



**TEACHERS' EXPERIENCES IN IMPLEMENTING HABITS OF MIND WHICH
PROMOTE MATHEMATICS LEARNERS' RELATIONAL UNDERSTANDING,
WHILE OPERATING WITHIN A COMMUNITY OF PRACTICE**

by

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Dissertation submitted in fulfilment of the requirements for the degree

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at the Cape Peninsula University of Technology

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Mowbray

November 2016

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DECLARATION

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ABSTRACT

Current insights into the South African education crisis suggest that emphasis needs to be placed on developing teachers' mathematical knowledge for teaching (MKfT) through ongoing professional development. Aiming to provide insight into teacher professional development, this research describes an initiative undertaken by a group of Mathematics teachers who formed a Community of Practice at their school. Through the implementation of Habits of Mind that promotes Relational Understanding, these teachers attempt to improve the teaching and learning of Mathematics at their school, and further their professional development. A qualitative phenomenological design of inquiry was conducted to describe the teachers' experiences when implementing Habits of Mind in their teaching. Group interviews, individual interviews and documentary sources were used to gain a rich description of the lived experiences of these teachers during the research period. To analyse the data a combination of Giorgi's phenomenological model and the interconnected model of professional growth was used. Results indicate three insights into teacher professional development: (1) Communities of Practice promote the sharing and development of MKfT through the mechanism of collaboration; (2) Teachers are challenged when implementing intervention strategies as firstly their learners are challenged in their literacy ability which limits their articulation in Mathematics lessons, and secondly they are faced with time constraints imposed by workload demands; (3) The attempt to implement intervention strategies within a Community of Practice, despite being challenging, encourages reflective practice which informs individuals' professional practice and supports ongoing professional development.

Key Words/Terms:

Professional development, Phenomenology, Relational Understanding, Habits of Mind, Community of Practice, Lived experience, Teacher Knowledge, Mathematics

ACKNOWLEDGEMENTS

I wish to thank:

- Dr S McAuliffe, for her many years of inspiration in my life. Her encouragement initiated the desire to further my qualifications while I was completing my undergraduate qualifications and lead me to this point.
- Prof C Vermeulen, for the wisdom and experience he has provided, especially through my postgraduate years. He has not only supported and guided me but has become a great role model.
- My family for not only supporting me, but also sharing me with my studies over the past few years. I especially thank my wife, Megan, for the much needed love, support and motivation.

DEDICATION

This dissertation is dedicated to two people who played a vital role in my life and my studies. Firstly, to my late father who unfortunately will not be there to take pictures of people sleeping on the stage at my future graduation as he has previously done. Secondly to my late grandmother whose constant prayer and support kept me motivated through challenging times. They were there when I started on this journey and will not see me finish. Thank you for your love and support.

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GLOSSARY

ANA	Mathematics Annual National Assessment
CCK	Common Content Knowledge
CK	Content Knowledge
CPUT	Cape Peninsula University of Technology
EE	Existing Experience
HCK	Horizon Content Knowledge
KCC	Knowledge of context and curriculum
KCS	Knowledge of content and students
KCT	Knowledge of content and teaching
MKfT	Mathematical Knowledge for Teaching
NE	New Experience
PCK	Pedagogical Content Knowledge
SCK	Specialised Content Knowledge
TPD	Teacher Professional Development
WCED	Western Cape Education Department
ZFM	Zone of Free Movement
ZPA	Zone of Promoted Action
ZPD	Vygotsky's Zone of Proximal Development

CHAPTER 1

INTRODUCTION

1.1 Introduction and background

Fleisch (2013, pp. 17–18) provides three key insights into the crisis in South African primary school education related to Literacy and Mathematics: (1) we are falling behind our counterparts worldwide, (2) longitudinally, our achievement has been neither positive nor negative in the past decade, and (3) we can now identify particular patterns in language and Mathematics underachievement which denote that most areas of Mathematics are exceedingly weak. Educators in Mathematics, both researchers and practitioners, need to examine ways of dealing with this issue. Badat and Sayed (2014, p. 127) state that a failure to act immediately, and with urgency, to reform South Africa's education system is a betrayal of its¹ constitutional ideals which leaves education in crisis.

The Department of Basic Education (2014) released the 2012 education statistics during 2014. In this document, the national results for the Mathematics Annual National Assessment (ANA) revealed a 41.2% average in grade 3, 37% in grade 4, 30.4% in grade 5, 26.7% in grade 6 and 12.7% in grade 9. It is important for South Africans, and especially those in the field of education, to confront the country's education crisis and devise ways to improve learner achievement (Taylor, 2011). Spaul and Kotze (2015, p. 13) list defects in South African Mathematics teaching. They argue that learners, who fall behind in Mathematics at any stage of their learning, if not assisted, stay behind. They state that many local studies have found that: "students acquire learning defects early on in their schooling careers and that these backlogs are the root cause of underperformance in later years". They go on to suggest that learners falling progressively behind in the curriculum eventually reach a point where they have fallen so far behind that no further learning can take place (Spaul & Kotze, 2015).

Venkatakrishnan and Spaul (2014) released an analysis of primary school teachers' mathematical content knowledge. In their analysis, they discuss the dire situation in South African schools: on average 79% of grade 6 Mathematics teachers lack the content knowledge required to understand the Mathematics taught in their own grade. Hill, Rowan and Ball (2005) state that mathematics teachers' content knowledge, for teaching the subject, directly influences learner achievement. They affirm that increasing teachers' mathematical

¹ 'its' pronoun for South Africa's.

knowledge for teaching (MKfT) has positive results on the way learners understand Mathematics: a teacher must possess a deep grasp of the principles of the subject discipline (Hill *et al.*, 2005). The main focus for South African mathematics teachers should be on both pre- and in-service teacher education, aimed at the development of their conceptual understanding of mathematics² (Taylor & Taylor, 2013).

Fortune (2013, p. 1) advocates that a practitioner's knowledge should constantly be enriched by appropriate research: effective researchers are skilled practitioners and *vice versa*. Professional development conducted outside ongoing practice does not reliably lead to change in classroom practice (Loucks-Horsley & Matsumoto, 1999). The combination of research and practice results in a union between the researcher as practitioner and academic phenomenology; a study viewed from a spectrum of lived experience. This research makes use of a phenomenological research design to describe the lived experiences of participants being researched. The investigation was conducted at the school at which I currently teach. Mathematics teachers formed a Mathematics Community of Practice (Wenger, 2000). Jita and Ndlalane (2009) encourage teacher collaboration, such as that offered by a Community of Practice. They argue that it is necessary for the professional development of South African teachers. The focus of the Community of Practice, researched in this study, is the improvement of learners' performance in Mathematics and mathematical understanding, in a way that will continue from grade to grade. The creation and functioning of this group answers the need for Mathematics intervention in learner understanding and professional development of Mathematics educators at school. 'Habits of Mind' was a tool used by this Community of Practice in their teaching in order to implement Habits of Mind in all grades and to promote learners' Relational Understanding of Mathematics.

Emphasis was placed by Cuoco, Goldenberg and Mark (1996, p. 376) on helping learners think of Mathematics in a way that mathematicians do: in this way learners are able to see Mathematics as a set of related areas. Learners are encouraged to see that all forms of Mathematics, whether measurement, fractions, geometry or algebra, are related to each other. This form of mathematical understanding has been referred to as Relational Understanding (Skemp, 1976). Mathematics teachers and mathematicians agree that mathematical 'Habits of

² Conceptual Understanding: Refers to having an understanding of mathematics which enables you to learn new ideas by connecting them to what you already know, i.e. linking concepts in mathematics so that your knowledge is organized into a coherent whole (Swafford & Findell, 2001).

Mind' facilitate this way of thinking (Swars, Stinson & Lemons-Smith, 2009). The focus of this research was to answer/investigate the following research question:

How do teachers experience implementing Habits of Mind as a tool which promotes Mathematics learners' Relational Understanding, while operating within a Community of Practice?

The focus of this research was to look at how this group of teachers experiences the implementation of Habits of Mind in promoting learners' Relational Understanding of Mathematics. The research did not attempt to measure the development of Relational Understanding among learners but focused on teachers' experience of implementing the Habits of Mind to improve teaching practices. Educators in South African schools are confronted with an education crisis, specifically related to up-skilling of Mathematics teachers. This research provides an example of how teachers can address the education crisis *as it affects them* by attempting to improve their own practices and deepen their own teacher mathematical knowledge for teaching (MKfT) (Hill, Ball & Schilling, 2008).

1.2 Rationale

I have witnessed the dire state of South African teacher knowledge (noted in the research of Venkatakrishnan and Spaul, 2014) first-hand in my career over the past five years. In the teaching and learning of Mathematics in schools, I have encountered situations where it was evident that teachers were limited by their knowledge of Mathematics. After conducting research into this shortcoming, I discovered that it was evident in my own experience. The need for developing teacher mathematical knowledge for teaching (MKfT) in South Africa was, and is, crucial to education reform (Mkhwanazi, 2014; Venkatakrishnan & Spaul, 2014; Hill *et al.*, 2008).

I am a research practitioner (Fortune, 2013). An appropriate research opportunity presented itself at my current school. Mathematics teachers requested the formation of a professional learning community which would allow them the opportunity to share mathematical knowledge for teaching and improve their practice. These teachers wished to find out more about interventions which they could implement in their practice and which could assist them in synchronising their methodologies, ensuring similar teaching approaches across all grades. I proposed that they form a Community of Practice to implement Habits of Mind that promotes Relational Understanding. This research made use of the opportunity to research

how these teachers embarked on self-directed professional development (Gaible & Burns, 2005), aiming to provide insights into teacher professional development.

1.3 Purpose statement

This research was prompted by the education crisis in South Africa and inspired by the hope of professional development of teachers to overcome that crisis (Venkatakrisnan & Spaul, 2014; Spaul & Kotze, 2015; Hill, *et al.*, 2005). By answering the research questions that follow, this study provides an example of how teachers can and do collaborate to improve their mathematical knowledge for teaching (MKfT): something which, ideally, could inspire other teachers to do the same. The aim of this research therefore was to provide insight into the professional development of mathematics teachers. This was achieved by describing how such teachers set about improving their own knowledge of Mathematics and tuition skills in order to tackle, on a small scale and in a limited yet realistic manner, the large-scale crisis in South African education.

Research questions

The following primary research question guided this study:

How do teachers experience implementing of Habits of Mind as a tool that promotes Mathematics learners' Relational Understanding, while operating within a Community of Practice?

To guide this research in answering the primary question, the following subsidiary questions were set out:

- What were teachers' perceptions of how Habits of Mind influenced their practice?
- What were their experiences as part of a Community of Practice?
- What were their perceptions of promoting Relational Understanding?

1.4 Literature review overview

In the literature review, a conceptual framework was used to gather literature which explained the four primary concepts underlining this research. These four concepts are: lived experiences, Habits of Mind, Relational Understanding and Communities of Practice. These four aspects make up the research question: '*How do teachers experience implementing*

Habits of Mind as a tool which promotes Mathematics learners' Relational Understanding, while operating within a Community of Practice?' The literature review, however, does not discuss these concepts in the order in which they occur in the primary research question. Instead, the concepts are ordered purposefully to relate them to their relevance to this research. In the literature review I first discuss the theory of situated cognition which allows me to formulate the relation of lived experiences and professional identity (Berdo, 1994; Clancey, 1997; Husserl, 1982). This relation justifies the descriptions made in this research of participants' experiences which are used to provide insight into their professional development (Wai Sum & Shi, 2016). I then discuss literature related to professional development of teachers and place this research within professional development models (Burns, 2005). I justify the relevance of Communities of Practice to professional development (Wilbourne, 2008; Brodie, 2014; Owen, 2014).

The literature review focuses on the concept of Relational Understanding using the theories of Vygotsky (1978) and Skemp (1976) to justify its relevance in Mathematics education. Relational Understanding is defined as the procedural knowledge to know what to do when solving a Mathematical problem and the conceptual understanding to know why you are doing it (Kilpatrick, Swafford and Findell, 2001; Pope, 2014). Once the concept of Relational Understanding is explained, the notion of Habits of Mind is related. In this research, the specifically selected Habits of Mind are described as being a tool that promotes Relational Understanding in the way learners think about and do Mathematics (Selden & Selden, 2005). These concepts are elaborated in Chapter 2.

1.5 Overview of methodology

The research was a qualitative phenomenological inquiry which described the experiences of the research participants. The site of the research was a school at which I am currently teaching. I am guiding a group of mathematics teachers who made a conscious effort to improve their learners' Mathematics understanding and achievement through their own professional development. The request of the teachers was to form a collaborative group in which they would be able to share ideas and practices and which they believed would improve their practice. In response to this I suggested the formation of a Community of Practice between these Mathematics teachers. I recommended implementing Habits of Mind as a classroom methodology that promotes learners' Relational Understanding. This research

investigated this phenomenon and describes the experiences of these teachers, as research participants, during the process.

I made use of seven group interviews, followed by two individual interviews with each participant; for data collection. These interviews were conducted and audio recorded over the eight-month research period. Participants were asked to keep anonymous reflective journals to document their experiences during the first six months of the research period. These reflective journals, along with learner books from the participants' classes, were used as documentary sources for further data collection and analysis.

Two models were used to analyse the data collected. Giorgi's (1975) procedural model was used primarily: to analyse the data and generate revelatory themes³. This analysis required all audio recordings to be transcribed, combined with data collected from the documentary sources, and read repeatedly in order for themes to emerge. These emergent themes were reflected on and the most-often occurring, or dominant themes were related to the research questions, generating revelatory themes. The second model used was the interconnected model of professional growth (Clarke & Hollingsworth, 2002). This model allowed for the mapping of interconnected patterns in participants' natural units⁴ which assisted in the formation of descriptions regarding the nature of their professional development.

1.6 Significance

South African teachers can increase their knowledge for teaching through professional development (Venkatakrishnan & Spaull, 2014; Spaull & Kotze, 2015). Despite a shift in interventions that promote the development of teacher knowledge in South Africa, a large part of local research suggests that effective development in teacher knowledge remains an elusive target (Mkhwanazi, 2014). Research reveals a need for collaboration between teachers which promotes development of teacher's mathematical knowledge for teaching (MKfT): comprising subject matter knowledge (SMK) and pedagogical content knowledge (PCK) (Hill *et al.*, 2008; Jita & Ndlalane, 2009). Few systematic academic inquiries have been made into aspects germane to teacher collaboration; such as developing professional learning communities in schools to encourage ongoing professional development (Steyn, 2013).

³ A revelatory theme is a theme which is relevant in answering the research questions (Giorgi, 1975; Whiting, 2002).

⁴ Natural units is the term used by Giorgi (1975) to describe participants experiences, their own comments, in the form of units of meaning which are segregated from the rest of the transcribed text.

In its aim to provide insights into teacher professional development, this research meets the need for promoting ongoing teacher professional development which is promoted through developing their MKfT within a Community of Practice. This research provides insight into self-directed professional development which has proven to be a more reliable way of promoting change in teacher knowledge and directly leads to change in classroom practice (Gaible & Burns, 2005; Loucks-Horsley & Matsumoto, 1999).

1.7 Scope and limitations

There are a number of limitations to this study specifically, and qualitative research generally. It is difficult to demonstrate how findings and conclusions are applicable to other situations because qualitative inquiries are usually specific to a small number of individuals and contexts (Shenton, 2004). It is important for the researcher to provide contextual information regarding the site and sample so that other practitioners can assess the transferability of results and conclusions. The site and sample of this research are discussed in paragraph 3.6.1. An overview of this section is as follows:

This research investigated a group of three primary school Intermediate Phase⁵ Mathematics teachers who were engaged in self-directed professional development (Gaible & Burns, 2005). The site was a school located in, and serving, a low-income community. These three teachers recently established a Community of Practice, collaboratively working to develop their mathematical MKfT (Wegner, 2000; Hill *et al.*, 2008). This research used a transcendental phenomenological method of inquiry⁶ to describe the experiences of these participants; aiming to provide insight into their professional development. To overcome the limitation of the small sample size, an in-depth description of the participants' context and experiences as Mathematics teachers is included in participant profiles which were used to complement the rich descriptions of the participants' experiences during the research period.

The positionality of the researcher poses a limitation in this research. To limit the influence of my personal bias or possible preconceptions related to the outcomes of this research, phenomenological reduction⁷ was implemented. This entailed a declaration of my positionality prior to the research period to allow me to become aware of the possible

⁵*Intermediate Phase*: Grades four to six.

⁶ *Transcendental phenomenology*: Creswell (2007) describes this as using a combination of textual descriptions of the participant's experiences, as well as structural descriptions of these experiences in terms of situations, conditions and contexts.

⁷ *Reductive Phenomenology*: A dimension of phenomenological research where the researcher reduces their influence on the research conducted, retaining its academic rigour (Spiegelberg, 1976).

influences on the research. This self-awareness assisted me to bracket⁸ these preconceptions and limit their influences on the research.

This research did not focus on any improvement in learner performance nor did it measure any extraneous factors which could have influenced the context of the participants. It did, however, provide an in-depth description of participants' experiences as they were described through the data collection instruments.

1.8 Outline of dissertation chapters

This dissertation is organised into five chapters.

Chapter One is the introductory chapter, in which the research is introduced by explaining the background, rationale, significance, limitations and purpose of this research. This outline of the research questions and aim includes an overview of the literature review and methodology.

Chapter Two is the literature review in which a conceptual framework is used to discuss the concepts guiding this research, and ground them in relevant literature and theories. The concepts discussed in this chapter were lived experiences, professional development and Communities of Practice based upon the theory of situated cognition, and Relational Understanding and Habits of Mind: founded on the theories of Vygotsky's relational ontology (Murphy & Carlisle, 2008) and Skemp's (1976) relational understanding.

Chapter Three deals with methodology, and depicts in detail the methods used for data collection and analysis. This methodology provides validity for the methodology used in this research and submits detailed descriptions of how the research questions were addressed in a comprehensive research plan. This strategy included a justification for the choice of research approach and a detailed description of a phenomenological research design. Further descriptions of the choice of site and sample are provided as well as explanations of the data collection instruments and processes. Issues surrounding the trustworthiness and authenticity of this research are addressed; including an in-depth vignette of the researcher's role in light of my positionality. The data analysis models used in analysing the data are described. This chapter concludes with an elaboration of the protocol followed to ensure ethical considerations are met.

⁸ *Bracketing*: a strategy of descriptive phenomenology where researcher attempts to suspend personal views related to the research to create a fresh unbiased outlook on the phenomenon (Spiegelberg, 1976).

Chapter Four presents and discusses the findings of the qualitative data analysis, results and interpretations. The findings are presented in three sections: (1) participant profiles are created from the data collected to create an in-depth look into participants' lived experiences and context, (2) the revelatory themes which emerged from the participants' descriptions are presented and discussed, (3) patterns of professional development evident in participants' experiences are discussed using an interconnected model of professional growth (Clarke & Hollingsworth, 2002).

Chapter Five presents the conclusions of the research. The chapter reflects on the research which was conducted in an attempt to answer the research questions and determine the extent to which the aim of this research was met. Summaries of the research aim, background and limitations were presented. This chapter concludes by discussing the insights into teacher professional development provided by this research and suggests recommendations for further research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides a coherent review of literature pertinent to this research; including concepts, theories, methods and history. The literature review illustrates influential research conducted in related research fields (Randolph, 2009). Gall, Borg and Gall (1996) maintain the role of the literature review is to delimit the research problem, seek new lines of inquiry, avoid fruitless approaches, gain methodological insights, identify recommendations for further research, and seek support from grounded theory. The literature review précis should be the framework for research, provide the researcher with guidelines for appropriate methodology and aid in the analysis when checking findings (Liehr & Smith, 1999). This chapter provides insight into notions of Relational Understanding in Mathematics education and implementation of Habits of Mind as an efficient tool for promoting Relational Understanding. Professional learning communities are described, such as Communities of Practice, as a means of developing teacher practice and professional development. The concept and relevance of lived experience in this research are explained in this section.

2.2 Structure

A conceptual framework is used to structure this literature review rather than a theoretical framework. Although conceptual and theoretical frameworks are often used as interchangeable concepts in literature, Imenda (2014) argues that they are two distinct constructs. A theoretical framework explicates the theory that the researcher has chosen to guide the research: it is the application of the underlying theory of the research, drawing out concepts from the theory in an attempt to provide an explanation for a particular phenomenon or research problem. Alternatively, the researcher, referencing only a single theory, or concept residing within the theory, may draw upon views resident in literature relevant to the research question using a conceptual framework. Using a conceptual framework allows the researcher to bring together various related topics and create a broader understanding of the phenomenon of interest: similar to an inductive⁹ process of linking smaller individual

⁹ Inductive and Deductive approaches: An inductive (theory building) approach is concerned with the development of concepts related to a phenomenon and the relationships of the concepts whereas a deductive (theory testing) approach tests known theories using new imperial data towards possible refinement, improvement or extension of the theory(s) (Bhattacharjee, 2014).

concepts to others which together reveal a coherent interpretation of conceivable relations (Imenda, 2014). The framework used in this literature review leans towards the theoretical framework: it draws upon the theories of Situated Cognition and Vygotsky's Relational Ontology. However, the concepts discussed in the literature review are related to each other using relevant literature. This review contains inductive processes associated with those of a conceptual framework. Thomas (2006) explains that the inductive approach characterises research which attempts to clarify the reduction process of qualitative data collected through development of themes to aid in creating meaning from raw material. This process describes what is being done in this research project; placing it in the inductive domain. Imenda (2014) formulates that the inductive approach to research favours the development of a conceptual framework because the theoretical framework requires a deductive approach. It is more appropriate to classify this framework as a conceptual framework since it uses the inductive process which Bhattacharjee (2012, p. 3) describes as inferring "theoretical concepts and patterns from observed data".

