was initially admitted into Bachelor degree of Science (BSc), which I did transfer from at the end of my first year. When I look back, the decision to be a teacher did not really come from within me; rather I was following my colleagues, who at the time had challenges with doing BSc. Unlike my friends, I had no academic trouble with continuing with BSc program, but because the group I associated myself with was moving to education, I felt compelled to join them.

So, as I remember my undergraduate years, I sought of glided through the last three years of Bed science. And at most times, I did everything in my power to drop method courses for Biological courses, which explains my peculiar result transcript. Basically, I never liked teaching, and the method courses were a blurry phase I had to go through.

When I finally completed and started teaching in 2007, I was excited about the prospect of being paid and life after university. In the classroom, however, it was a nightmare! The reality of teaching was so frustrating, with the pressure to effect change in a group of students who also seemed bent towards the opposite of my every effort. As I look back into my teaching experience now, I realize that there was never point in any time where I reflected on what I learnt from the method courses. But still, I always tried to make my lessons interesting. I was outgoing and many students in all the schools I have taught in, found it quite easy to talk to me. I believed in teaching and treating all students equally or fairly despite their outward behaviors or notorious fame. My creativity and enthusiasm with sciences, my ability to see things in a humorous and yet meaningful way, have made my teaching years better and interesting than I ever imagined they would be.

I am a teacher, not born with the talent to teacher, but I have developed into a teacher. I am here, seeking to further my teaching career, one that I never dreamt will be mine.