2.3 Overview

The aim of this literature review is to discuss concepts relevant to this research. These concepts are discussed with reference to the aim of the research; relating views of relevant literature in order to provide relevance of the concepts to the research. The research question, *'How do teachers experience implementing Habits of Mind as a tool which promotes Mathematics learners' Relational Understanding, while operating within a Community of Practice'*, reveals the four main concepts guiding this research. These concepts, Lived experiences, Communities of Practice, Relational Understanding and Habits of Mind, are discussed within this conceptual framework.

The rationale behind the ordering of the sections in the literature review is first to introduce the underlying theory of Situated Cognition, and second to discuss relevant concepts such as Lived Experiences, Communities of Practice and Habits of Mind in their relation to the theory of situated cognition. The discussion takes place with reference to relevant literature and other research conducted within, and related to, this research.

The concept of lived experiences is discussed first to define how teacher identity and lived experiences are linked. This relation is important since the next section on professional development assumes the link has been made. The section on professional development is placed between lived experiences and Communities of Practice to channel the discussion between the two concepts. Placement of this section links the need for professional development with teacher identity and motivates the use of Communities of Practice to satisfy this need. The location of this research within Professional Development frameworks and models is discussed to justify the relevance of Communities of Practice in professional development. Once this justification is made, Communities of Practice are discussed with reference to relevant literature to strengthen the flow of discussion from Situated Cognition to Lived Experience to Professional Development and last to Communities of Practice. The sections that follow focus on explaining the use of Habits of Mind which promote the development of Relational Understanding. Relational Understanding is discussed in the literature review before Habits of Mind because it determines the choice of which Habits of Mind are chosen for this study. Given that Habits of Mind were chosen in order to promote Relational Understanding, the importance and relevance of Relational Understanding to the research are dealt with first. Second the relevance of Relational Understanding to the participants' goal of improving learners' performance in Mathematics is examined. I follow this aspect by discussing what Habits of Mind are. I justify the choice of the specific Habits of Mind chosen for this research by making links to relevant literature and research. The flow diagram Figure 2:1 below illustrates these links in a visual overview of the chapter.

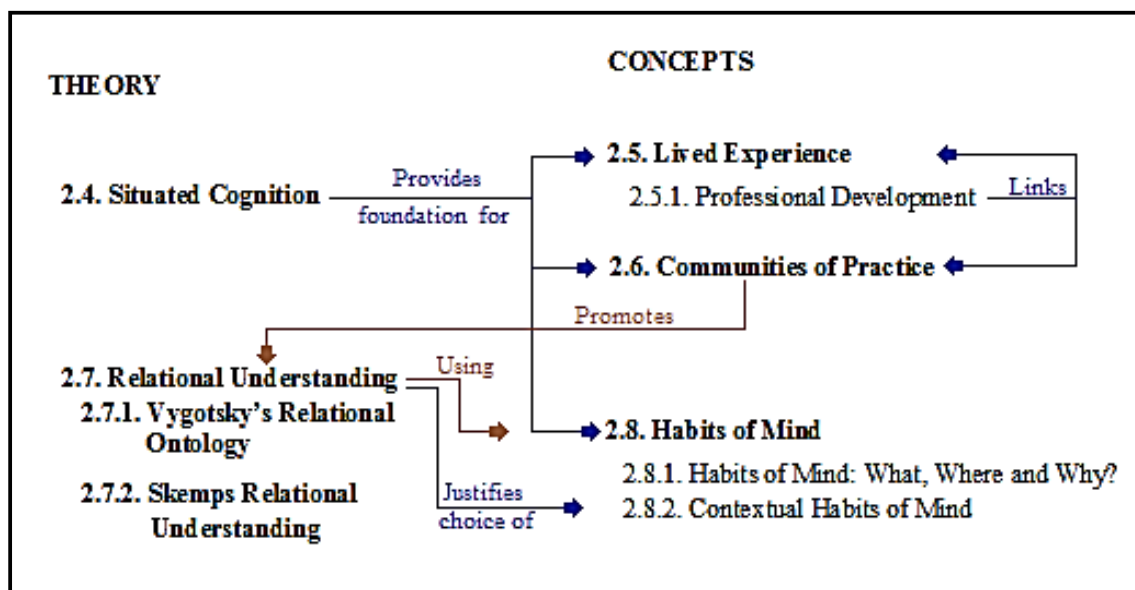


Figure 2:1 Literature Review Overview

2.4 Situated Cognition

Situated Cognition provides the theoretical foundation needed to describe key concepts in this research. This section deals with the theory of Situated Cognition by linking it to the various concepts guiding this research. The theory of Situated Cognition refers to the learning premise whereby knowledge is created within the context or environment in which the activity generating the knowledge takes place so that the knowledge cannot be separated from its original context or situation (Brown, Collins & Duguid, 1989). The situation, referred to as the activity in which the knowledge is learned and how the knowledge is used in context, is an integral part of what is being learned. Learning and cognition are fundamentally situated (Brown *et al.*, 1989). This concept is referred to as Social Situatedness, or simply as situatedness: Derry (2013, pp. 24, 108) states that theories of situatedness present human mental functioning as fundamentally related to cultural, institutional and historical contexts involved in knowledge formation.

Social interactions, as described in the theory of Situated Cognition and their importance in the development of individual intelligence, can be found in the works of Vygotsky and, although it is not always referred to, have to a certain extent influenced theories of situated cognition (Clark, 1997; Hutchins, 1995; Krishner & Whitson, 1997). Vygotsky (1978, p. 40) proposes that there is an organisation of higher cognitive processes of organisms which occurs through mediated action in response to stimuli in the environment. However, Wertch, Tulviste and Hangstorm (1993) argue that Vygotsky's (1978, p. 243) failure to specify the social cognitive processes involved is often said to be antithetical to arguments of situatedness which he pursued. Husserl (1982) supports the concept of situatedness when explaining the crucial nature of the attachment of the researcher to the lived world in which the research participant is situated. Husserl (1964, p. 177) terms this inward consciousness of the situated environment as the individual's *lived experience*. The concept of lived experiences is a fundamental part of this research and is discussed in paragraph 2.5.

Deliberating on this concept, Vygotsky (1978) distinguishes between two levels of mental functions: (1) elementary mental functions, which are functions innately existing in both humans and other animals, and (2) higher mental functions which develop through drastic transformations of elementary mental functions and the use of psychological instruments. Vygotsky (1981, p. 137) lists, as psychological tools: language, various systems for counting,

mnemonic techniques¹⁰, algebraic symbol systems, works of art, writing, schemas, diagrams, maps, mechanical drawings and conversational signs. His argument is that elementary mental functions consist of natural mental functions such as elementary memory, perception and attention; whereas higher mental functions are exclusive to humans and require transitional links between the social or cultural stimulus and the mediated response to the stimulus. This argument strengthens his association between the situated environment and the individual's development. Egocentric speech is a term used by Vygotsky (1962) to motivate his ideas regarding mental functions, emphasising the role of language in the transformation of thinking processes. Here he differentiates between social speech and inner speech. Social speech is shared between others: more specifically other people; whereas inner speech is an inward speech systematising an individual's own thinking. Egocentric speech is the shift from social speech to inner speech accentuating the use of human language as a psychological tool which creates thought. Vygotsky believes that language is animatedly associated with thinking and frees us from direct perceptual experiences; enabling the representation of past, future and un-present experiences.

Carpenter and Lehrer (2009) allude to what Vygotsky dubs psychological tools, referring to speech or human language, by using the term 'articulation'. They link articulation to reflection; claiming that these aspects are two forms of mental activity that lead to understanding, suggesting that articulation is reflection in the public form. Carpenter and Lehrer (2009) discuss the internal process of reflection through mindful examination which epitomizes what Husserl (1964) regards as the inward perception within one's lived experiences. The close association between reflection and its influences on the individual's identity and lived experiences is a theme that re-occurs frequently throughout this research.

The following quotation identifies two lines of cognitive development proposed by Vygotsky (1960, p.17):

"The growth of the normal child into civilisation usually involves a fusion with the processes of organic maturation. Both planes of development – the natural and the cultural – coincide and mingle with each other. The two lines interpenetrate one another and essentially form a single line of sociobiological formation of the child's personality".

Vygotsky (1960) identifies biological factors considered to be the elementary mental functions associated with the natural plane of development and socio-historical factors

¹⁰ Mnemonic Techniques: techniques used to aid in memorizing or remembering something.

associated with the cultural plane of development. These factors on the two planes are where physiological tools, such as human language, are invented and used to intermediate to higher mental functions. The process by which an individual makes use of physiological tools for the transformation of mental functions, Vygotsky (1960) names 'signification' which is one of two key principles associated with the transformation of elementary mental functions to higher mental functions. Wertsch (1992, p. 549) states that the second principle is the General Law of Cultural Development which Vygotsky (1978) defines as a twofold development. This twofold development first occurs at a social, inter-psychological level and later transforms into an individual intra-psychological level. The belief that cognitive development and consequently intelligence emerge as a result of participation between biological factors and social environmental factors is central to Vygotsky's Sociocultural Theory of Development which has later been termed situatedness (Lindblom & Ziemke, 2003). Lave (1991) states that this concept of situatedness is extensively present in the theories of cognitive science and Situated Cognition (Lindblom & Ziemke, 2003). Bourdieu (1987) describes this social interaction as one in which individuals develop their personal identities: something Kostogriz and Peeler (2004) explain as associated with the individual's lived experiences.

Although fundamentally similar to cognitive theories, theories of situated cognition possess the essential premise that learning has a social disposition and cannot occur autonomously. The theory proposes that society and culture share a common role in learning (Lave, 1996). Lindblom and Ziemke (2003), as well as Wertsch (1992), underline the similarities between the social cognitive theory of Vygotsky and theories of situated cognition. Lave (1966) and Winbourne (2014) discard social cognitive theories when discussing situatedness; stating that the focus of social cognition rests too much on the individual. Yet it is hard to argue against cognitive theorists, specifically Vygotsky (1978), in the development of situated cognition theories (Winbourne, 2014).

Berdo (1994) and Clancey (1997) discuss two tenets related to situated cognition. The first is the interwoven nature of cognition and context, by which meanings are inseparable from their interpretation and by which knowledge is linked to the relations of which it is a product (Hung, Looi and Koh, 2004). Clancy (1997) explains that the second tenet signifies the nature of cognition-in-action (Hung *et al.*, 2004, p. 194) which describes how an individual's memory is not stored but is rather a processed memory which means that every thought is a reconstruction. Heidegger (1962) considers interpretation to be fundamental to all aspects of

situatedness; stating that existence is in essence the same as interpretation seeing that individuals cannot be separated from their interpretations. The situated cognition perspective does not divorce persons, context, culture and language from the construction of meanings (Hung *et al.*, 2004): learning and action cannot be separated from each other since knowledge is developed through the activity in which it is manifested. Therefore situations co-produce knowledge through activity (Brown, Collins & Duguid, 1989).

Brown and Duguid (2000, p. 121) highlight two critical distinctions in the learning process: learning “about” and learning “to be”. Learning about can take place by anyone learning about something. The authors use the analogy of learning about Tibetan medicine without the need to become a Tibetan doctor. Learning to be, however, requires engagement in the practice being learned. This in turn forms the essence of social identity development and is aligned with situated cognition regarding learning within practice. Brown and Duguid (2000) explain that individual identities are observed and mutually established or re-established through interactions within a Community of Practice situated in contexts; making them ideal for learning to take place (Hung *et al.*, 2004).

Reflecting on what was discussed above from literature relating to Situated Cognition, the following concepts arise. First, the concept of lived experiences, and identities, has been referred to many times when discussing Situated Cognition. This reference is a result of the deep-seated bond between the situated environment, individuals’ lived experiences and the Situated Cognition theory (Berdo, 1994; Clancey, 1997; Husserl, 1982). This situated environment, when examined in literature, relates to the physical environment and the social, historical and cultural environments. Second, the combination of situated environments (i.e. social, historical and cultural) is where the individual’s reflections on identity, as a response to simulation within the situated environment, can be observed when the individual is operating within a Community of Practice (Brown & Duguid, 2000). Communities of Practice are depicted as rich in situated contexts and ideal for learning: the appropriate locality for this research (Hung *et al.*, 2004). Third, the importance of psychological tools has been described as understood by Vygotsky (1981) in situatedness. Crawford (1995) discusses these tools by explaining that the appropriation should not be the only concern: invention of new tools is what truly constitutes socio-cultural development. Her view of the individual’s interaction with the immediate environment is one in which old tools are dismissed and replaced by new emergent tools. Stable tools are recognised within the social culture and used by most of the individuals interacting within the environment.

Understood in this way, new emergent tools within the situated environment observed in this research are the Habits of Mind implemented by participants in their teaching. These tools are either assimilated by the Community of Practice, being the participants, and possibly become stable tools, or dismissed as new tools emerge through interaction with these tools within the situated environment. These concepts, namely lived experience, Communities of Practice and Habits of Mind, are discussed and explained in this literature review in sections 2.5–2.8.

2.5 Lived experience

“The term lived experience signifies givenness of internal consciousness, inward preceivedness” (Husserl, 1964, p. 177)

Lived experience, according to Husserl (1964), is the interpretive availability of an individual when under observation and a definitive basis of intelligibility (Van Manen, 2007). This criterion denotes that lived experiences of participants allow their perceptions of a phenomenon being studied to become available for the researcher to interpret. Hung *et al.* (2004) highlight the role of lived experiences in situated learning, or learning using situated cognition strategies when considering a balanced view of learning. Van Manen (2010, p. 5) states that to research experiences is to know the world in which the participant exists: *“to know the world is profoundly to be in the world in a certain way, the act of researching – questioning – theorizing is the intentional act of attaching ourselves to the world, to become fully part of it, or better, to become the world”*. To research and describe lived experiences in a systematic manner, the researcher has to uncover the ‘essence’ of the experiences with depth and richness: something which can be done through a phenomenological research design (Husserl, 1982). A similar study undertaken by Wai Sum and Shi (2016) researching the professional roles of a Physical Education teacher in Hong Kong explored lived experiences. The choice of investigating lived experiences in their research arose from a concern to gain insight into the lived world of the research participants by describing their professional identity and development. This approach explores lived experiences; which provides insight into teacher professional development by describing participants’ experiences.

Koopman (2015) claims that, by investigating lived experiences, through the use of a phenomenological research design, he was able to gain entry into the inner world of each participant. Koopman (2015) refers to Husserl’s (1975, p. 4) view that “phenomenology is a form of inquiry that describes the lived experiences of others and informs us about the

participant's perception..." This research makes use of a phenomenological methodology design in order to research the lived experiences of teachers participating in the research as explained further in paragraph 3.5.

Two fundamental concepts in this research have been identified when discussing Situated Cognition: Lived Experiences and Identity¹¹. These two concepts are closely related but not identical or interchangeable. Wenger (2000, pp. 238-243) explains identities as a fourfold amalgamation: he defines identity first in terms of the individual's experiences of practice, second in terms of the individual's relations within a Community of Practice, third as modes of belonging to a Community of Practice, and last as the individual's self-identification within a community and ownership of the meaning of this identification. These definitions are discussed in paragraph 2.6. Concisely, the two concepts, lived experiences and identity, are related because an individual's identity is influenced by his or her lived experiences. An individual's identity is defined by the lived experiences shared with other individuals when part of a Community of Practice.

Wenger (2000), referring to Eckert (1989, p. 238), states that knowing, learning and sharing knowledge are not abstract procedures but all part of belonging: just as an individual's knowing¹² is interwoven with his or her identity within a Community of Practice. Wenger (2000) states that identities are crucial to social learning systems because: (1) identities link competence and experience with knowing, informing the individual of decisions made within a social community, (2) open up identities to a situated environment, through the act of engaging and suspending them according to social boundaries, allowing for learning from interactions within the community, and (3) individuals' identities are living vessels in which communities and boundaries are developed as experiences within the situated environment. Wenger (2000, p. 239) lists three crucial qualities which must coexist in order for a healthy social identity to be realised. These are:

Connectedness: Identity is a lived experience of belonging, or not belonging to social communities. A strong identity requires deep-rooted connections with others through shared lived experiences and mutual commitments, amongst other social interactions.

¹¹ Refer to paragraph 2.4.

¹² Wenger (2000: 226) defines knowing as the act of participating in complex social learning systems, and is therefore a way of displaying competence as defined in such communities.

Expansiveness: Healthy identities require multi-membership, seek a vast range of experiences and are open to new possibilities.

Effectiveness: Identities are vessels of participation, or non-participation, within the social world. Healthy identities are socially empowering.

Schools are institutions that have complex socio-cultural networks; something which implies that the identity of the teacher, or teacher identity, stems from a convergence of lived experiences and socio-cultural histories. This view of schools is becoming more accepted (Kostogriz & Peeler, 2004). Teacher identity can be associated with teacher professional identity since a teacher is essentially identifiable as a professional. Researching teacher professional identity is vital to teacher education: it contributes to understanding what it is to be a teacher in today's schools and provides relevant insights into a rapidly-changing field of education (Beijaad, Meijer & Verloop, 2004). Brown and Duguid (2000) suggest that teacher identities are best developed within a Community of Practice.

In conclusion, this section elaborates on the concepts of lived experiences and identities. It discusses teacher professional identity and its influence in school systems. Last, the role of a Community of Practice in developing teacher professional identity was alluded to; something which will be discussed in paragraph 2.6. Now that the association has been established between teacher experiences and teacher professional identity, the next section discusses professional development in some detail. This section on professional development establishes the role of Communities of Practice in teacher professional development, so continuing the discussion from situated cognition to Communities of Practice (paragraph 2.6.

2.5.1 Professional development

This section provides insight into teachers' lived experience. Teacher professional identity can be associated with lived experience (Beijaad, Meijer & Verloop, 2004). Killion and Hirsh (2011) support this association by crediting teachers' lived experiences of professional development with the direct influence of classroom practice.

Mathematics teachers need to search for new ways to improve teaching practices and deepen knowledge and understanding of teaching and learning Mathematics. Taylor and Taylor (2013) accentuate that they found many South African teachers' subject knowledge was insufficient to provide their learners with an adequate understanding of the subject discipline. Taylor and Taylor (2013) recommend both pre- and in-service training; emphasising development of teachers' conceptual understanding¹³ of the subject. Their analysis suggests that mathematical content knowledge is necessary, but that teachers require a more specialised fundamental content knowledge which is important within the South African terrain. Venkatakrishnan and Spaul (2014) draw on the work of Ball, Thames & Phelps (2008) when considering frameworks in the development of South African Mathematics teachers' content knowledge. Jita and Ndjalane (2009) urge clusters¹⁴, or networks, in South African schooling districts. They believe such clustering assists in creating opportunities for teachers to challenge, and develop, their subject content knowledge (CK) and pedagogical content knowledge (PCK). These two concepts, namely CK and PCK, were introduced by

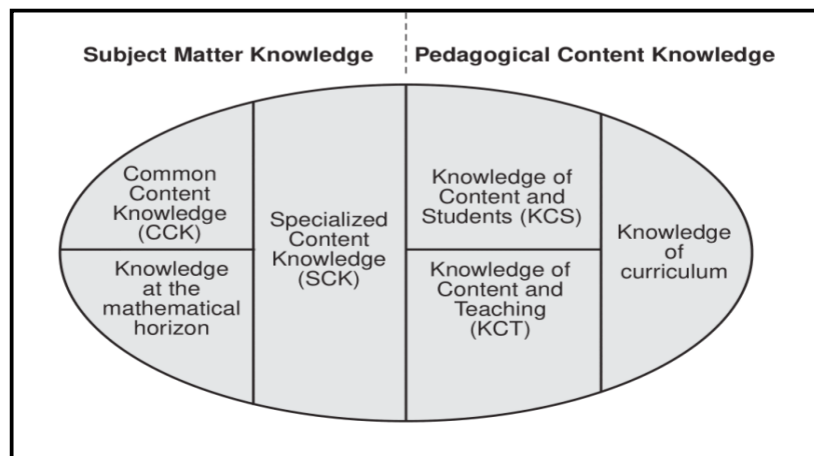


Figure 2:2 Domain map for mathematical knowledge for teaching (Hill *et al.*, 2008, p. 377)

Shulman (1986) but newer conceptualisations have emerged since then. Hill, Ball and Schilling (2008) more recently illustrate teacher knowledge, more specifically mathematical knowledge for teaching (MKfT), in a domain map Figure 2:2.

¹³ Conceptual Understanding: Refers to having an understanding of mathematics which enables the linking of concepts in mathematics so that your knowledge is organized into a coherent whole (Swafford & Findell, 2001).

¹⁴ Clusters: This refers to collaboration, where methods and intervention strategies are shared, between teachers in different schools which are located in close proximity to each other.

The right side of this domain map retains the name given by Shulman (1986), pedagogical content knowledge: Hill *et al.* (2008) have subdivided it into three categories. Hurrell (2013) explains these subdivisions as:

Knowledge of content and students (KCS): A combination of knowing about students and Mathematics subject knowledge.

Knowledge of content and teaching (KCT): A combination of knowing about teaching and Mathematics.

Knowledge of context and curriculum (KCC)¹⁵: Knowledge of the strands in, and proficiencies from, the Mathematics curriculum, as well as a familiarity with the structures of the curriculum.

The left side of the domain map is referred to as subject matter knowledge which Ball *et al.* (2008, p. 389) describe as '*professionally orientated subject matter knowledge in Mathematics*'.

Common Content Knowledge (CCK): Commonly known Mathematical knowledge of individuals, teachers and non-teachers alike, who make use of Mathematics.

Specialised Content Knowledge (SCK): Mathematical knowledge and skills unique to the teaching of this subject.

Horizon Content Knowledge (HCK): The ability to apprehend how mathematical topics are related to one another across the span of Mathematics included in the curriculum.

Venkatakrishnan and Spaul (2014) conclude in their research that South African teachers' performance indicates gaps in teacher mathematical knowledge for teaching (MKfT). Descriptions of these gaps resemble the domain map drawn by Hill *et al.* (2008); referred to as CCK. Venkatakrishnan and Spaul (2014) conclude that their research proves the need for urgent in-service professional development.

Improving on instructional practice of teachers through development of new knowledge and techniques is the focus of effective professional development which has as its goal improving the learning of learners (Wei, Darling-Hammond, Richardson & Orphanos, 2009). Helsby

¹⁵ Knowledge of curriculum (Hill *et al.*, 2008) was later referred to as Knowledge of context and curriculum (Hurrell, 2013)

and McCulloch (1996) discourage a dormant teaching life and encourage teachers to create their own opportunities for professional development. Gaible and Burns (2005) provide three models for teacher professional development (TPD): Standardised TPD, Site-based TPD and Self-directed TPD.

Standardised TPD: selected teachers attend workshops or receive outside training on a particular area where growth is needed in the school. On returning to the school, these teachers provide professional development on what they have learnt, to their colleagues.

Site-based TPD: signifies that teachers collaborate with facilitators (who are masters in their field) through a more gradual process on development and training. This collaboration takes place either in the school itself or in teacher training institutions and focuses on situational problems facing individual teachers: it allows for the mastering of pedagogical skills of those teachers receiving the training.

Self-directed TPD: indicates that teachers take their own initiative and govern their own professional development. This type of TPD allows for both individual and cooperative approaches by which teachers determine their own goals and choose their own activities to help them reach these goals (Gaible & Burns, 2005, p. 25).

The professional development being described in this research falls in the self-directed teacher professional development model: it is self-initiated independent learning through collaboration of teachers, using available resources; teachers are attempting to develop their mathematical knowledge for teaching (MKfT) through collaboration in a Community of Practice. Developing mathematical knowledge for teaching, as depicted in Figure 2:2, encompasses all forms of content, subject and pedagogical knowledge described in analogous research. Positive aspects of a self-directed professional development model are (1) it helps teachers seeking professional development to become models of lifelong learning, (2) teachers collaborate seeking advice from more knowledgeable colleagues, and (3) self-initiated professional development often leads to communities of support and development provided between staff in different schools (Pelgrum & Law, 2003). Brodie (2011; 2014) conducted research into teacher professional development within professional learning communities in a South African context. She suggests that, based on her research, it is imperative that teachers go through a process of professional development: however there is no evidence that current teacher development programmes satisfy this need (Brodie, 2014, p.

25). She supports the notion of teacher development within Communities of Practice stating that:

Six key characteristics of successful professional development programs have been identified: they are long-term and developmental; they focus on artefacts of practice such as student thinking, tasks and instructional practices; they use actual classroom data; they encourage design and reflection on the part of teachers; they are job-embedded (school-based) and therefore blur boundaries between teaching and learning about teaching and they promote the development of professional learning communities.

Clarke and Hollingsworth (2002, p. 947) conducted research focussed on teacher professional development. They state: ‘If we are to facilitate the professional development of teacher, we must understand the process by which teachers grow professionally and the conditions that support and promote that growth.

They discredit the relevance of teacher development programmes, stating that their¹⁶ ability to apply relevant learning theories and research, such as that of professional development models, is infrequent. Clarke and Hollingsworth (2002) specify that when considering professional development of teachers, it is important to explore the notion of ‘teacher change’ which exists in the literature of Doyle (1990), Guskey (1985) and Johnson (1996). Guskey (1986) suggests two crucial factors in teacher professional development programmes, which, if not taken into account, will undoubtedly contribute to the ineffectiveness, and possible failure, of the program itself. The first of these is teachers’ motivation to engage in professional development. Teachers participating in this research, fortunately, are participating in the self-directed TBD model as described above. The professional development programme is self-initiated which means that these teachers are motivated because they have what Guskey (2002, p. 382) describes as the ‘belief that it will expand their knowledge and skills, contribute to their growth, and enhance their effectiveness with students’. The second crucial factor suggested by Guskey (2002) is the importance of teacher change. Guskey (2002) explains that professional development initiatives focussed on teacher change are designed to initiate a change in teachers’ beliefs, perceptions and attitudes which may lead to a change in their practice and ultimately result in improved student learning. Clarke and Hollingsworth (2002, p. 948) describe six perspectives of teacher change:

¹⁶ Their: a pronoun referring to the ability of the teacher development programs.

- Change as training: something done to teachers causing them to change: “; that is, teachers are changed”
- Change as adaption: teachers change their practices in adaptation/response to something
- Change as personal development: teachers seeking change in an attempt to improve their personal practice
- Change as local reform: teachers change something in search of personal growth
- Change as systemic restructuring: teacher changing policies of the learning system
- Change as growth or learning: teachers, who are themselves learners in a learning community, inevitably change through professional activities.

Guskey (2002) emphasises the need for professional development initiatives in order to become more effective in the process of examining teacher change which suggests the use of alternative models to guide these initiatives and make them more effective. An example of an alternative model of professional growth can be seen below in Figure 2:3.

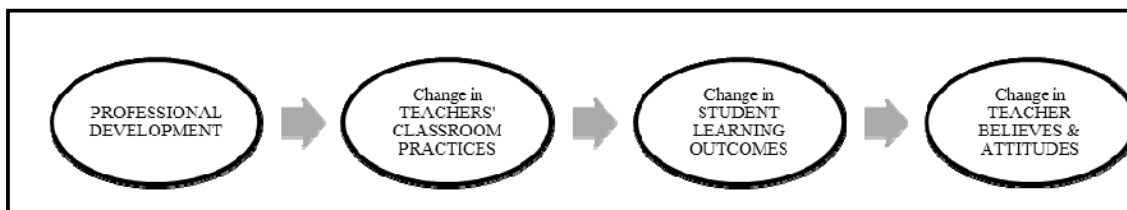


Figure 2:3 An alternative model of professional growth (Guskey, 2002: 383)

This alternative model of professional growth which could assist in examining teacher change is based on, but does not sequentially adhere to it, is based upon Guskey’s (2002) premise that professional development initiatives have three major goals: (1) changing teachers’ classroom practices, (2) changing teachers’ beliefs and attitudes, and (3) changing learning outcomes of students. Clarke and Hollingsworth (2002) criticise the alternative model for being too linear; they are in favour of a model which they describe as analogous to Guskey’s (2002) model. The model posed by Clarke and Hollingsworth (2002) involves continuous interplay between teachers’ beliefs and attitudes, their classroom practices and student learning outcomes. In accordance with this linking, they encourage the use of the

interconnected model of professional growth. The interconnected model can be seen in Figure 2:4 below: the four domains are illustrated and act as examples of interceding processes using solid and broken arrows.

The interconnected model above implies that teacher change occurs through the interceding processes of reflection and enactment between four domains. The term ‘enactment’ is chosen to describe the translation of teacher beliefs into action which occurs in the domain of practice; implying that each action symbolises an enactment of what the teacher knows, believes or has experienced. This implication, however, does not limit the process of enactment to the domain of practice because the interceding processes can occur between any of the domains. The term ‘reflection’ (Clark and Hollingsworth, 2002, p. 6) refers to Dewey’s (1910) explanation of reflection being “active, persistent and careful consideration”. By using these interceding processes, reflection and enactment, as pathways between domains, this

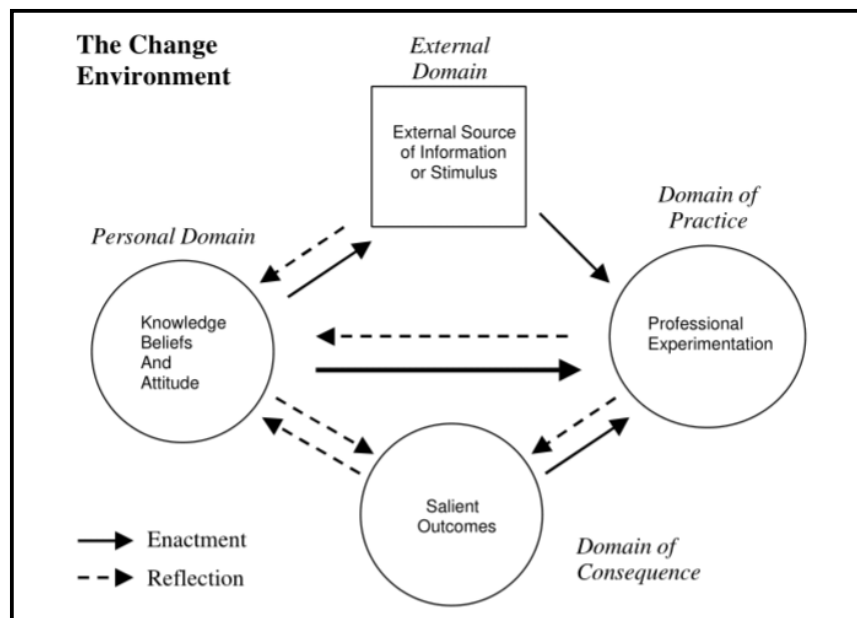


Figure 2:4 The interconnected model of professional growth (Clarke & Hollingsworth, 2002: 951)

model recognises the complex nature of professional growth by identifying multiple pathways of teacher change between the four domains. Clarke and Hollingsworth (2002, pp. 950–951) state that these four domains encompass change in the teachers’ professional world in response to professional development: (a) teacher change as a result of new knowledge, attitudes and beliefs – personal domain, (b) teacher change in response to experimentation

with new teaching strategies – domain of practice, (c) teacher change in relation to salient¹⁷ outcomes in response to classroom practice – domain of consequence, and (d) teacher change in response to stimuli located outside of the teacher’s personal world related to external support or sources of information – external domain.

Clarke and Hollingsworth (2002) credit the interconnected model with allowing researchers who are conducting research related to the professional development of teachers, the opportunity to map alternate pathways between domains which recognise the idiosyncracies¹⁸ of teacher professional development. The application of this model to this research is discussed further in paragraph 3.8.2.

2.6 Communities of practice

For teacher professional development to become more effective, an innovative pedagogical model promoting collaboration and constant teacher support needs to be adopted (Meletiou – Mavrotheris & Mavrotheris, 2006). Zern (2002) states that most teachers exist in professional isolation, with limited opportunities to collaborate with their colleagues. Collaborative learning communities, such as Communities of Practice promote teacher learning and development (Meletiou – Mavrotheris & Mavrotheris, 2006). Wilbourne (2008) is of the opinion that all learning can be accounted for in terms of an individual’s involvement in, and developing a sense of, identity, while being within a Community of Practice in some way.

In related local research, Brodie (2014) reveals that an increasingly researched and developed topic is that of professional learning communities. While researching ways in which Mathematics teachers could create and sustain professional learning communities focusing on learner errors, Brodie (2014, p. 222) concurs that “successful professional learning communities create environments where teachers can explore their strengths and weaknesses with colleagues; develop collaborative solutions to problems of practice; and implement new ideas collectively for the benefit of learners”.

Owen (2014) lists the benefits of professional learning communities in her research which focused on teacher professional development (what she termed professional growth). In her findings, Owen (2014, p. 54) concludes that while literature indicates core elements of professional learning communities such as “shared vision and values, collegiality, joint

¹⁷ Salient: what teachers perceive to be prominent, relevant or significant outcomes

¹⁸ Idiosyncrasy is the word used by Clarke and Hollingsworth (2002) and refers to a usual characteristic or habit. In this context relates to ability to recognise characteristics of individuals’ professional development.

practical activities and student learning data, teacher inquiry and leadership support opportunities” there are other pivotal characteristics of professional learning communities evident in her research. These characteristics provide insight into the importance of school leadership in the early stages of establishing the professional learning community. Owen (2014) finds that engaging in challenging debates between members of professional learning communities supports members’ professional development and sustains transformative educational practices which improve student learning.

The term ‘Community of Practice’, as a professional learning community, is given to a collaboration of individuals working together towards a shared furthering of knowledge (Lave & Wenger, 1991). The Community of Practice theory is a Vygotskian theory aimed at the social construction of knowledge as opposed to individualistic learning views (Ernest, 2002). Wenger (2000, p. 227) believes Communities of Practice have their origins in the beginning of human history and that they are essential to our learning: they are at the core of human capability to form meaningful knowledge. He defines knowing as a way of exhibiting competences defined in social communities, stating that individuals experience unique ways of knowing but the interplay of this in social communities is where learning occurs. Wenger (2000) describes two components to knowing as: (1) competence, which is knowing, established by the community, or communities, over time, and (2) experience, which is ongoing knowing of the world as a member of the community. The interaction between these components of knowledge he defines as a dynamic shared relation between the individual and social learning systems, being the Community of Practice.

Wenger (1998, pp.73-82) reveals three dimensions which he believes describe how Communities of Practice define competence, as seen in Figure 2:5. He believes these dimensions reveal progress within the Community of Practice.

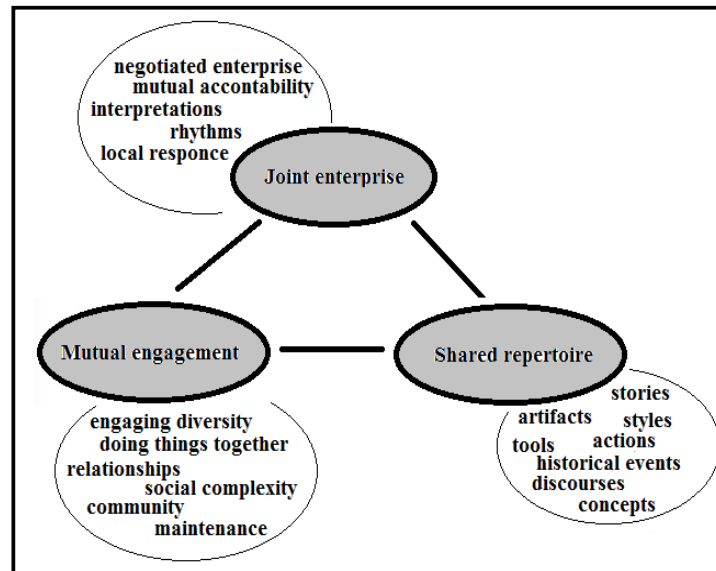


Figure 2:5 Dimensions of Communities of Practice, adapted from Wenger (1998: 72)

Joint enterprise: How the community takes the initiative to keep learning at the heart of the Community of Practice. The term used to describe this is learning energy.

Mutual engagement: This is described as the depth of social capital. Like capital in any organisation, this is seen as something built up over time and is in the form of trust, openness and other social interactions in which community members interact to address the focus of any task collaboratively.

Shared repertoire: The degree of self-awareness of the Community of Practice allows members to reflect and develop its self-conscious. This notion broadens understanding of the communities' practices, allows multiple perspectives to emerge and helps realise possibilities of progress.

Wenger (2000) distinguishes between three modes of belonging within these social learning systems which capture the various forms of social interaction in these communities. These modes of belonging are:

Engagement: This mode refers to collaboration of individuals with their fellow members of the community. In this mode the individual learns what he or she is capable of doing and learns how the world responds to such actions which deeply shape lived experience and identity.

Imagination: Wenger (2000, pp. 227-228)) refers to Anderson (1983, pp. 4–6) who describes nations as communities; stating that no-one can engage with full community of any nation. However, using our imagination, even though imagining something factual and not fantasy, individuals are able to empathise with the nation without fully engaging with it and all its members. It is important for the individual to be able to imagine life within the community which involves constructing a self-image of own identity within it. This ability allows orientation and reflection of one's situation, as well as possibilities of participation within the social environment.

Alignment: This mode refers to an individual's ability to manage activities so that the realisation of the community goals becomes the intended outcome. This is, however, not a single-orientated course of action but a co-ordinated standpoint of mutual consent in the community. This collaborative aspect is important for the individual's identity formation.

Wenger (1998) cites two benefits of distinguishing between these modes. First, he believes it to be an effective way to study, classify or distinguish between communities by comparing the extent to which each model influences the community. He explains that each community has a unique combination of influences: one community might be based more on imagination, whereas another may be more focussed on engagement. Second Wenger (1998, pp. 173-181) believes that as the different modes require, and provide, opportunities for different shared activities, balancing the degree of influence of the different modes is beneficial for the community. These modes can be both conflicting and complementary to one another in the unique situation of the community. It is important for the community to fine-tune alignment between these modes in accordance with the shared goal. An example of such alignment within this research project is where teachers, operating within a Community of Practice, co-ordinate modes of belonging towards the shared goals of improving learners' results and providing professional development for themselves.

These models of belonging, together with the three dimensions of progress Figure 2:5, work together in producing an effective Community of Practice. Wenger accordingly (2000. p. 230) states "Without the learning energy of those who take initiative, the community becomes stagnant. Without strong relationships of belonging, it is torn apart. And without the ability to reflect, it becomes hostage to its own history". Communities of Practice need to interact with a number of elements for engagement of the modes and dimensions to take

place. Wenger (2000, pp. 230-232) lists six elements which aid a community in designing itself. These are:

Events: Organising activities in which the community can be brought together around a single purpose is classified as an event. This event could be a formal or informal meeting, presentation, problem-solving session, relevant to the communities' joint objectives. These events aid in development of community identity.

Leadership: Internal leadership is an essential part of Communities of Practice. The community needs multiple forms of leadership for all its various members to play their roles effectively but central leadership can be concentrated on one or two members who co-ordinate day-to-day work of the Community of Practice.

Connectivity: Communities require a rich fabric of connectivity between members and therefore, over and above events, it is important to make opportunities for communication between members on different platforms.

Membership: The choice, and limitations, of a community's membership are crucial to effectiveness. Members within the community should not be so numerous that the identity of the Community of Practice is lost; overextended communities should diffuse into sub-groups. This diffusion ensures that the focus of the community remains intact.

Projects: Assuming responsibility over learning agendas allows for deeper shared commitment of members and improves practice.

Artefacts: These are assets developed by the community over time. A community needs to maintain and develop such artefacts in order for them to retain usefulness for the evolving community.

These elements can be discerned within this research and such discernment increases the relevance of Communities of Practice in this research. The leadership within the community decides on a joint task: the need for professional development. This task can be associated with the learning energy of the Community of Practice. The structuring of regular meetings which will be discussed in paragraph 3.6.3 satisfies the elements of creating events and learning projects in which communication over different platforms is achieved. The indented goal of this will be for the community to have a newly-developed artefact which assists the

Community of Practice to reflect on practice and deepen its self-awareness. This reflection allows the professional development of the Community of Practice to occur.

DuFour (2004) criticises the familiar cycle of intended school reform efforts. Such efforts he holds are often abandoned as a result of implementation failure. He advocates a Professional Learning Community (PLC) model, such as Community of Practice. He emphasises that these communities can avoid the cycle by encouraging educators to reflect critically, sustaining the community's existence and allowing it to become deeply rooted in the school's culture. Jita and Ndlalane (2009) believe that community-based approaches promote collaboration, construction and sharing of Content Knowledge (CK)¹⁹ and Pedagogical Content Knowledge (PCK) in a meaningful way. Cochran-Smith and Lytle (1999, p. 250) postulate that learning fundamental ideas related to both teacher knowledge and practice, stems from teachers interacting in learning communities in which they share knowledge of practice (acquired through formal training), knowledge in practice (knowledge gained through teaching experiences), and knowledge for practice (a combination of the other two). Successful learning communities develop collaborative solutions to issues in practice and promote collective implementation of new ideas for learner benefit. This is achieved through sharing experiences of members of the community, identifying areas for improvement in practice and implementing change in order to satisfy both teacher and learner needs (Katz, Earl & Ben Jaafar, 2009)

2.7 Relational understanding

The two remaining concepts to be discussed, Habits of Mind and Relational Understanding, are closely linked in this research. The reason for this proximity is that the purpose of the specific Habits of Mind being used here is to promote development of learners' Relational Understanding of Mathematics. In order to expand on this aspect it is important to discuss the concept of Relational Understanding as understood by this research. The use and selection of the specific Habits of Mind used in this research are related to it.

The human ability to develop and identify patterns²⁰ in nature has allowed man to develop human knowledge to where it is today. All forms of science involve pattern recognition, structuring and predicting. Humans have a natural propensity to create order out of what

¹⁹ The term content knowledge as described by Jita and Ndlalane (2009) could be encompassed within subject matter knowledge (Hill *et al.*, 2008), refer to Figure 2:2.

²⁰It is important to note that the word '*pattern*' is used but refers more to regularity (which will be further explained later).

seems to be chaos (Storr, 1992). This ability to organise nature into a knowledge base of relational science is how humans develop knowledge. This propensity should be relevant to Mathematics education. Skemp (1978, p. 9) stresses the importance of Relational Understanding, linking it to learners' ability to do Mathematics. The Department of Basic Education (2011) makes reference to relations in Mathematics throughout the Curriculum and Assessment Policy Statement (CAPS) which is the current National Curriculum Statement (NCS). Although Relational Understanding, specifically, is not highlighted, developing relations in Mathematics is stressed in the specific aims and skills in this curriculum statement. In the CAPS document, the Department of Basic Education (2011, p. 8) states that Mathematics is seen as “a human activity that involves observing, representing and investigating patterns and quantitative relationships in physical and social phenomena and between mathematical objects themselves”. The concept of learning through making relations can be traced as far back as Vygotsky (1978) in his Sociocultural Theory of Learning. In this theory he makes use of the development of cognitive schemas which comprises grouped knowledge stored in the brain. He claims that, unless related schemas are linked to each other, where old schemas are related to new ones, true learning does not take place.

2.7.1 Vygotsky's Relational Ontology

Vygotsky's Relational Ontology Theory provides a justification for linking Habits of Mind, Relational Understanding and education. Relational Ontology relates the socio-cultural theories of Dewey, Piaget and Vygotsky. While Piaget and Dewey take a more Darwinian stance; treating learning as a product of, or adaptation to, nature, Vygotsky's ontology holds more of a Marxist position²¹ : learning takes place through collaboration between individuals. The emphasis placed on teaching and learning is the development of tools which pass on from generation to generation to aid in the development of knowledge (Murphy & Carlisle, 2008). In this context, the tools are the Habits of Mind developed collaboratively in the classroom, discussed as tools in paragraph 2.4. Developing relations between schemas becomes a goal in itself to learners; allowing them to develop their own sense of agency. Learners feel the enriching sense of understanding. Relating schemas is organic in quality. Skemp (1976, p. 24) states that “This is the best way I have been able to formulate a quality by which they seem to act as an agent of their own growth”.

²¹ Marxist Position: focus on the individual's role in the production process, in this context the production of knowledge.

Vygotsky (1978) mentions three previously major theoretical positions generally held by theorists in his field relating to the interaction between children's learning and development: (1) child developmental processes are independent of the processes of learning, (2) child development is learning, and (3) a combination between the first two positions in order to overcome their extreme views. Vygotsky rejects all three positions in favour of an interpretation concerned with the relation between learning and development. His preliminary argument is that a child's learning begins long before attending school, and that all learning taking place at school has a relation to previous learning in the child's history. Vygotsky (1978, p. 90) states that "From this point of view, learning is not development; however, properly organised learning results in mental development and sets in motion a variety of developmental processes that would be impossible apart from learning". An essential feature of learning is that it produces the Zone of Proximal Development by which an assortment of developmental processes operate, but only when the child is creating relational interactions between prior knowledge and the physical and social environment. The internalisation of this knowledge becomes part of the learner's independent developmental achievement (Vygotsky, 1978).

Vygotskian theory is frequently viewed as a support for effective teacher and learner engagement: the teacher is regarded as the more knowledgeable²² other who provides scaffolding in the Zone of Proximal Development in order for learners' potential capacity to develop (Warren, 2009). Valsiner (1987, pp. 99–106) expanded Vygotskian Zone Theory into three zones: Vygotsky's Zone of Proximal Development (ZPD), the Zone of Free Movement (ZFM) and the Zone of Promoted Action (ZPA). Vygotsky's ZPD according to Valsiner (1997) is seen as development that includes the social environment as well as the individuals in it. Vygotsky (1978, p. 87) dubs it a *tool* used by educators and psychologists to understand a child's *internal course of development*. ZPD is focused on the learning that takes place when individuals manage their connection with their learning environment and others in this environment. The origin of the Zone of Free Movement's lies in the work of Lewin (1933) and is concerned with the structures and possible limitations, within the learning environment which includes: the learner's agency, behaviour, preconceived limitations and abilities as well as external factors such as the availability and access to *learning* aids, the nature of assessment, all forms of curriculum (national, school, overt and covert) and organisation of the environment. (Goos & Bennison, 2008). ZFM provides the

²² Vygotsky originally used the word 'knowing'

environmental organization needed to access, and use these structures by individuals in the environment. This access can be regulated either by the individual themselves or a joint action between different individuals but is an internalised learning process (Galigan, 2008).

The Zone of Promoted Actions is promoted by the more knowledgeable other; including the use of activities towards the promotion of schema development which is an element that should be present in ZPD. This zone, ZPA, supports this research because it advocates the implementation of promotional tools, such as Habits of Mind. Being the more knowledgeable other, the teacher's knowledge of content and pedagogy is a vital factor in effective teaching and learning (Bobis, Clarke, Clarke, Thomas, Wright, Yong-Loveridge & Gould, 2005). It is important that the teacher knows more in terms of facts and has a well-developed concept of how these facts fit together relationally in the larger schema. Teachers who have this more explicit knowledge enable learners to develop conceptual relations as opposed to the stagnant understanding and segregated facts linked to instruction from teachers with a limited knowledge base.

Developmental Zones have implications for teachers' professional development, highlighting the benefits of collaborative endeavours between two or more in the aim of improving one's practice. Neilsen, Barry and Staab (2007) convey the benefits of collaboration between teachers towards professional development; stating that it is a way for novice teachers to learn from the experiences of more experienced others. For teachers' professional development to take place effectively, teachers need to participate in, and become part of, a Community of Practice that supports the transition of teachers with limited knowledge, to those with a greater mathematical knowledge for teaching (MKfT²³). Teacher knowledge is key in providing a Zone of Promoted Actions where promotional tools are used effectively for instruction that features conceptual connections (Warren, 2009).

2.7.2 Skemp's Relational Understanding

Skemp (1976) defines mathematical understanding as having two meanings. One is instrumental understanding; the ability to use memorised rules to arrive at an answer. The second is Relational Understanding; the ability to know what procedures to use to solve a problem and why those procedures are applicable. He claims that where Relational Understanding exists, less remembering and application of rules are required: greater focus

²³ Hill, *et al.* (2008)

falls on general application of principles. Like Vygotsky, Skemp promotes relational thinking and understanding.

In the context of this study, Relational Understanding refers to learners' ability to relate new concepts in Mathematics to previously learnt schemas. Often learners do not link different concepts in Mathematics. A learner does not necessarily see that addition is linked to multiplication, that subtraction is the inverse of addition, or that decimals are another form of fractions. Learners tend to see all these concepts as separate, unrelated pockets of knowledge. Relational Understanding is fundamental in enabling learners to see the connections between areas in Mathematics, to grasp the fact that all Mathematics is interlinked. Once a learner is able to identify and understand such linkage, he or she is moving towards Relational Understanding of Mathematics (Skemp, 1976).

Relational Understanding is adaptable to new tasks: once a learner understands the application of a method and the reasons for using the particular method, he or she can relate the method to appropriate problems and then adapt the method to new problems (Skemp, 1976). In light of this benefit, Relational Understanding of concepts allows for understandings of one area in Mathematics to be transferred to other areas in the subject through adaptation of those understandings to fit the situation. This adaptation allows for common cognitive processes to apply to all areas in Mathematics.

Benefits of Relational Understanding include:

- As schemas grow, awareness of possibilities in Mathematics enlarges and allows for connections to be made more easily,
- It generates more confidence for a person to attempt new ways of reaching the answer without help. This confidence leads to enjoyment of the work by developing agency for the subject – the development of agency for learning is a benefit associated with Vygotsky's Relational Ontology (Murphy & Carlisle, 2008),
- Relational Understanding constructs conceptual structures used to develop understanding of the subject as a whole (Reason, 2003).

In more recent research, Pope (2014) challenges current teaching practices and curricula in their over-reliance on reinforcing algorithms²⁴. Pope (2014) claims that Skemp's (1976) highly-influential descriptions of instrumental and Relational Understanding have been widely adopted in the terms 'procedural' and 'conceptual' learning respectively. Procedural learning focuses more on the procedures, such as algorithms, used in calculation, whereas conceptual learning refers to the understanding of how and when to use specific procedures; learners develop network-related schemas when learning Mathematics. Pope (2014, p. 151) describes the current argument which exists about consensus of teachers' classroom practices. Algorithms are currently the sole focus of learning which privileges procedural learning and deprives learners of authentic mathematical experiences essential in the development of Relational Understanding. Kilpatrick, Swafford and Findell (2001, p. 118) define the term 'conceptual understanding' as one in which learners have "organised their knowledge into a coherent whole, which enables them to learn new ideas by connecting those ideas to what they already know". This definition of conceptual understanding is useful in making the connection between Skemp's (1976) term Relational Understanding and the more recently coined conceptual understanding. Kilpatrick, Swafford and Findell (2001, p. 121) describe procedural fluency as knowledge of procedures, knowledge of when and how to use them appropriately and skill in performing them flexibly, accurately and efficiently". This explanation of procedural fluency resembles an aspect of Relational Understanding: Skemp (1976) describes one part of it as having the ability to know what procedures to use to solve a problem. The combination of procedural knowledge and conceptual understanding meets Skemp's (1976, p. 20) definition of Relational Understanding by which he defines as "knowing both what to do and why.

Research conducted by Foster (2013) and Ofset (2012) corroborates that there is a strong focus on teaching solely in lines of procedural learning. Pope (2014) considers the overemphasis on procedural fluency to be detrimental to learners' Relational Understanding of Mathematics. Pope (2014) cites Foster (2013, p.152) stating: "I have previously argued that the ideological valuing of procedural knowledge has a tendency to fragment the curriculum into meaningless, bite-sized facts and skills, learned with little Relational Understanding.

²⁴ Algorithms: not merely referring to algebraic rules but all methods of calculation such as long division, column methods of addition and subtraction, etc.

In summary, Relational Understanding is beneficial in teaching and learning Mathematics because it connects schemas, assimilating knowledge and collaboration between individuals. Relational Understanding creates conceptual structures which can be used as tools that aid in the development of knowledge and understanding of the subject as a whole, and which are transferable between generations. Relational Understanding as initially described by Skemp (1976) can be associated with the terms procedural fluency (knowing what to do) and conceptual understanding (knowing why to do it) found in the work of Kilpatrick *et al.* (2001), Ofset (2012), Foster (2013) and Pope (2014).

2.8 Habits of Mind

2.8.1 Habits of Mind: What, Where and Why?

Mark, Cuoco, Goldenberg & Sword (2010, p. 505) state that “Although it is necessary to infuse courses and curricula with modern content, what is even more important is to give students the tools they will need in order to use, understand, and even make Mathematics that does not yet exist”. The development of tools to support the development of understanding in Mathematics is believed to be a requirement in the classroom to structure teaching and learning of the subject. Many teachers have been exposed to more current ideas of teaching Mathematics but it is not always easy to put theory into practice. Current recommendations in literature emphasise the critical nature of developing, Habits of Mind to aid learners’ mathematical development (Mark *et al.*, 2010). Once these Habits of Mind are developed and the required kind of thinking in Mathematics is established in learners, learners are able to apply them in the context of geometry, calculus, statistics, trigonometry, algebra, and in other areas (Achieve, 2008).

So *what* are Habits of Mind, *where* did they come from and *why* are they an efficient tool in the promotion of Relational Understanding? Habits of Mind are an idea investigated by Cuoco, *et al.* (1996). It was viewed as a way to organise the Mathematics curricula so as to encourage high-school and college students to think of Mathematics in the same way that mathematicians do. Since then it has become of considerable interest in the field, gaining the attention of Mathematics teachers and others in the field of Mathematics (Swars, Smith, Smith & Hart, 2009). Habits of Mind are regarded as ways of thinking about Mathematics, specific ways of thinking about a specific area in Mathematics and ways of doing Mathematics. Habits of Mind are considered to be helpful in this regard (Selden& Selden, 2005). Bass (2005) sees Habits of Mind as practices that are used by mathematicians and

emphasises the importance of cultivating these practices in young children to harness their intuitive minds. Bass (2005, p. 422) describes a need for Habits of Mind in the educational process; arguing that it maintains balance and integrity to all aspects of the educational process. Cuoco (2008, p. 2) mentions that the elusive nature of intellectual sophistication and higher order thinking in Mathematics can be met through a ‘Habits of Mind’ inspired syllabus that encourages explicit attention to mathematical ways of thinking. Some examples of Habits of Mind are: doing/undoing, building rules to represent functions and abstracting from computation (Driscoll, 1999), pattern sniffers, experimenters, describers, thinkers, use of multiple points of view, breaking things into parts, etc. (Watson, 2006), reasoning with relations, generalising with geometric ideas, investigating invariants and sustaining reasoned exploration (Driscoll, DiMatteo, Nikula, Egan, June & Kelemanik, 2008).

2.9 Contextual Habits of Mind

The choice of which Habits of Mind were required for the needs of this research was made carefully. It would be counterproductive if, like Watson (2006), endless lists were made of Habits of Mind for different stages of teaching and learning. That would be in conflict with the goal of developing Relational Understanding where the focus is on having less to remember (Reason, 2003). The nature of Relational Understanding calls for a definitive list of habits that is relevant for all areas of Mathematics. Similar to what has been decided upon in this research, Charbonneau, Jackson, Kobylski, Rogninski, Sulewski, and Wattenberg (2009) chose to define key Habits of Mind to develop particular elements of Mathematics in the classroom. The Habits of Mind used in this research have been selected based on fundamental understanding of Mathematics. Mathematics as a science of pattern and structure is widely accepted by many in the field. Mulligan, Mitchelmore, Kemp, Marston and Highfield (2008, p. 11) mention this notion when they state “virtually all Mathematics is based on pattern and structure”. Many studies into the benefits of using patterning in Mathematics teaching and learning conclude that learning takes place through the use of pattern identification and structuring produces development in Relational Understanding and mathematical proficiency (Kilpatrick & Swafford, 2002). The concept of pattern can be confused by linking it to number pattern (such as 2; 4; 6; 8; ... or 123; 134; 145; ... etc.), geometric patterns (square; triangle; circle; square; triangle; ...) or other repeating patterns. This overlap is one aspect of the broader meaning of pattern used by Mulligan *et al.* (2008). What is pattern in Mathematics? Orton (2005, p. vii) succinctly defines pattern in Mathematics as the search for order, so that regularity is more likely than not. Pattern as used

here in its broader mathematical sense to refer to regularity. The Habits of Mind selected in this study have been chosen around this core idea of regularity and structure.

The first habit of mind used is “identify regularity”. In a research paper discussing Mathematics practices, Bass (2008) includes this habit of mind by calling it “seeking patterns or structure”. It is helpful to learners if they are encouraged to perceive, comprehend and use pattern wherever possible in Mathematics (Orton, 1992). If they can identify regularity they can do something with it. Often authors refer to this as a habit of mind when focussing on transitioning from arithmetic to algebra as abstracting regularity from calculations (Mark *et al.*, 2010). Regularity can be seen in all areas of Mathematics. For example, when given a number of different quadrilaterals, learners could identify that they all have four sides and four angles. They have now recognised a pattern or identified regularity present in all quadrilaterals. Another example would be identifying, after doing a few additions involving the digits ‘7’ and ‘8’, that the number 15 is always reached. The learner determines whether that continues when adding ‘70’ and ‘80’ ($= 150$), ‘47’ and ‘68’ ($= 115$); however, adding ‘17’ and ‘83’ ($= 100$), does not produce a 5. After doing the latter, the learner(s) might come to the conclusion that when ‘7’ is added to and ‘8’, ‘5’ is obtained; provided the place value is the same, unlike in ‘37’ and ‘83’. The steps taken to identify this regularity have enabled the learner to formulate, represent, and solve Mathematics problems regarding adding ‘7’ and ‘8’. All the learner has done initially is to notice the regularity (Smith, Hillen & Catania, 2007). By identifying the regularity, and making a conjecture, regarding ‘7’ and ‘8’ or even that all quadrilaterals have four sides and four angles, the learner has formulated his own rule or procedure when dealing with a particular concept. Now every time he or she sees a shape, it is simple to say whether the shape is a quadrilateral or not because all quadrilaterals have four sides and angles. If a learner is given the number sentence $57 + 28 = 84$ he/she can now through his understanding tell it is false because there is no ‘5’ in the answer. This illustrates a learner’s comprehension of concepts while promoting their Relational Understanding of Mathematics by relating learned concepts to new situations. However learners will need to be prompted to explain their identification of the regularity in order to show and develop their Relational Understanding.

At this point the second habit becomes relevant: to “discuss the regularity”. Generating and sharing answers help learners develop their Relational Understanding. Carpenter and Lehrer (2009, pp. 22–23) state that reflection and articulation are two forms of mental activity which develop mathematical understanding by relating learned concepts to new ones; similar to

Relational Understanding. They explain that reflection entails a mindful examination of the mathematics acquired in relation to prior knowledge: learning does not develop through acquiring new knowledge but through adaptation of prior knowledge. To reach true understanding of a concept being acquired, a learner, through the process of reflection, can either: (a) assimilate it by relating it to prior schemas, or (b) accommodate for the new knowledge by adjusting existing schemas to suit the knowledge being acquired (Wang, Hwang & Ho, 2013). Carpenter and Lehrer (2009, p. 22) state that “Articulation requires reflection, and, in fact, articulation can be thought of as a public form of reflection”. Articulation is a vital outcome of education and a benchmark for understanding Mathematics through accommodation and assimilation of schemas as described in Relational Understanding. In this habit of mind, reflection and articulation need to be merged in a collaborative effort to communicate the essence of the regularity that has been identified in order to describe it critically. The word ‘discuss’ implies articulation and a marriage between reflection and articulation. When communicating mathematical ideas, articulation takes many forms and can be communicated verbally, diagrammatically, pictorially, in mathematical models or in written form. All of these forms of communication can be seen as articulation (Carpenter & Lehrer, 2009).

Collaboration and sharing of ideas establish a positive classroom culture, give learners an opportunity to practice accountability, clarity and respect, and allow the class not to rely on the teacher to supply the answer in all instances (Smith *et al.*, 2007). This habit of mind can be described as articulation of a generalisation using mathematical language. When learners generalise, they are developing a solution to the problem by creating a rule to be used when this type of problem recurs in the future. By allowing learners to discuss, the teacher promotes mathematical language which, when developed, grants them the ability to articulate their thoughts mathematically to solve problems (Watson, 2006; Mark *et al.*, 2010). Learners can independently create Mathematics that is new to them; challenging each other’s reasoning. This creation aids in correcting errors. Learners contemplate answers. By enhancing this internal process of drawing on their own knowledge to create new knowledge, learners form a mental map of schemas which allows for adaptation in future tasks (Reason, 2003). Leikin (2007, p. 2 335) links this process of discussion to ‘Habits of Mind’ by explaining the notion of *solution spaces* which are areas where learners are encouraged to help each other problem solve through discussion and collaboration. This strategy correlates

with Vygotsky's ontology when he mentions the benefits of individuals collaborating to form new knowledge (Murphy & Carlisle, 2008).

The third habit taken from Driscoll (1999, pp. 1–2) in his algebraic Habits of Mind includes the concept of “reversibility”, do and undo, or working backwards. If the learner understands how to do something, then he/she should be able to undo it as well. This is a good way to check whether what a learner has articulated in the previous habit holds true. Reversibility allows learners to develop counterarguments to their conjecture which are limitations, or where their generalisation does not work. By working backwards, learners are able to solidify both reasoning and understanding. For example, if $4 + 6 = 10$ then a learner should be able to know what $10 - 6$ is. Another example would be to allow learners to define their own properties of a square by letting them identify the patterns. They might arrive at the premise that all the angles are the same or all the angles are 90° no matter how big or small the square, or that all the sides are of equal length. Or learners may assume that if the object is rotated, there are four positions where the shape looks the same. To show reversibility, the teacher describes a square through its properties: learners need to identify that it is a square. Driscoll's (1999) concept of “reversibility”, however, is an algebraic focussed Habit of Mind and a concern is that it might not be applicable to all areas of the subject. Vermeulen (2008) suggests algebraising of the South African arithmetic curriculum; explaining that the difficulties many learners in higher grades experience in algebra stem from lack of understanding arithmetic relations in lower grades. He suggests that as there is a close relation between arithmetic and algebra. Algebra, being generalised arithmetic, should be introduced as algebraic thinking in lessons as early as grade one, before the introduction of formal algebra in higher grades. Reversibility as a Habit of Mind promotes development of early algebraic thinking in learners. It is important to admit that this Habit might not always be easy to implement and might at times not be manageable especially in areas of Data Handling and Geometry. There are instances where arithmetic concepts are used to solve problems in these subject areas where reversibility could be applied. Warren, Mollinson and Oestrich (2009, p. 10) state that “The power of Mathematics lies in the intertwining of algebraic thinking and arithmetic thinking”.

The fourth and final habit is to “justify your conjecture”. Learners need to justify that understanding of the concept holds true: meaning that they have to explain reasoning by proving examples of it in practice. Justification is a good way to develop mathematical proficiency through adaptive reasoning which is a capacity for logical thought (Kilpatrick,

2002). Justification could be demonstrated by drawing various squares and checking whether the properties identified are true for all squares, or by adding '7' and '8' in various forms will produce '5'. This allows learners to see the limitations of their conjecture in counterarguments. For instance if '7' and '8' are added, a '5' is obtained but not when I multiply, divide or subtract with the same digits. The ability to justify is a large advantage to learners in developing their ability to do Mathematics (Mulligan, Mitchelmore, English, & Robertson, 2010). When Aristotle first separated theology and universal science, he did so by viewing knowledge as reason based on justification. He coined the notion of rationalism which viewed the principle of knowledge as intellectual and deductive. Justification enables the fundamental nature of understanding through reasoning (Bhattacharjee, 2012).

To summarise, the Habits of Mind used in this research are:

- Identify regularity (something that repeats, is common, a pattern).
- Discuss the regularity (collaborate, evaluate, articulate and reflect, consolidate).
- Do and undo (inverse, reversibility, working backwards).
- Justify (explain, reflect, predict).

The Habits of Mind chosen above can be linked to the statement of Mulligan *et al.*, (2008, p 11) "virtually all Mathematics is based on pattern and structure". The selected Habits of Mind enable the learner to first identify the pattern (the regularity). Then, by discussing and working backwards, the regularity is generalised and structured. Justifying the conjecture provides a way to finalise the generalisation.

2.10 Conclusion

The purpose of this literature review was to discuss and advocate the concepts used in this research and provide relevant literature and a theoretical foundation. Despite drawing upon the theories of situated cognition and Vygotsky's relational ontology, the concepts discussed in the literature review were related to each other in an inductive process associated with a conceptual framework. The theory of Situated Cognition provides a foundation which justifies the link between lived experiences and professional development within a professional learning community, such as a Community of Practice. Literature described a deep-seated bond between lived experiences and the situated environment where the individual's learning occurs. This situated environment is where the individual reflects on

their identity. Furthermore teachers' professional identity can also be associated with their lived experiences, therefore developing teachers' lived experiences has a direct influence on their classroom practice and professional development (Berdo, 1994; Clancey, 1997; Husserl, 1982; Beijaad et al., 2004; Killion & Hirsh, 2011). The reflection of individuals on their professional identity, and possible development thereof, can be cultivated and observed within a Community of Practice (Brown & Duguid, 2000; Hung et al., 2004). The use of Habits of Mind, described as being specific ways of thinking about and doing Mathematics (Selden & Selden, 2005), was justified by associating it with Relational Understanding and providing a relevant theoretical underpinning. Vygotsky (1981) describes the importance of psychological tools associated to both theories of Situated Cognition and Relational Understanding. These tools can be related to the use of Habits of Mind which can be closely linked to Wenger's (2000) description of artefacts: assets that, if useful, are retained, maintained and developed by a Community of Practice over time. The Habits of Mind which were chosen for this research were selected in order to promote Relational Understanding, which is defined as having the procedural fluency to know what mathematical procedures to use as well as the conceptual understanding to know why to use the procedures (Skemp, 1976; Pope, 2014).

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter presents a detailed explanation of the methodology used in conducting this research in order to validate the process. This chapter provides an accurate and detailed description of how the research was conducted, in addition to the rationale behind the choice of procedures selected for data collection (Kallet, 2004). Bhattacharjee (2012, p. 35) describes the methodology section as the blueprint for empirical research which is tasked with answering the research questions. According to Bhattacharjee the methodology section explains three processes: (1) the data collection process, referred to as the research design, (2) the instrument development process, and (3) the sampling process. Kallet (2004) stresses that the research methodology description needs to be explained in enough detail so that: (1) the research can be repeated by other researchers who should reach the same findings using the data and methodology presented (2) that the audience can judge the validity of the research conclusion(s).

Bhattacharjee (2012) states that the methodology section answers the research questions. The primary question for this research is *‘How do teachers experience implementing Habits of Mind as a tool which promotes Mathematics learners’ Relational Understanding, while operating within a Community of Practice?’* The focus of the research, however, is not on the promotion of Mathematics learners’ Relational Understanding but on the experiences of the teachers, as research participants. The teachers attempt to improve their practice and provide an insight into the professional development of educators. To guide this research, in answering the research question, three subsidiary questions were poised: (1) what were the teachers’ perceptions of how Habits of Mind influenced their practice, (2) what were their experiences as part of a Community of Practice, and (3) what were their perceptions of promoting Relational Understanding?

This research adopts a qualitative approach²⁵: one key quality control of qualitative research is the validity of the research and its findings. The proper collection and interpretation of data is at the heart of a valid study and enables conclusions accurately to reflect, represent and describe the real world as researched (Yin, 2011). Maxwell (2009, pp. 244–245) lists seven

²⁵ Reasoning for this adoption explained in section 3.3

strategies to address validity in qualitative research. Yin (2001, p. 79) describes these strategies as:

- Intensive field involvement: producing an in-depth understanding, making opportunities for repeated observations or interviews;
- Rich data: detailed and varied, covering fully the field involvement;
- Respondent validation: having feedback from participants to increase validity;
- Search for discrepant evidence and negative cases: test competing explanations or negative cases in the data;
- Triangulation: using more than one data collection instrument;
- Quasi-statistics: using actual numbers to stress the relevance of data presented instead of using adjectives such as 'rare' or 'prevalent';
- Comparison: comparing results across various settings, groups or events.

Maxwell (2009) suggests that not all strategies need to be met in every qualitative research endeavour. This chapter uses these strategies as a guideline to ensure the validity of the methodology.

The purpose of this chapter is to establish the validity of this research by justifying the research approach and design. An adaptation of Bhattacharjee's (2012, p. 35) three processes listed in the first paragraph of this section is used to define the methodology as transparently and meticulously as possible. Four processes are described and justified: (1) use of phenomenology as a research design within a qualitative approach; (2) data collection process and choice of site, sample and data collection instruments; (3) steps taken to ensure trustworthiness and authenticity; and (4) the method used to analyse data collected.

3.2 Research plan

This section provides an overview of the research plan. Subsequent sections of this chapter describe each step of the methodology guiding this research. To avoid repetitiveness in the research plan, two tables are used. These two tables provide an overview of the research plan.

Table 3:1 below depicts the four methodological processes described in this chapter which have been adapted from Bhattacharjee (2012). The table indicates the paragraph number where they are located.

Table 3:1 An overview of the four methodological processes described in this chapter (Bhattacharjee, 2012, pp. 35)

PROCESS DESCRIBED		
1. Method of inquiry		Paragraph number
Approach	Qualitative	3.3
Design	Phenomenology	3.4 and 3.5
Perspective	Transcendental Phenomenology	3.4 (Paragraph 3)
2. Data collection		
Sampling Strategy	Convenience Sampling	3.6.1
Data collection instruments	Group interviews	3.6.3 A.
	Documentary sources	3.6.3 B.
	Individual interviews	3.6.3 C.
3. Trustworthiness and Authenticity		
Methodological techniques	Triangulation of themes	3.7.1
	Organisation of data	3.7.2
	Outside auditors	3.7.3
	Phenomenological reduction	3.7.4
4. Data Analysis		
Analysis Model	Giorgi's Phenomenological Model	3.8.1
	The interconnected model of professional growth	3.8.2

The second table in this section, Table 3:2, depicts an overview of the data collection process (Bhattacharjee, 2012): it tabulates the data collection period, indicating the collection instruments, the date(s) of collection and a brief description of the data collected. This table is a combination of Table 3:3 and Table 3:4 (which will be utilised in paragraph 3.6.1), but differs from them in that it provides a complete overview of all data collection instruments

used during the research period. The documentary sources, namely the reflective journals and learner books, together with their time period are included in this table. The reason for collating all collection instruments into one table below is to provide a coherent overview of the research design.

Table 3:2 A summarised overview of the data collection instruments used in the research period

Completed by/on:	Collection Instrument	Brief description of data collected
11 Feb 2015	Group Interview 1	Using Habits of Mind in relation to Addition & Subtraction.
24 Feb 2015	Group Interview 2	Using Habits of Mind in relation to Number patterns.
11 March 2015	Group Interview 3	Using Habits of Mind in relation to multiplication & division
21 April 2015	Group Interview 4	Using Habits of Mind in relation to 2-D Shapes
05 May 2015	Group Interview 5	Using Habits of Mind in relation to fractions & length
18 May 2015	Group Interview 6	Using Habits of Mind in relation to 3-D objects
11 June 2015	Group Interview 7	Group shares their experiences during research period
11 Feb – 11 June	Reflective Journals	Individuals record their experiences in reflective journals during research period.
22-25 June 2015	Individual Interview 1	Individuals share their personal lived experiences
22–29 September 2015	Individual Interview 2	Individuals have another opportunity to share their personal lived experiences and have the opportunity to validate my interpretations with regards to their experiences.
After September 2015	Learners' Books	Learners' books were collected by me after the research period to be used to complement the data collected during the interviews.

3.3 Research approach

This research has adopted a qualitative approach to describe the lived experiences of teachers. A qualitative approach is appropriate when researching lived experiences. MacDonald and Headlam (2009, p. 8) associate this approach with establishing “how people interpret their experiences and the world around them”. They credit the qualitative approach with providing in-depth insights into what is being researched; so allowing the researcher to gain an understanding of the underlying reasons and motivations for the methodological processes used in collecting and analysing data. The depth achieved from a qualitative approach enables

the researcher to establish how participants interpret their experiences in the context in which they experience them. This in-depth description of participants' experiences in context is paramount in this research.

Yin (2011, pp. 7–8) lists five features associated with qualitative research, which allows for (1) studying the meaning of people's lives under real-world conditions (2) representing the views and perspectives of individuals concerned (referring to the participants) in a study, (3) covering the contextual conditions within which such individuals live (4) contributing insights into existing or emerging concepts that may help to explain human social behaviour, and (5) striving to use multiple sources of evidence rather than relying on a single source alone. These five steps justify the adoption of a qualitative approach since this research uses multiple data sources to provide insight into the professional development of teachers through descriptions of their lived experiences. This research describes participants' experiences so that the research approach can be specified as a descriptive qualitative approach. Kothari (2004) defines this specific approach to qualitative research as descriptive because there is no direct control over the variables such as contextual factors, environmental factors, past experiences which influence the findings and the inferences drawn. This definition is relevant when reiterating that the aim of the research is to investigate how teachers experience the implementation of Habits of Mind that promote Relational Understanding. The focus in the data collection is not to search for positive or negative results of the implementation of Habits of Mind in a subjective or selectively biased manner. Instead, the focus of the research falls on describing how implementation of Habits of Mind was experienced by teachers within a specific Community of Practice using their inferences and researching their lived experiences during the research period.

3.4 Research design

This research describes the lived experiences of research participants and takes the form of a phenomenological study. Lived experience can be regarded as human experience emerging from what the individual has lived through, experiences which develop self- or reflective awareness (Lewis-Beck, Bryman & Futing Liao, 2004). Lived experience is an important part of teacher identity which is formed from the convergence of multiple socio-cultural histories of lived experiences (McGregor, 2003). As explained in paragraph 2.5 teachers' lived experiences is strongly associated with professional identity and is defined by Van Manen (2007) as the interpretive availability of a research participant's definitive basis of

intelligibility. In related research, Shi (2016) credits researching lived experiences when attempting to gain insight into participants' professional development. Koopman (2015) describes the phenomenological design of inquiry as describing the lived experiences of participants which inform the researcher about their perceptions. Detmer (2013, p. 1) credits phenomenology as one of the most influential philosophical movements in the last century. Phenomenological research defines a phenomenon through all aspects of lived experience which applies to sensed experiences and attitudes such as morality or politics (Detmer, 2013). Holloway (2005) describes phenomenology's aim as describing a participant's lived experiences. This research project describes the lived experience of participants. A phenomenological design of inquiry is appropriate.

Giorgi (2007) describes two perspectives within phenomenological research: two methods which can be assumed by the researcher. The first is the transcendental phenomenological method of inquiry which Creswell (2007, p. 60) describes as a combination of written down or transcribed descriptions of participants' experiences as well as structural descriptions of these experiences in terms of situations, conditions and contexts²⁶. The second perspective is the hermeneutic phenomenological method of inquiry which is more focused on the interpretation of the meaning of the lived experiences and which can be seen as an extension of the transcendental method; only more text focussed²⁷ (Van Manen, 1990). This research follows the transcendental method: it uses textual methods to describe the experiences of the participants and interview transcriptions as its primary data source.

The phenomenological design of inquiry is now explained in detail and its suitability for this research is explained.

3.5 Phenomenology

The Collins English Dictionary (1991) defines the phenomenological movement as founded upon philosophical views of the German mathematician Edmund Husserl (1960, p. 1 168). This definition focuses on providing a detailed description of the conscious experiences of those in the phenomenon described). Holloway (2005, p. 47) states that: 'Phenomenology aims to describe a person's lived experiences in an attempt to enrich lived experience by drawing out its meaning'. Phenomenology is an attempt to describe lived experiences free

²⁶ This refers to the contextual factors where the lived experiences of the participants are situated. Refer to paragraph 2.4.

²⁷ Text focused: meaning that it is more focused on existing literature.

from pre-conceived assumptions on the objective reality attached to the experiences (Halloway, 2005). The core motive of phenomenological research is to describe *lived experiences* of the individuals existing in the phenomenon under review. Because such experiences are those of unique individuals in a unique situation, phenomenological research examines not what the reality is but what it is conceived to be (Burns & Grove 2003). The phenomenological design of inquiry is suited for this research since it describes, as stated by Jasper (1994, p. 309), the “true meaning of phenomena being explored through the experiences of them as described by the individual”. This research provides insight into teacher professional development through describing the experiences of participants in terms of their own perceptions. Since the phenomenological design of enquiry explores the lived experiences of individuals to produce descriptions of a phenomenon being studied, it was relevant to use this research design in this research.

3.5.1 When to use Phenomenology

Streubert-Speziale and Carpenter (2003, p. 48) credit phenomenology as useful in researching professions where practice is grounded in holistic development²⁸. The authors advise the implementation of phenomenology in qualitative research which has the purpose of expanding awareness about a particular phenomenon, tightening the bond between experiences, as well as the concepts and theories used when explaining the experiences.

3.5.2 Dimensions in Phenomenological research

Spiegelberg (1976) describes five dimensions of phenomenological research. These dimensions are constitutive, descriptive, essential, reductive and interpretive.

3.5.3 Constitutive Phenomenology

This area of phenomenology is related to a phenomenon as it is constituted (recognised, accepted, established) in the consciousness of those experiencing the phenomenon. Constitutive phenomenology concerns itself with the advancement of participants' experiences from initial impressions of the phenomenon to a broader and more established perspective of what has been experienced (Spiegelberg, 1975). This perspective relates fully to this research which involves studying the change and development of the lived experiences

²⁸Holistic development is defined by the Department of Education (2004, p. 244) as an “all rounded impression of a learner’s progress”...”development of values, attitude and social development” .

of the participants in the Community of Practice as they engaged in using Habits of Mind in their teaching aiming to advance their professional development.

A. *Descriptive Phenomenology*

The focus of this area of phenomenology is on the richness and depth of the lived experiences of the participants. Descriptive phenomenology describes the genuine exploration of a specific phenomenon free from, as far as possible, preconceived judgments in an attempt to provide an intuitive description of the experiences of the participants (Streubert-Speziale & Carpenter, 2003). There are four strategies used in phenomenological research to aid in this process: (i) bracketing, (ii) intuiting, (iii) analysing and (iv) describing. These four stages are explained below.

i. *Bracketing*

Bracketing is a concept used in phenomenological research: the researcher brackets personal views related to the research in an endeavour to create a fresh, unbiased outlook on the phenomenon. Holloway (2005) refers to bracketing as a process in which presuppositions and assumptions are held in suspension in order to improve academic rigour and trustworthiness. Holloway (2005) explains that complete separation between personal experience and research is difficult to achieve. Interpretive approaches to phenomenology claims that complete separation through bracketing is impossible. Creswell (2007) explains that in research, such as this project, which involves participants sharing experience of a particular the phenomenon, a common understanding is forged. Complete separation from lived and personal experiences limits the in-depth comprehension of the personal experiences of the teachers, as research participants.

Bracketing was used in this research to limit the influence of my presuppositions and assumptions throughout both data collection and data analysis phases. I had to bracket personal experience before proceeding with the experiences of the research participants. This bracketing entailed limiting my opinion and focusing on the members of the Community of Practice's description of their experiences (LeVasseur, 2003).

ii. *Intuiting*

Once preconceived assumptions and opinions have been bracketed, the researcher can be submersed within the phenomenon, experiencing it afresh and free from what has been

bracketed. This allows for a true, comprehensive interpretation of the experiences being observed, resulting in a common understanding of the phenomenon being studied. This is the intuiting process (Streubert-Speziale & Carpenter, 2003) which allows the researcher to develop a true understanding of experiences as they are described by the participants during the data collection opportunities. Non-leading and open-ended questions are essential to facilitate this process (Streubert-Speziale & Carpenter, 2003). This strategy was applied during the research period: I bracketed personal opinions and used semi-structured interviews. Interview questions were not used to lead the participants but to stimulate discussion; to allow participants opportunities to voice their lived experiences of the phenomenon.

iii. Analysing

In phenomenological research the analysing process is focussed on identifying the essence of the phenomenon using the data collected. The researcher needs to compare the descriptions collected from the participants and identify themes which are common and interrelating (Brink & Wood, 1998). Analysing methods are discussed in paragraph 3.8.1 where Giorgi's (1975) phenomenological model is explained: one of the models used to guide me throughout the analysis of the collected data.

iv. Describing

When describing data collected during analysis and findings stages of the research, the researcher needs to refrain from imposing preconceived expectations or assumptions in order to provide an impartial description of the phenomenon as it was experienced and reported by the participants. The description process in phenomenological research needs to occur last in the four strategies. After analysis and identification of common themes drawn from data, the phenomenological researcher's aim is to describe what has been identified and communicate it to others as it was reported by the participants (Streubert-Speziale & Carpenter, 2003). This research follows this manner of describing participants' experiences by allowing the reader the opportunity to follow the analysis process from the identification of the themes to where the themes are grouped and conclusions are made. This procedure allows the reader the opportunity to judge the validity of the research and its findings (Kallet, 2004).

3.5.4 Phenomenology of Essence

Essence in phenomenology, or phenomenology of essence, is associated with the strategy of analysis in descriptive phenomenology: it involves identification of patterns in the data collected and establishment of common themes. A theme can be interpreted as an essence of the phenomenon; by identifying these essences the researcher can determine what is accidental and what is essential when engaging in the phenomenological description (Streubert-Speziale & Carpenter, 2003). Identification and comparison of themes which emerge from participants' experiences comprise the method used when analysing data in this project as discussed in the data analysis paragraph, 3.8.

3.5.5 Reductive Phenomenology

To remain objective during the research process, reductive phenomenology needs to be applied throughout the investigation. Reductive phenomenology is a methodological technique in phenomenological research used to maintain credibility, trustworthiness and academic rigour in research. It entails the researcher limiting personal bias by bracketing assumptions in order to achieve a pure description of the phenomenon. Reduction is a crucial step in preserving objectivity and academic rigour: it separates the context of the researcher from the content of the phenomenon, conserving the purity of the data collected. Husserl (1960) refers to this separation as *epoche*; describing it as the researcher preventing their belief system from making preconceived judgements. In this light it is important that the researcher delays all revisiting of the literature until data has been collected and analysed in order to implement true phenomenological reduction (Streubert-Speziale & Carpenter, 2003). This technique of delaying transcription and reading of data collected until after the group interviews have concluded was used during the research period in this research. This technique helped to maintain academic rigour through reductive phenomenology; limiting the influence of emergent themes evident in the data from influencing me during the data collection period. The practice of reductive phenomenology in this research is described in paragraph 3.7.4.

3.5.6 Interpretive Phenomenology

Interpretive phenomenology unearths the underlying subjective experiences that participants have as a result of the context in which they find themselves (Holloway, 2005). It seeks to research human consciousness through probing during discussions, observing the

phenomenon as it is being experienced by the participant, and undertaking immediate interviews after observations have been completed. Since observations were not used for data collection in this research, interpretive phenomenology was gained through reflective journals which allowed participants to record their reflections of what they experienced during the research period while they were experiencing it. Individual interviews, held towards the end of the research period, provided the opportunity to use probing questions; allowing for interpretive phenomenology to be practised.

In conclusion, this section describes the phenomenological research design of inquiry in order to provide further insight and justification regarding choice of its implementation in this research project. The phenomenology design of inquiry explores the lived experiences of participants: such exploration is relevant since this research examines teachers' experiences (Streuberd-Speziale & Carpenter, 2003). The different dimensions in phenomenological research were explained: constitutive phenomenology, descriptive phenomenology, phenomenology of essence, reductive phenomenology and interpretive phenomenology (Spiegelberg, 1976). Their implementation and relevance to this research were explained.

3.6 Data collection process

In this section the data collection process is discussed: by (1) providing the motivation behind the choice of site and sample, (2) describing the importance and motive for including participant profiles, and (3) explaining the rationale behind the choice of data collection instruments.

3.6.1 Site and Sample

Purposive sampling was used as a sampling strategy for this research. Yin (2011, p. 88) explains that in qualitative research, samples are chosen in a deliberate manner because the purpose behind the selection is for the sample to yield the most relevant, plentiful and rich data applicable to the research topic. The sampling strategy utilised in this research cannot be termed opportunity sampling which is usually employed when the sample selected for a study does not represent a wider population but only the sample group itself (Cohen, Manion, & Morrison, 2007). In this research, the sample group was a group of primary school teachers engaged in self-initiated professional development²⁹. As in opportunity sampling, they do not

²⁹ Refer to paragraph 2.5.1.

represent all primary school teachers they yield rich data providing insight into teacher professional development, specifically self-initiated.

The site was a school located in, and serving, a low-income community. Staff decided to address the issue of poor numeracy and literacy results at the school. This led to two groups being formed by teachers: one dealt with literacy and the other Mathematics. The group addressing Mathematics was labelled a Community of Practice since they were a group of individuals collaboratively working to develop their mathematical knowledge for teaching³⁰ (Wegner, 2000). Ernest (2002) associates this collaborative effort with Vygotsky's relational ontology and other socio-constructivist theories; stating that Communities of Practice are aimed at social construction of knowledge instead of individualistic learning. This Community of Practice was the subject of this research and consisted of three Intermediate Phase³¹ Mathematics teachers. This Community of Practice intended to collaborate in their efforts to improve their practice which they believed would improve their learners' performance in Mathematics. I proposed that the focus of the Community of Practice should be to implement Habits of Mind as a tool to promote Mathematics learners' Relational Understanding which has many benefits; as described in the literature review (CHAPTER 2). This research made use of this opportunity, observing how teachers experienced the implementation of Habits of Mind that promote Mathematics learners' Relational Understanding at this school (Cohen, *et al.*, 2007).

Given that the research was observing an existing Community of Practice which had already established itself prior to the commencement of the research period, I had the opportunity to familiarise participants with the concepts of Habits of Mind and Relational Understanding before any data collection processes began. Being a member of the Community of Practice prior to the research period, I introduced the use of Habits of Mind as a tool to promote Mathematics learners' Relational Understanding in September 2014. This introduction allowed research participants approximately five months to familiarise themselves with using these Habits of Mind before commencement of the research in February 2015. This familiarisation was not a planned pilot study such as that which Yin (2011, p. 37) explains assists the researcher in testing and refining aspects or logistics for the final study. This period of using the Habits of Mind passed before the research period formally began. The phenomenon, which was being studied, was an initiative undertaken by the school and its

³⁰ MKfT (Hill *et al.*, 2008). Refer to paragraph 2.5.1.

³¹ *Intermediate Phase*: Grades four to six.

teachers to improve their practice. This phenomenon could not be constricted to any time limits demanded by the research period. This lapse of time was beneficial to the research: it gave me insight into logistics, for instance time needed for processes such as Community of Practice meetings, and gave participants time to familiarise themselves with the necessary concepts and procedures similar to those implemented during the research period (Yin, 2011).

3.6.2 Participant Profiles

Qualitative research allows for multiple meanings and interpretations; the focus of qualitative and phenomenological inquiry is on the experiences, or voices, of participants (Lawrence-Lightfoot & Davis, 1997). It is important to provide detailed information about participants by the use of profiles generated from data collected from individual interviews, group interviews, documentary sources and classroom observations. These profiles consist of general information regarding participants' background, past experiences, educational status and beliefs, and their time as Mathematics educators. This general information provided in the profiles assists the research by providing a rich description of participants' lived experiences. To unify qualitative methodologies of science and art, Lawrence-Lightfoot (1983) challenges traditional research strands followed by scholars: he introduces a method of portraiture which, in qualitative research, is defined by Quigley (2013, p. 841) as embracing descriptive, aesthetic and experiential dimensions in the form of narrative inquiry. The researcher is able to describe phenomena in a systematic and purposeful manner using beauty and aesthetic properties of art. Portraitists, or more relevantly qualitative researchers, are tasked with combining context, voice, relations, emergent themes and the aesthetic whole in order to provide the reader with an authentic portrait of the research setting and participants (Muccio, Reybold & Kidd, 2015). In accordance with this combination of elements, providing participant profiles allows the researcher to enable the reader the opportunity to formulate an image of the participants who revealed their experiences for this study. Use of participant profiles allows the researcher to practise the constitutive dimension in phenomenology by systematically describing development of participants' lived experiences from initial interpretations to more established ones; progressing through the research period (Spiegelberg, 1976). This assists in the aim of the research which is to provide insight into the professional development of teachers. Participant profiles are included in paragraph 4.3.

3.6.3 Data collection instruments

An important aspect of research is the strategy of using multiple sources for data collection. This mechanism enhances credibility (Yin, 2003). Three data collection instruments were used in this research: (1) group interviews with all three participants in their Community of Practice, (2) individual interviews with each participant at the end of the research period, and (3) documentary sources; the teachers' reflective journals used throughout the research period and learners' Mathematics workbooks from the participants' classes used in the lessons taught during the research period.

3.6.4 Group interviews

The use of group interviews which are referred to as discussion or focus groups, is a market research technique that has proved useful in social sciences research. The discussion generated during group interviews, as compared with individual interviews, generates a more relaxed environment in which individuals feel more confident and secure, limiting participants' bias and generating more varied, in-depth opinions from a number of individuals simultaneously. By holding interviews in a location familiar to interviewees, their school staffroom, anxiety amongst participants could be mitigated. Interviewing more than one individual simultaneously raises practical concerns for which the researcher has to prepare: discussion can digress from the topic or any one individual participant can take over leadership and steer the interview in the way he or she desires. These group interviews were semi-structured and followed a framework of pre-planned questions to guide the conversation and keep discussions focused on the topic. The framework was flexible; adapting to new themes as they arose (MacDonald & Headlam, 2009). Yin (2011) describes qualitative interviews which are not structured interviews, as the most dominant mode of interviewing when conducting qualitative research. He places the researcher in a role in which he does not have a list of questionnaire-like questions but instead has a mental framework of the research questions as a guide during qualitative interviews. Yin (2011, p. 134) describes qualitative interviews as different from structured interviews: they do not follow a list of questions or become self-leading conversations. He adds that specific questions posed by the researcher during qualitative interviews differ according to the context or setting of the interview.

Before commencing with these group interviews, it was important to bracket any personal experiences. To do so I had to describe all experiences and opinions I had regarding this research, prior to its commencement. This was done by writing them down and can be seen in

the researcher's reflective vignette (paragraph 3.7.4). This vignette created an awareness of my own personal bias which could have resulted in leading questioning during the group interviews (Creswell, 2007). Perfectly achieved bracketing is seldom achieved but researchers who embrace the use of this technique of describing personal experiences and bracketing them before engaging with the views of others claim greater rigour in their data collection (Moustakas, 1994). By audio-recording the discussion during the group interviews, I was able to free myself of the demands of note-taking. I was able to focus on facilitating the flow of the discussion (MacDonald & Headlam, 2009).

The group interviews were scheduled to be held bi-weekly³² throughout the research period of five months but, due to demands of school meetings, school holidays and other factors, were postponed when necessary. Seven group interviews took place within the research period lasting approximately sixty to seventy minutes each. The basic structure of the discussions during group interviews and date within the research period can be seen in Table 3:3. Interviews did not inflexibly adhere to this structure which was used more as a guideline to focus the discussion.

The Community of Practice met regularly before these group interviews and was introduced to using Habits of Mind as a tool that promotes Relational Understanding. These group interview meetings were less focussed on introduction of the research concepts than they were on teacher experiences

Table 3:3 An overview of the group interviews depicting the date, discussion topic and agenda

No.	Date of Meeting	Topic Area	Interview Agenda
Group Interview 1	Wednesday 11 February 2015	Addition & Subtraction	40 min of reflective feedback on the participants experiences using the Habits of Mind in their teaching thus far. 20 min reflective feedback on: the teaching approach to addition and subtraction, how to use Habits of Mind in teaching this topic, is there any specific habit that should be focused on in this topic?
	Contextual influences		
	Participants' teaching time was limited by learners' athletics training in the morning. Interview was held on the scheduled date.		

³²Bi-weekly: Every second week

No.	Date of Meeting	Topic Area	Interview Agenda
Group Interview 2	Tuesday 24 February 2015	Number Patterns	40 min of reflective feedback on the participants experiences using the Habits of Mind in their teaching.
	Contextual influences		20 min reflective feedback on: how to use Habits of Mind when teaching number patterns, which approach to use that allows for the use of the habits, and does any specific habit(s) suit this topic more?
	Participants continued to experience limitations on their teaching time as a result of athletics training. Interview was held on the scheduled date.		
Group Interview 3	Wednesday 11 March 2015	Multiplication and Division	40 min of reflective feedback on the participants experiences using the Habits of Mind in their teaching.
	Contextual influences		20 min reflective feedback on: the teaching approach for multiplication and division, how to use Habits of Mind in teaching it, and is there any specific habit(s) that should be focused on in this topic?
	Participants were recovering from limitations being placed on their teaching time due to athletics training. The interview was scheduled for 10 March but an urgent staff meeting postponed the interview to the next day.		
Break for school holiday (01 – 13 April 2015)			
Group Interview 4	Tuesday 21 April 2015	2-D Shapes	40 min of reflective feedback on the participants experiences using the Habits of Mind in their teaching.
	Contextual influences		20 min reflective feedback on: the teaching approach for 2-D shapes, how to use Habits of Mind in teaching it, and is there any specific habit(s) that should be focused on in this topic?

No.	Date of Meeting	Topic Area	Interview Agenda
	No interviews were held at the end of the first term to allow the participants the time needed to finalise their reports. This interview was originally scheduled for 24 March but was postponed to the third term.		
Group Interview 5	Thursday 05 May 2015	Fractions and Length	40 min of reflective feedback on the participants experiences using the Habits of Mind in their teaching.
	Contextual influences		20 min reflective feedback on: the teaching approach for fractions and length, how to use Habits of Mind in teaching it, and is there any specific habit(s) that should be focused on in this topic?
	This interview was originally scheduled for 21 April but was postponed subsequent to the rescheduling of group interview 4.		
Group Interview 6	Monday 18 May 2015	3-D objects	40 min of reflective feedback on the participants experiences using the Habits of Mind in their teaching.
	Contextual influences		20 min reflective feedback on: the teaching approach for 3-D objects, how to use Habits of Mind in teaching it, and is there any specific habit(s) that should be focused on in this topic?
	This interview was originally scheduled for 06 May but was postponed subsequent to the rescheduling of group interview 5.		
Break for exams (25 May – 03 June)			
Group Interview 7	Thursday 11 June 2015	Reflecting on and summarising overall experiences	Participants discuss their overall experiences during their implementation of the Habits of Mind.
	Contextual influences		They then share their thoughts on their professional development during this period.
	This interview was originally scheduled for 20 May but was rescheduled to after the exam period subsequent to the rescheduling of group interview 6.		
No.	Date of Meeting	Topic Area	Interview Agenda

No.	Date of Meeting	Topic Area	Interview Agenda
Group Interview 1	Wednesday 11 February 2015	Addition & Subtraction	40 min of reflective feedback on the participants experiences using the Habits of Mind in their teaching thus far.
	Contextual influences		
	Participants’ teaching time was limited by learners’ athletics training in the morning. Interview was held on the scheduled date.		20 min reflective feedback on: the teaching approach to addition and subtraction, how to use Habits of Mind in teaching this topic, is there any specific habit that should be focused on in this topic?
Group Interview 2	Tuesday 24 February 2015	Number Patterns	40 min of reflective feedback on the participants experiences using the Habits of Mind in their teaching.
	Contextual influences		
	Participants continued to experience limitations on their teaching time as a result of athletics training. Interview was held on the scheduled date.		20 min reflective feedback on: how to use Habits of Mind when teaching number patterns, which approach to use that allows for the use of the habits, and does any specific habit(s) suit this topic more?
Group Interview 3	Wednesday 11 March 2015	Multiplication and Division	40 min of reflective feedback on the participants experiences using the Habits of Mind in their teaching.
	Contextual influences		
	Participants were recovering from limitations being placed on their teaching time due to athletics training. The interview was scheduled for 10 March but an urgent staff meeting postponed the interview to the next day.		20 min reflective feedback on: the teaching approach for multiplication and division, how to use Habits of Mind in teaching it, and is there any specific habit(s) that should be focused on in this topic?
Break for school holiday (01 – 13 April 2015)			

No.	Date of Meeting	Topic Area	Interview Agenda
Group Interview 4	Tuesday 21 April 2015	2-D Shapes	40 min of reflective feedback on the participants experiences using the Habits of Mind in their teaching.
	Contextual influences		20 min reflective feedback on: the teaching approach for 2-D shapes, how to use Habits of Mind in teaching it, and is there any specific habit(s) that should be focused on in this topic?
	No interviews were held at the end of the first term to allow the participants the time needed to finalise their reports. This interview was originally scheduled for 24 March but was postponed to the third term.		
Group Interview 5	Thursday 05 May 2015	Fractions and Length	40 min of reflective feedback on the participants experiences using the Habits of Mind in their teaching.
	Contextual influences		20 min reflective feedback on: the teaching approach for fractions and length, how to use Habits of Mind in teaching it, and is there any specific habit(s) that should be focused on in this topic?
	This interview was originally scheduled for 21 April but was postponed subsequent to the rescheduling of group interview 4.		
Group Interview 6	Monday 18 May 2015	3-D objects	40 min of reflective feedback on the participants experiences using the Habits of Mind in their teaching.
	Contextual influences		20 min reflective feedback on: the teaching approach for 3-D objects, how to use Habits of Mind in teaching it, and is there any specific habit(s) that should be focused on in this topic?
	This interview was originally scheduled for 06 May but was postponed subsequent to the rescheduling of group interview 5.		
Break for exams (25 May – 03 June)			

No.	Date of Meeting	Topic Area	Interview Agenda
Group Interview 7	Thursday 11 June 2015	Reflecting on and summarising overall experiences	Participants discuss their overall experiences during their implementation of the Habits of Mind. They then share their thoughts on their professional development during this period.
	Contextual influences		
	This interview was originally scheduled for 20 May but was rescheduled to after the exam period subsequent to the rescheduling of group interview 6.		

3.6.5 Documentary sources

The use of documentary sources in data collection is often marginalised in qualitative research, however it can be just as useful as, and sometimes more effective than, interviews and observations (Mogalakwe, 2006). Mogalakwe (2006) refers to Scott (1990) who characterises two types of access a researcher has to data collected: mediate access and proximate access. Proximate access refers to direct access where the researcher personally witnesses the event, whereas mediate access is described as indirect access. Mogalakwe (2006, p. 223) states that documentary sources provide mediate access to the event being researched, or data collection opportunity, providing the researcher with “visible signs of what happened at some previous time”. Yin (2011, p 147) refers to the qualitative researcher’s data collection method of collecting objects, where he lists documents as one of these objects. He states that collection and examination of objects, such as documents, provides insight into the physical and social environment of what is being researched just as it exposes “invaluable data about things not directly observable”. He adds that collected objects, such as documents, can complement data collected from interviews. Documentary sources which were used as a data collection instrument in this research were (1) anonymous reflective journals written by each of the participants, and (2) learners’ Mathematics work books.

When emerging from a new and possibly challenging experience, reflection is of utmost importance. Reflection on the lived experience of a situation allows for understanding and improvement of practice. By expressing ourselves through reflection we become aware of the experience, and improvements grow from this awareness. If no reflection takes place, the beneficial opportunity of the experience and professional development or improvement of practices which come with the experience, are missed (Caring, 2004). The reflective journal

which teachers used throughout the research period allowed them to write and reflect on their experiences when implementing Habits of Mind in their lessons. These journals, as previously mentioned were anonymous and allowed teachers more freedom in their reflection: experiences recorded could not be traced back to individuals. Anonymity in data collection guarantees greater honesty from the practitioner (Cohen, *et al.*, 2007). The journals were used to assist in collecting data which acquired deeper reflections of the participants directly after their lessons, as opposed to days after the lessons when the group and individual interviews were held.

Yin (2011, p. 148) states that examples of students' work can assist the researcher to understand the content of the teaching taking place in the classroom environment. The use of learners' books as a documentary source in this research complements the data collected from the interviews with the teacher participants and assists by providing examples of the teaching taking place during the research period. Yin (2011, p. 150) states that documentary sources can reduce researcher reflexivity³³. Such sources are hardly influenced by the researcher's actions. He explains that interviews can be reflexive as a result of the researcher's influence on the participants and participants' influence on the researcher. Documentary sources are influenced by neither of these types of reflexivity although the researcher should remain aware of the danger of subjective bias as a result of non-reflexive contextual or environmental factors. Mogalakwe's (2006) explanation of Scott's (1990, pp. 224-8) quality control criteria when using documentary sources guided the process of using learners' books as a documentary source. The criteria observed were: (1) *authenticity* which refers to the researcher knowing that the document is genuine and reliably sourced, (2) *credibility* which determines if the document is free from bias or error, (3) *representativeness* which questions if the document is typical of its kind and not untypically representative: an example of this would be the book of a learner who was absent for the lesson in question, and (4) *meaning* which refers to whether the documents' data is clear and comprehensible to the research. To ensure quality control of data collection through learner books, I was not handed a learner's book by the participant: something which Mogalakwe (2006, p. 226) explains could be "prepared independently and beforehand". Instead, I personally selected more than one book from each class for purposes of authenticity and credibility, while being mindful of the criteria listed by Mogalakwe (2006). This procedure was followed by utilisation of the data in

³³ *Reflexivity* refers to the influence that the researcher's presence and actions on the participants during direct data collection opportunities (Yin, 2011: 312)

the books to complement the interview data through comparison between books of peers to account for representativeness and meaning.

The themes which were generated in the interviews, group and individual, were compared to those generated from the data collected in the reflective journals and learner books for more authenticity using triangulation of data (Mogalakwe, 2006).

3.6.6 Individual interviews

Individual interviews were conducted at the end of the research period during which each participant discussed personal experiences during the five-month period. In-depth interviews are often associated with phenomenological research (Creswell, 2007). Two main questions guided each individual interview: (1) What have you personally experienced during these past five months while attempting to implement Habits of Mind in your teaching?, and (2) What experiences, past or present, influenced or affected your experiences? (Moustakas, 1994). These questions were submitted to participants one week prior to the individual interviews in order for them to gather their thoughts and to provide more in-depth answers. The individual interviews rendered an opportunity to me and participants to gain feedback regarding my interpretation of their self-reported behaviours and views from the data collected in the group interviews and reflective journals. Maxwell (2009, p. 244 – 245) elucidates that allowing *respondent validation* minimizes misinterpretation. Respondent validation grants participants opportunities to validate a researcher's initial interpretations and adds to the validity of the research. Table 3:4 indicates the dates and foci of these individual interviews. The dates are indicated in a date period and not according to specific dates: each participant was interviewed on a separate day.

Table 3:4 An overview of the individual interviews depicting their date period and foci

No.	Date period	Interview Foci
Individual interview 1	22 – 25 June 2015	Individual participants share their personal lived experiences over the research period, as well as experiences as a Mathematics teacher prior to the research period.
Individual interview 2	22 – 29 September 2015	Individuals have another opportunity to share their personal lived experiences as well as have the opportunity to validate my interpretations with regards to their experiences.

Bracketing was also implemented during these individual interviews as their aim was to provide a more in-depth look at the individual participants and their lived experiences. All individual interviews were audio recorded and transcribed for analysis.

3.7 Trustworthiness and Authenticity

Procedures for maintaining trustworthiness and authenticity depend on methodological techniques such as (1) triangulation of themes, (2) correct organisation of data during collection and analysis, (3) use of outside auditors for quality control, and (4) in relation to phenomenological research, practice of phenomenological reduction throughout the research period (Fishman, 1999; Zucker, 2009; Whiting, 2002). These four techniques are described below in relation to their purpose within this research.

3.7.1 Triangulation

Mogalakwe (2006, p. 229) states that: 'Through method triangulation, a researcher can rise above the personal biases that stem from single methodologies'. By using two or more data collection instruments I was able to triangulate findings which increase credibility and trustworthiness (Yin, 1994). Triangulation allowed me to compare themes evident in the collected data between different forms of the data which had been collected by means of various instruments. Identifying themes in the data is a method to organise and analyse data

effectively, and to triangulate findings more efficiently. Identifying themes, is a way of arranging messy, non-linear, data associated with qualitative data collection (Strauss & Corbin, 1997; Marshall & Rossman, 2006). Efficient organisation is an effective way to maintain credibility in data collection (Yin, 2003) and is discussed in paragraph 3.7.2 below.

3.7.2 Organisation of data

It is important for the researcher to remain structured in the data collection process in order to maintain the credibility of the data which has been collected. In response to this, Yin (2003, p. 105) advocates maintenance of a *chain of evidence* in structuring and organising data efficiently during qualitative research. In this research project, use was made of the electronic data base AtlasTi to organise data during the analysis phase. This electronic database ensured that the data collected and themes generated were cited³⁴ accurately. Accurate citation of data helped maintain structure as well as dependability of data; assisting me further in maintaining a chain of evidence (Yin, 2003). Because successful organisation of data is crucial in qualitative research, the use of an electronic database, such as AtlasTi, can be a fundamental resource which improves organisation and reliability of qualitative data analysis (Yin, 2003). These types of Computer Aided Data Analysis Software (CADAS), however, have been criticised in one significant respect: there is a danger that they distance the researcher from the data being analysed, and/or collected, possibly removing some of the rich essence of qualitative research data (Baxter & Jack, 2008). Although the AtlasTi data analysis software was used to aid me in the organisation of the data, I personally transcribed all the data. This personal transcription avoided possible separation from the research. Implementing the methods described in this section ensured that the collection and analysis processes were made easier, were more organised, accurate and reliable (Bhattacharjee, 2012).

3.7.3 Outside auditors

A method advocated by Whiting (2002) was employed in this research: outside auditors, or more specifically an expert group, were used to check and audit the analysis of the data collected. This was done to ensure that authenticity and dependability of the data analysis remained intact. This was done by allowing these auditors to read through the analysis of the data and determine the validity of it. They then provided feedback, recommendations and required revised drafts of the data analysis to be done until they were convinced of its

³⁴ Citing the Data: recording when and where the collection took place, the reason for collection, who or what is contributing the data, etc.

reliability. The expert group in this research were two lecturers who are Mathematics education specialists and experienced researchers who were supervising this research. Baxter and Jack (2008, p. 555) elucidate that “One strategy that will ensure that you remain true to the original case is to involve other research team members in the analysis phase and to ask them to provide feedback on your ability to integrate the data sources in an attempt to answer the research questions”.

3.7.4 Phenomenological reduction

Giorgi (1975) admits that analysis of phenomenological data could be criticised for relying on researcher interpretation which could be different if another researcher analysed that same data. He advocates that this apparent discrepancy is less of a concern if the interpreter reads the participants’ descriptions while practising phenomenological reduction³⁵. This procedure ensures the quality of the findings is not contaminated. Mogalakwe (2006, p. 229) states that, although interpretations might differ, they are never completely different but divergent: a way of looking at the same data in slightly different terms. As mentioned above, to mitigate misinterpretation, Whiting (2002, p. 71) allowed a colleague³⁶ to review processes in her analysis and found that although their wording differed slightly, the resemblances in their descriptions were ‘uncanny and reassuring’.

Phenomenological literature from Heidegger (1967) and Merleau-Ponty (1962) promote researcher involvement in the phenomenon being research which could be perceived to weaken the credibility phenomenological reduction as described by Husserl (1927). To remain true to phenomenological reduction, Van Manen (1990) suggests the use of reflective vignettes by which the researcher informs the reader of the position in the phenomenon and declares any possible bias. The reflective vignette adds to Husserl’s phenomenological reduction in an attempt to limit researcher bias and has been included below.

3.7.5 Researcher’s Reflective Vignette

As an undergraduate student completing my Bachelors of Education degree I developed a fondness for learning theories of Mathematics education. This inclination drew on my past experiences of being a physiology major and my fondness for Mathematics in my childhood schooling. This interest led to me continuing with part-time postgraduate studies after

³⁵ Phenomenological reduction: reading without prejudice or prejudgements (refer to paragraph 3.5.5).

³⁶ Outside auditor (refer to paragraph 3.7.3).

qualifying and working as an educator. Majoring in Mathematics, I completed a postgraduate Honours degree in education, specialising in Mathematics while continuing to increase my input in the implementation of the Mathematics curriculum at the school where I was teaching. During this time I continued to gain recognition as a Mathematics educator and when applying for a new teaching post, I was offered, and accepted, a post as a Mathematics subject head in the school where the research for this project is being conducted.

Among many undertakings I was asked to oversee the delivery of the Mathematics curriculum at this school. I was tasked by the School Management Team (SMT) with coordinating, and initiating, a grouping of the Mathematics teachers which would be focussed on improving the Mathematics results at the school. After discussing this idea with the staff, it was evident from their responses they desired an opportunity, such as this, where they could share practices and experiences. They felt that collaboration of this nature would assist them in their professional development and improve their teaching of the Mathematics curriculum. I led this professional learning community (Brodie, 2011), which I later re-named a Community of Practice (Lave & Wenger, 1991).

The research took place within the first two years of my teaching at this school during the initial stages of the establishment of this Community of Practice. I seized this opportunity to introduce teachers to Relational Understanding in their practice because I had experienced the benefits of this technique in my career and been exposed to the concept during my studies. The implementation of Habits of Mind which promote Relational Understanding arose in response to the research that was conducted paragraph 2.8).

My personal bias, a belief in the benefits of implementing Habits of Mind that promote Mathematics learners' Relational Understanding, needs to be declared. Having studied these concepts, and had success regarding learner performance in assessments when promoting Relational Understanding in my teaching, I needed to be self-critical enough to acknowledge my own areas of prejudice within this research. I am conscious of the possible areas of reading that may have overly influenced my research criteria. For this reason I applied phenomenological reduction throughout this research by bracketing³⁷ any prejudices of which I was aware (Creswell, 2007; Husserl, 1967). Despite the fact that complete separation of the researcher's influence through bracketing is an impossibility, the desire to achieve it remains

³⁷ Bracketing – a strategy used in descriptive phenomenology where the researcher's presuppositions and assumptions are held in suspension in order to improve academic rigour and trustworthiness (Holloway, 2005). Refer to paragraph 3.5.3A.i.

at the heart of the transcendental method of phenomenological inquiry (Moustaches, 1994). Husserl (1976, p. 8) describes bracketing in phenomenology as “the methodology through which I come to understand myself as that ego and life of consciousness in which and through which the entire objective world exists for me, and is precisely as it is”.

It is important to clarify my role as a researcher within this research. Nørskov and Rask (2011) fashion a combination of the work of Stafford and Stafford (1993) and Gold (1958) to describe the different roles which could be assumed by a researcher conducting research. Safford and Safford (1993) refer to two general roles: (1) the overt role, and (2) the covert role. Nørskov and Rask (2011) explain these roles as the overt researcher being considered an outsider by participants, whereas in the covert role the researcher becomes an insider and is considered a group member by the participants. Gold (1958) categorises the degree of assimilation of the researcher in the role in four areas: (1) the complete participant, (2) the participant-as-observer, (3) the observer-as-participant, and (4) the complete observer. McMillan and Schumacher (2006) later revise Gold’s (1958, p. 345) roles into six researcher roles: (1) complete observer, (2) full participant, (3) participant observer, (4) insider observer, (5) interviewer, and (6) participant researcher. Nørskov and Rask (2011) are in favour of the researcher assuming a hybrid role; placing himself in multiple roles relating to the specific needs of the research at any given time throughout the research period. This hybrid approach suited my role within this research. Being part of the Community of Practice prior to the commencement of the research period, my role was both covert and full participant researcher. This role was relevant: I myself was a fully participating member of the Community of Practice and considered an insider. Later, as the research period commenced, I had to become an outsider in order to practise reductive phenomenology and limit my influence in the voices, referring to the participants’ experiences of the Community of Practice. I had to discard the role of full participant and assume the role of interviewer which McMillan & Schumacher (2006, p. 345) describe as a role that is typically assumed by phenomenological researchers. During this period I did not participate in meetings as a member of the Community of Practice but served as the interviewer; by asking probing questions in order to extract the essence of the participants’ experiences. The data collected from the meetings were the participants’ experiences and my own. Being mindful of the researcher roles I assumed at different stages during the research period allowed me to practise phenomenological reduction and limit my personal preconceptions from influencing the data collected.

In summary, to maintain the trustworthiness, validity and academic rigour of this research, I used a combination of research techniques. First, I used multiple sources of data to triangulate themes which emerged. Second, I relied upon outside auditors for feedback and interrogation of the data analysis. Third, I practised qualitative research techniques such as maintaining a chain of evidence, citing the data when collected, and using AtlasTi to assist in the organisation of data. Last, I practised phenomenological reduction by declaring possible influences I could have had on the data collected; being conscious of my personal preconceptions and assuming different researcher roles relevant to the needs of the research at a particular moment.

3.8 Data Analysis

Two models were used to guide the analysis of the data: (1) Giorgi's (1975) phenomenological model, and (2) the interconnected model of professional growth (Clarke & Hollingsworth, 2002). First, Giorgi's (1975) model was used to analyse the data according to a phenomenological design of inquiry. Being a novice in phenomenological research, Giorgi's model provided the structure and guidance I needed for assistance during the data analysis phase: the analysis of data is an area of concern in phenomenological research, having the potential to be misused and biased (Corben, 1999). Second, since this research is exploring teacher professional development, the interconnected model of professional growth was used to guide me in exploring teacher change³⁸ (Clarke & Hollingsworth, 2002). These two models are explained and their implementation in analysing the collected data is described.

3.8.1 Giorgi's Phenomenological Model

In this section I explain Giorgi's (1975) phenomenological model which, as previously stated, is applied in this research to analyse the data. Giorgi's model is grounded in Husserl's (1960) philosophy and adopts his central belief that the phenomenological researcher must retain the purity of the facts and the truth of how they are revealed. Phenomenological approaches, such as Giorgi's (1975), seek to give the phenomenological method of research a framework which improves academic rigour and trustworthiness. Academic rigour and trustworthiness are areas in which phenomenological research has been criticised by social science research (Omery, 1983). A core principle of Giorgi's (1975) model is that participants of a research

³⁸ Refer to paragraph 2.5.1

project be seen as fellow humans, of equal status so that co-operation between participants and researcher is required. This principle applies to this particular research project. I was operating in the Community of Practice together with all other participants, co-operating throughout the data collection period when interviews were conducted.

The model is explained in four steps adapted from Whiting's (2002) more recent application of Giorgi's model in her phenomenological research.

Step 1: Read through all the data as a whole.

Phenomenological reduction is essential in this step. By doing this initial reading and applying phenomenological reduction during the process, allowed complete views of the participants' experiences to form. I was able to view phenomena directly as opposed to perceiving phenomena through my preconceptions (Rose, Beepy & Parker, 1995; Cohen & Omery, 1994). Reading through the data as a whole allowed me to gain a sense of the contextual worlds of the participants, providing the opportunity to gain insight into their actual experiences. This insight aided in later analysis of data so that I did not attempt to interpret the data but rather kept the experiences true to the words of the participants (Giorgi, 1975). Husserl (1960) refers to this form of data, namely experiences before they have been put into themes, as pre-predicative³⁹ experiences.

Step 2: Determine meanings expressed by participants by reading and re-reading transcripts.

In this step I pieced together the experiences of participants in relation to the phenomenon being researched. I was still not focussed on the specific aim of the research, so I had to be absolutely open to the meaning of the experiences in their entirety and remain empathetic to the participants' experiences as they were being recounted (Giorgi, 1975; Wertz, 1983). Each of these experiences was separated from the text into units of meaning as they appear in the transcribed interviews or documentary source. To do this I needed to read painstakingly through the text many times in order to identify these experiences in their natural meanings. Giorgi (1975) refers to these as natural units. Once these units of meaning are separated from the text, I was able to read them repeatedly in order to identify central themes which highlight the core meaning of the experience, free from interpretation or relation to the aim of the study (Giorgi, 1975). Table 3:5 provides an example of how this process looked during the analysis

³⁹ Pre-predicative experiences refer to the researcher's initial feelings of the participants' experiences before systematically determining the meanings expressed by the participants' experiences.

phase. Whiting (2002) used a tabular method when analysing data using Giorgi's (1975) model. She, however, replaced his term 'central theme' with 'conceptual theme'. She did this in order to refer directly to the concept which is central to participants' perceived experience. To assist in analysing the data according to Giorgi's (1975) model, I used my own adaptation to Whiting's (2002) tabular method because I found it to be a more organised way of analysing data. I retained her natural unit and conceptual theme columns but added in the code column which distinguished between new and existing experiences of participants (NE and EE)⁴⁰: I added a source column which assisted me in citing⁴¹ the natural unit of Teacher A⁴² (Group interview 7 – GI7).

Table 3:5 Step1 and Step 2 of Giorgi's (1975) model in an adaptation of Whiting's (2002) tabular method

Source	Natural unit	Code	Conceptual theme
Gi7	A. I have always taught with this focus in mind, where the learners learn the work so that they can understand and link the topics to the real world. I like what this um relational learning is saying but I have always taught with that in mind. So that the learners must understand and not just have to study the work all the time.	EE	Relational Understanding helps them use Maths in real world. Learners need to understand Maths not just study it.

Step 3: Interrogate the themes according to the purpose of the study.

It is paramount that phenomenological reduction through bracketing be implemented at this stage since presuppositions can lead to misinterpretation of the participant views (Ashworth & Hagan, 1993). To do this I personally admitted my presumptions and preconceived judgements, acquiring self-awareness about my own presuppositions which strengthened the implementation of phenomenological reduction (Giorgi, 1975). Once phenomenological reduction was implemented, the next phase was to sift through the information acquired in Step 2, questioning the themes identified in a methodical, systematic fashion so that fundamental themes, central to the aim of the research, were identified. To do this I referred back to the aim of the research and the research questions, using them as a filter when questioning the validity of the themes identified in Stage 2 (Giorgi, 1975). In relation to this

⁴⁰ NE and EE were codes used in this research: NE – experiences which occurred during the research period, EE experiences which occurred prior to the research period.

⁴¹ Refer to paragraph 3.7.2.

⁴² Teacher A – pseudonyms were used to protect participants' identities (refer to paragraph 3.9).

research I asked how this theme related to the experiences of the teachers with regards to providing insight into their professional development, using the three subsidiary questions as a guide (paragraph 3.2).

Re-iterating her (2002) implementation of Giorgi's (1975) model using a tabular method to structure natural units into themes, her first two columns consisted of (column 1) natural units where Whiting wrote the experiences of the participant in their natural meaning and (column 2) the conceptual themes, diverging from Giorgi's (1975) central themes, of each natural unit⁴³. Whiting (2002, p. 68) then added a third column which she named 'revelatory themes'; a term she claimed was in keeping with the terminology used by Giorgi (1975). The revelatory themes are generated from the conceptual themes which were generated from the natural unit discussed in Step 2. To determine the revelatory theme, I needed to look at each conceptual theme and ask how it relates to the aim of this research, and the research question(s). Whiting (2002) asserts she had to ask this question a number of times before she was able to determine the revelatory theme: a procedure which was analogous to my experience. Whiting stated that not all conceptual themes have a revelatory theme: not all conceptual themes are fundamental themes and are not uniformly relevant to the aim of the research and the research question(s). The revelatory theme allowed me to determine the relevance of each conceptual theme and the relevant perceived participant's experience: his or her natural unit, to the aim of the research. Table 3:6 below indicates the end-product of this process.

Table 3:6 : Example of the table used in data analysis indicating the revelatory theme, adapted from Whiting (2002)

Source	Natural unit	Code	Conceptual theme	Revelatory theme
Gi7	B. I have always taught with this focus in mind, where the learners learn the work so that they can understand and link the topics to the real world. I like what this um relational learning is saying but I have always taught with that in mind. So that the learners must understand and not just have to study the work all the time.	EE	Relational Understanding helps them use Maths in real world. Learners need to understand Maths not just study it.	Teachers perception of Relational Understanding

⁴³ Refer to paragraph 3.8.1 B.

Step 4: Drafting a descriptive statement of essential, non-redundant themes.

Giorgi (1975, p. 97) describes this step as “Once the themes have been thusly enumerated, an attempt is made to tie together into a descriptive statement the essential, non-redundant themes”. This is done by fashioning a description of the various revelatory themes with regards to their link to the nature and aim of the research. These descriptions admittedly might be relevant only to the situation of this research but some might be applicable to other situations (Giorgi 1975). Once individual descriptions of the revelatory themes were compiled, I was able to formulate an overview of the data collected from the participants’ experiences with regards to the aim of this research.

Giorgi (1975) is adamant that although other research disciplines require framework development in their data analysis, it is not necessary in phenomenological research since the description of revelatory themes undoubtedly reveals what the researcher has been told about the investigated phenomena by the participants’ experiences. Omery (1983) acknowledges Giorgi’s (1975) model of developing a way to classify and structure themes, as seen in other qualitative disciplines, stating that it is a successful coping method for data analysis in phenomenological research. Arranging data in this way, which Macdonald and Headlam (2009, p. 22) refer to as thematic generation, allowed for better reliability as reliable research is based more on consistency than accuracy (Bhattacharjee, 2012).

3.8.2 Interconnected model of professional growth

The aim of this research is to provide insight into the professional development of teachers. It is important that perceptions of participants be discussed to describe their experiences during the research period and their experiences be examined in light of the perceived changes in their professional development. To do so, the interconnected model of professional growth was used: natural units of participants associated with revelatory themes⁴⁴ were examined in order to provide insights into their perceived professional development (Clarke & Hollingsworth, 2002). The interconnected model of professional growth is analogous to Guskey’s (2002) alternative model which assists in researching teacher professional development through examining teacher change and is based on the premise that professional development initiatives have three major goals: (1) changing teachers’ classroom practices, (2) changing teachers’ beliefs and attitudes, and (3) changing the learning outcomes of

⁴⁴ Revelatory themes were identified in Step 4 of Giorgi’s (1975) model (refer to paragraph 3.8.1 **Step 4**).

students (Clarke & Hollingsworth, 2002). Re-iterating paragraph 2.5.1 the interconnected model described by Clarke and Hollingsworth (2002, pp. 950-951) implies that teacher change occurs through the interceding processes of reflection and enactment between four domains (a) teacher change as a result of new knowledge, attitudes and beliefs, personal domain, (b) teacher change in response to experimentation with new teaching strategies, domain of practice, (c) teacher change in relation to salient (prominent, relevant or significant) outcomes in response to classroom practice, domain of consequence, and (d) teacher change in response to stimuli located outside the teacher's personal world related to external support or sources of information, external domain. These domains in the interconnected model of professional growth can be seen in Figure 3:1.

Clarke and Hollingsworth (2002) claim that the interconnected model allows researchers who are conducting research related to the professional development of teachers, the opportunity to map alternate pathways between domains which recognise the idiosyncrasies⁴⁵ and individuality of teacher professional development. This accreditation they deduce from the model's application in three studies conducted by Clarke, Carlin and Peter (1992), Hollingsworth (1999) and Clarke (2001) which provided the empirical foundation for the interconnected model of professional growth. To explain the implementation of this model in the analysis of data in relation to this research, I make use of three sections in the chapter: (A) interconnections, (B) functions, and (C) patterns in teacher professional development.

⁴⁵ Idiosyncrasy is the word used by Clarke and Hollingsworth (2002) and refers to a usual characteristic or habit. In this context relates to ability to recognise characteristics of individuals' professional development.

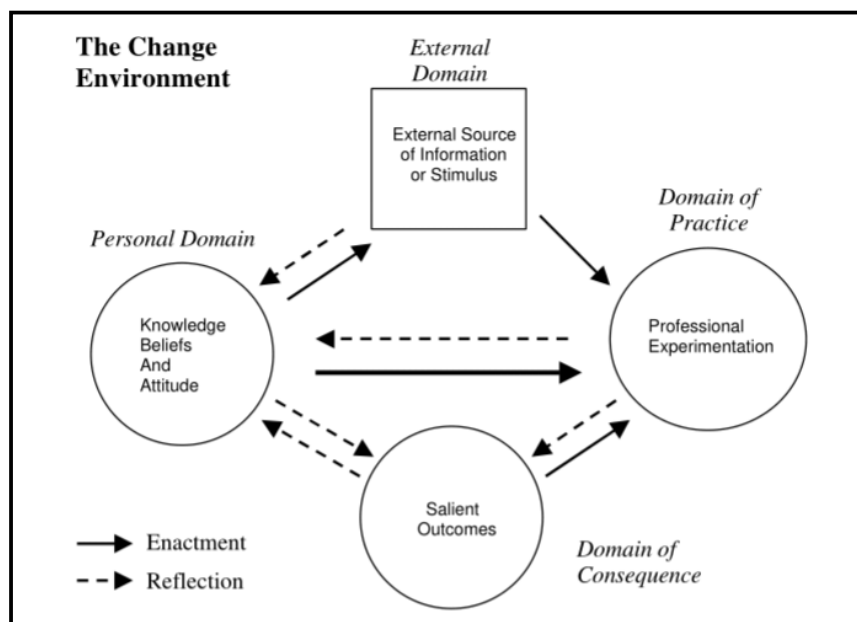


Figure 3:1 The interconnected model of professional growth (Clarke & Hollingsworth, 2002, p. 951)

A. *Interconnections*

Examining interconnections between the domains through the interceding processes of enactment and reflection is important in determining the functionality of the interconnected model of professional growth. Reiterating paragraph 2.5.1, the term ‘enactment’ describes the translation of teacher beliefs into action, implying that each action symbolises an enactment of what the teacher knows, believes or has experienced. The term ‘reflection’ refers to Dewey’s (1910, p. 6) explanation of reflection as “active, persistent and careful consideration”. Examining, and identifying significant patterns in the interconnections made through the interceding processes, enactment and reflection, between the four domains, allows the model to recognise the complex nature of teacher professional growth by identifying multiple pathways of teacher change between these domains.

In view of the fact that situations of experimentation in classroom practice⁴⁶ are open to contrasting interpretations from different teachers, the teacher’s interpreted or perceived change, rather than the observed change of others, is constructive to the teacher involved, as well as the researcher who is researching teacher professional development. Thus ‘changes in teacher beliefs regarding the efficiency of new practices are mediated by teachers’ inferences

⁴⁶ Experimental classroom practice would refer to situations such as what is occurring in this research where teachers are experimenting with using Habits of Mind in the classroom practice.

linking new practices to salient⁴⁷ outcomes. Clark and Hollingsworth (2002, p. 957) elucidate that these ‘salient outcomes will inevitably reflect on the teacher’s existing conception of the goals of instruction, and acceptable classroom practice; that is, the teacher’s knowledge and beliefs’. The model below, Figure 3:2., illustrates an example of interconnections interpreted by teachers in the interconnected model. In this example, Clarke and Hollingsworth (2002) illustrate the possible processes of change occurring in each of the domains. In light of this research the “new in-service programme” described in the external domain refers to the introduction of Habits of Mind into their teaching which could induce change in the other domains as described in this example. The interceding processes (reflection and enactment) shown in this example are examples: when mapping interconnected patterns these processes differ from this example.

Clarke (2001) refers to arguments where classroom practice is not adequately understood if

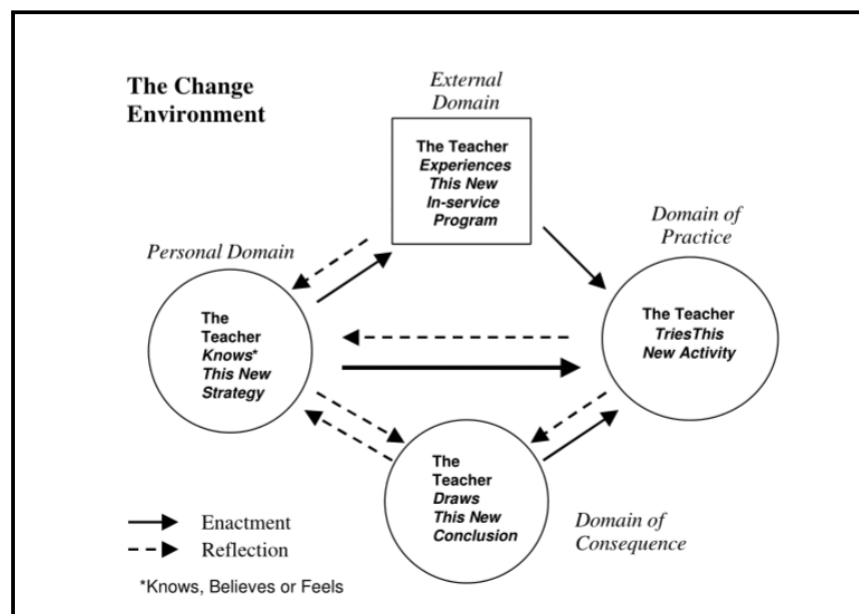


Figure 3:2 Interactions interpreted on the interconnected model of professional growth (Clark & Hollingsworth, 2002: 957)

both teacher and learner practices as well as constructed meaning are not interrogated as a professional development phenomenon. Clark and Hollingsworth (2002), however, oppose these arguments stating that in light of this interconnected model, only the teacher’s interpretations (reflections) of the actions (enactments) within the phenomenon of change (where professional development occurs) are of importance where the focus is to model and explain teacher growth. The focus of the interconnected model on teachers’ interpretations to

⁴⁷ Salient: what teachers perceive to be prominent, relevant or significant outcomes

examine interconnection between domains of professional growth is in line with the phenomenological design practices in this research which focuses on the perceived experiences of the participants collected through group and individual interviews and complemented by triangulating data collected from documentary sources. The interconnected model was useful in this research in providing a way for looking more deeply into participants' experiences and searching for insights into teacher professional development. In phenomenology, participants' experiences are collected as data, so perceptions of their professional development are sought after. As explained by Clark and Hollingsworth (2002), the interconnected model is designed to examine these perceptions, interpretations or experiences as described by participants who assisted this research.

B. Functions

Clarke and Hollingsworth (2002, pp. 957 – 958) emphasise that the interconnected model is primarily a model of teacher growth. It has more general applications in professional development research which refers to three functions that the model serves in research: (1) as an *analytical tool* – where the model has considerable success in categorising teacher change through identification of structural patterns in teacher professional growth observed through change in one domain leading to change in another, (2) as a *predictive tool* – speculatively explained as the model allowing for the identification of structural patterns which could be used to suggest mechanisms where teacher change could be promoted, as well as possible avenues for teacher professional development, (3) as an *interrogatory tool* – where the model facilitates outlining specific research questions (theoretical and practical) relating to possible pathways to professional development, the role played by specific processes introduced to the environment, considerations for new practices informed by related outcomes, and school contextual factors or constraints impacting on teachers' inclinations to reflect on their practice. When using the interconnected model, the research findings should be used to inform professional development practices of others in the same profession (Clark & Hollingsworth, 2002). This is the intended use of the model in this research project which offers insights into the professional development of educators through the description of teachers' experiences.

C. Patterns in teacher professional development

The interconnected model of professional growth enables the researcher to identify specific patterns in teacher professional development, or professional growth, by examining

interconnections between the four domains. The model allows an empirical identification of sequences in which teacher change occurs and which is deduced from teachers' experiences of the phenomenon being researched. Clark and Hollingsworth (2002, p. 958) use the term *change sequences* to describe the change evident in empirical data only where interconnections are made between two or more domains through enactment and reflection. In her (1999) teacher professional development research using the interconnected model, Hollingsworth found evidence of change in certain aspects of all participants' practices or beliefs. She found that all occasions of teacher experimentation in their practice led to change in one domain; leading to change in another domain and so forming a change sequence. Both Hollingsworth (1999) and Clark and Hollingsworth (2002) conclude that evidence of change sequences does not translate into lasting professional development, however, because teacher change induced by a single instance of experimentation in practice might be constituted as momentary change. Examples of change sequences can be seen in Figure 3:3 below⁴⁸.

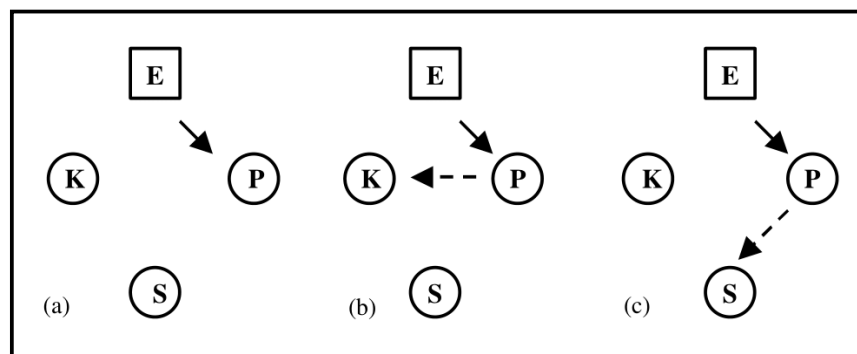


Figure 3:3 An example of three change sequences (Clark & Hollingsworth, 2002: 959)

These change sequences were evident in Hollingsworth's (1999) research where she describes teacher change which went no further than these interconnections illustrated in Figure 3:3; which are still classified as change sequences. It is important for the researcher to identify evidence of lasting change in the domains associated with teacher practice or knowledge and beliefs through multiple interconnections referred to by Clark and Hollingsworth (2002, p. 958), as *growth networks*. The interconnections evident in a growth networks can be seen in Figure 3:4.

⁴⁸ Key: E – external domain, P – professional experimentation, K – knowledge beliefs and attitudes and S – salient outcomes. These are the four domains evident in Figure 3:1

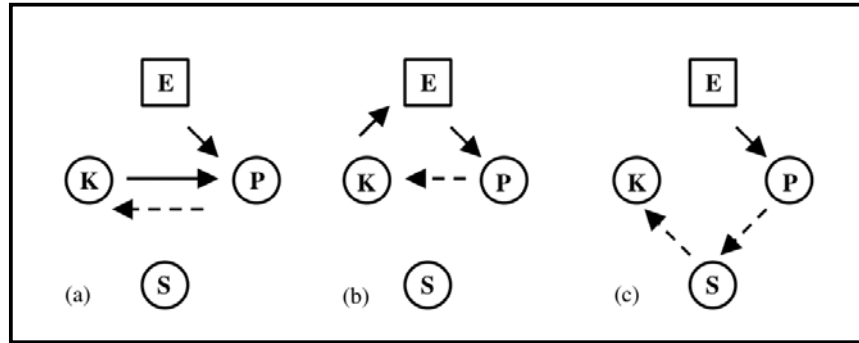


Figure 3:4 An example of three growth networks (Clark & Hollingsworth, 2002: 959)

When comparing Figure 3:3 and Figure 3:4, it is evident that interconnections of the change sequences are different to those of the growth networks; primarily in the change which is induced in the personal domain (K) and domain of practice (P), and secondarily in the complexity of the interconnections, where growth networks are more complex in their interconnections. Both Hollingsworth (1999) and Clark and Hollingsworth (2002) encourage the use of the interconnected model, being informed of both change sequences and growth networks so that researchers do not mistake short-term change for long-term professional development.

Clarke *et al.* (1992), Hollingsworth (1999) and Clark and Hollingsworth (2002) all acknowledge that the interconnected model is capable of representing multiple patterns of

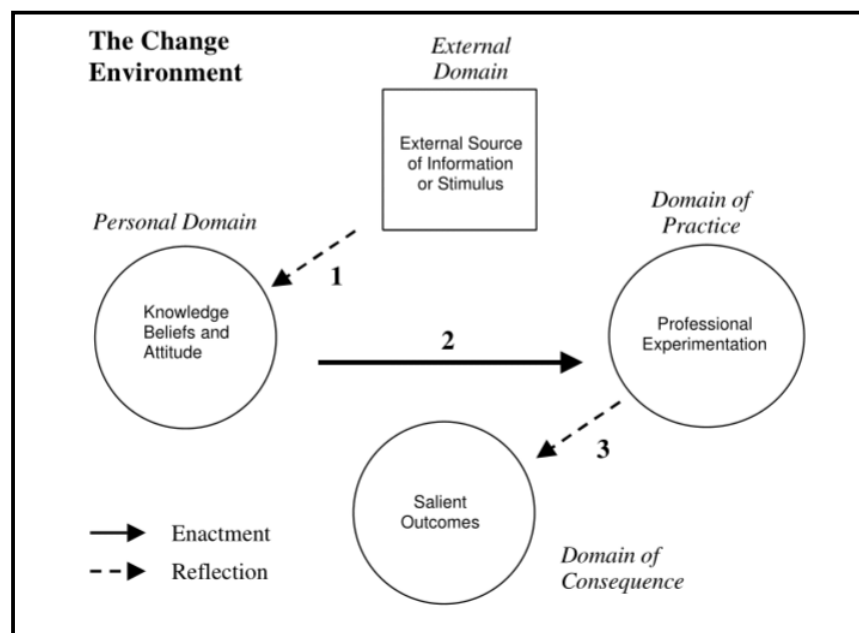


Figure 3:5 Example 1 of a growth network Clark & Hollingsworth, 2002: 960)

growth networks. Figure 3:5, Figure 3:6 and Figure 3:7, illustrate three examples of different interconnected patterns of growth networks represented by the interconnected model.

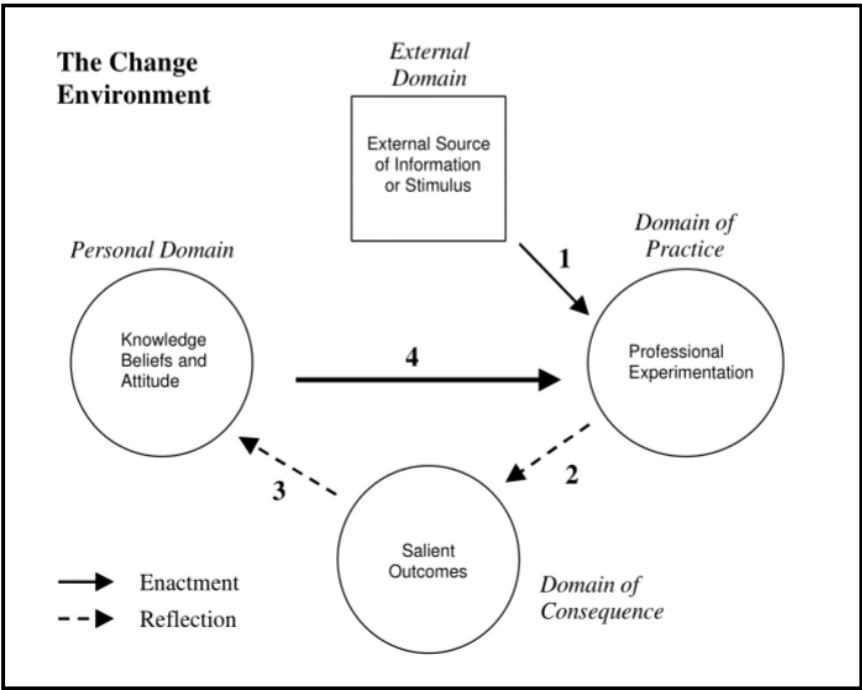


Figure 3:6 Example 2 of a growth network Clark & Hollingsworth, 2002: 961)

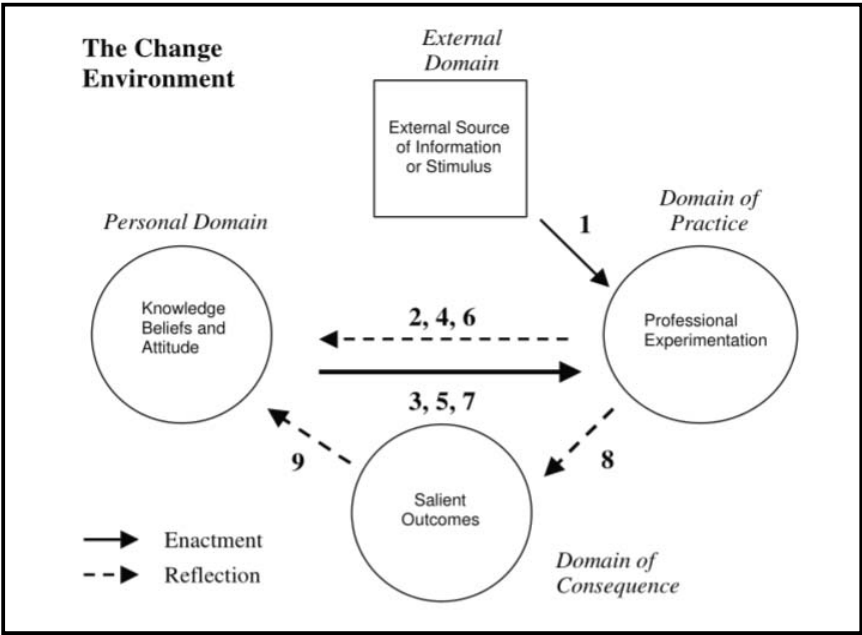


Figure 3:7 Example 3 of a growth network Clark & Hollingsworth, 2002: 962)

These three examples were identified in Hollingsworth's (1999) research and increase in their complexity of interconnections between the domains. They all remain growth networks and are associated with lasting professional development.

In conclusion, the interconnected model of professional growth is an important analytical tool in this research: it aids in analysing professional development taking place through examining teachers' experiences. Being informed as to the differences between short-lived change identified in change sequences and lasting professional development identified in growth networks is an important aspect in analysing the data collected: something which provides deeper insight into the professional development of these participants. It is important to understand that multiple growth paths can be evident in the data collected. Each participant could interpret the phenomenon differently; leading to multiple interconnected patterns. This multiplicity would not be accessible to the researcher if the phenomenon were not subjected to the interconnected model.

3.9 Ethical considerations

Yin (2011, p. 38) affirms that, when doing research, it is critically important that the researcher upholds a strong sense of ethics: numerous discretionary choices are made by researchers, especially in qualitative research. He goes on to say that transparency on the part of the researcher, regarding procedures, not only assists the formation of trustworthiness and credibility but is considered to be ethical practice.

Yin (2011, p. 39) explains that researcher integrity is an important aspect of qualitative research: the procedures and designs associated with this type of research are likely to be more flexible than those of other research types. It is important that there is sufficient evidence that the researcher has made every effort to be accurate and fair. A method for reserving researcher integrity while conducting the research is created by disclosure. Declaring any personal preconceptions that could affect the research lens used by the research to interpret data, as occurred in this research in the 'researcher's reflective vignette' (paragraph 3.7.4), is a means of disclosure which assists in sustaining researcher integrity and transparency (Yin, 2011).

Yin (2011) states that in both qualitative and non-qualitative research using human participants, prior approval from an instructional review board is required (44). He refers to

the National Research Council (2003, pp. 23–28), listing three main procedures which must be addressed for approval from an instruction research board.

Obtaining voluntary informed consent from participants, usually by having them sign a written statement (“informed” meaning that the participants understand the purpose and nature of research):

- Assessing the harms, risks, and benefits of the research, and minimising any threat of harm (physical, psychological, social, economic, legal, and dignitary harm) to participants;
- Selecting participants equitably so that no groups of people are unfairly included or excluded from the research; and
- Assuring confidentiality about participants’ identities, including those appearing in computer records and audio- and videotapes (Yin, 2011, p. 46).

To conduct the research ethically according to these three procedures no names of school, staff members or children were disclosed (Jackson, 2008). Participants were allocated pseudonyms by which they were known in the research. Letters of permission were given to, signed and returned by all participating teachers and the principal of the school. These letters can be seen in APPENDIX A: Letter of consent (Principal) and APPENDIX B: Letter of consent (Teacher). These letters are to obtain informed consent from participants, although Yin (2011, p. 47) advises the qualitative researcher to be prepared to allow participants the opportunity to query the researcher. He avers says that the researcher needs to be prepared for questions arising: he or she should not respond in a defensive manner but rather handle the situation transparently in a friendly conversation. These skills, he believes, are intrinsic to professional research.

All group and individual interviews were conducted on the school premises, with permission of the principal and the Western Cape Education Department (WCED), and did not intentionally hinder the teaching and learning process in any way (Silverman, 2011). Ethical clearance forms were sent to the WCED; thus providing informed consent from all parties involved. Ethical clearance from both CPUT and WCED was granted before the commencement of the research (Appendices: APPENDIX C: Cape Peninsula University of Technology Ethical Clearance Form and APPENDIX D: Western Cape Education

Department Ethical Clearance Form). Finally, the selection process regarding participants was explained thoroughly in the paragraph 3.6.1, to avoid unfair exclusion.

Yin (2011) explains that to be transparent in research, a researcher needs to allow for data to be available for inspection from peers or colleagues and participants in the research. To avoid any deception in the research, participants were fully aware of the nature and aim of the research before, during and after the process. Participants had full access to the dissertation once completed. During the individual interviews they had an opportunity to confirm or query my interpretations regarding the data collected.

3.10 Conclusion

In conclusion, this chapter describes and justifies the research approach and design. This was done firstly by explaining the choice of approach and design of the research. A qualitative approach was chosen as it is appropriate when researching and describing lived experiences (MacDonald & Headlam, 2009). A transcendental phenomenological design of inquiry was followed, which uses transcriptions of participants' lived experiences to describe their situation, conditions and contexts. Secondly, this chapter discusses the data collection process with respect to the site and use of purposive sampling as well as providing the rationale behind the choice of data collection instruments. Three data collection instruments were used namely: (1) group interviews, (2) individual interviews, and (3) documentary sources such as learners' books and reflective journals kept by participants. Thirdly a description of the steps taken to ensure trustworthiness and authenticity was given. Four methodological techniques were used to maintain trustworthiness and authenticity in this research namely: (1) the triangulation of themes between the different collection instruments (sources), (2) using a chain of evidence which is necessary in the organisation of data in qualitative research, (3) the use of outside auditors to audit and interrogate the analysis of the data collected, and (4) the implementation of phenomenological reduction which assists the researcher in distancing personal preconceptions or prejudgements from the analysis and findings. Lastly the hybrid use of (1) Giorgi's (1975) model, used in analysing data in phenomenological research, with (2) the interconnected model of professional growth (Clarke & Hollingsworth, 2002), used to provide insight into participants' professional growth through analysing their descriptions, was described and justified.

CHAPTER 4

RESULTS, ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter presents the findings of the research drawn from data collected and analysed during the research period. This research took the form of a phenomenological study: the chosen phenomenon is studied through the lived experiences of the participants (Detmer, 2013). The method of phenomenological inquiry in this research is that of transcendental phenomenology: a combination of textual descriptions of participants' experiences and contexts of the experiences of the chosen phenomenon (Creswell, 2007). All data collected was transcribed, where necessary, so that textual descriptions can be produced.

As described in paragraph 3.6.3, three data collection instruments were used in the collection of data. These instruments were (1) seven group interviews, (2) two individual interviews with each of the three participants⁴⁹, and (3) documentary sources in the form of both reflective journals kept by the research participants throughout the research period, and learners' books collected from each of the participants' classes. To ensure that the academic rigour of this research remained intact, four methodological techniques were used: (1) triangulation of emergent themes in the data collected by the different collection instruments (Yin, 1994), (2) maintenance of a chain of evidence to structure and organise the data efficiently (Yin, 2003), (3) inclusion of external auditors to audit my analysis of the collected data (Baxter & Jack, 2008; Whiting, 2002), and (4) practise of phenomenological reduction throughout the research period by which I declared and bracketed any personal prejudice or prejudgements which could bias the research (paragraph 3.7).

The aim of this chapter is to present, discuss and relate data relating to the primary question of the research. The primary question for this research project is: *'How do teachers experience implementing Habits of Mind as a tool which promotes Mathematics learners' Relational Understanding, while operating within a Community of Practice?'* The focus of the research is not on the promotion of Mathematics learners' Relational Understanding but on the experiences of the teachers, as research participants, when they improve their practice: something which ultimately offers an insight into their professional development. This chapter explores the following subsidiary questions in relation to the data collected: (1) what

⁴⁹ Adding up to six individual interviews in total.

were teachers' perceptions of how Habits of Mind influenced their practice, (2) what were their experiences as part of a Community of Practice, and (3) what were their perceptions of promoting Relational Understanding?

4.2 Structure

The chapter has been structured into three sections. The first section provides profiles of the participants who shared their experiences. The task of a qualitative researcher is to provide an authentic portrait of the research participants; which is the reason behind providing participant profiles (Muccio *et al.*, 2015). The participant profiles provide a deeper look into the life-worlds of the participants and are fundamental to phenomenological research. Life-worlds of participants offer a clear view into the complex environment in which participants exist (Husserl, 1927; Heidegger, 2005). The second section presents and discusses the revelatory themes⁵⁰ identified by means of *thematic generation* based upon data collected (Macdonald, *et al.*, 2009). The intention is to reproduce the lived experiences perceived by participants during the research period. This section briefly discusses and organises the revelatory themes in light of the research question and subsidiary questions. The third section examines interconnected patterns emerging from participants' experiences: an examination which allows the analysis of teacher professional development pathways (Clarke and Hollingsworth, 2002).

Findings in phenomenological research are not intended to be generalized to all teachers in similar situations. The aim is to describe the experiences of these participants in such a way as to gain insight and understanding of the specific phenomenon under review. The participants undertake self-initiated professional development to improve their practice paragraph 2.5.1. The record of ways in which teachers collaborate extends understanding of teaching and learning Mathematics. Teachers reading this research record may be inspired to embark on a similar programme of self-improvement (Degand, 2015).

Table 4:1 explains the codes used in Chapter 4. The left side of the table refers to the source from which data originated, including the dates of collection. The right side refers to codes used to identify the pattern of new and existing experiences which will be explained in paragraph 4.4, as well as the codes used to explain the relevant domain in the interconnected

⁵⁰ Revelatory theme(s) is the term used by Giorgi (1975) and Whiting (2002) in the phenomenological model used in this research to analyze data. A revelatory theme is a theme which is relevant in answering the research questions.

model used in the analysis of data in light of teacher professional development (paragraph 3.8.1).

Table 4:1 Codes used in ordering and labelling of data collected and represented in this research.

SOURCE			CODE	
Code	Description	Date Collected	Key	Description
Gi1	Group Interview 1	11 Feb 2015	EE	Existing Experience
Gi2	Group Interview 2	24 Feb 2015	NE	New Experience
Gi3	Group Interview 3	11 March 2015	Domains in interconnected model	
Gi4	Group Interview 4	05 April 2015	E	External domain
Gi5	Group Interview 5	05 May 2015	P	Domain of practice
Gi6	Group Interview 6	18 May 2015	K	Personal domain
Gi7	Group Interview 7	11 June 2015	S	Domain of consequence
Ii1	Individual Interviews 1	22-25 June 2015	Interceding processes	
Ii1	Individual Interviews 2	28-29 Sep 2015	→	Enactment
RJ	Reflective Journals	11 Feb – 11 June 2015	--->	Reflection

4.3 Teacher Participant Profiles

Participant profiles were developed using information gleaned chiefly from data collected in individual interviews with participants. Additional data collected from group interviews and documentary sources were used where relevant. I visited the classrooms of participants when conducting individual interviews and had an opportunity to observe the classroom environment of each participant. Information gained from this classroom observation aided in development of their profiles. The participant profiles provide a deeper look into the life-worlds of participants and introduce participants who shared their experiences for the benefit of this research. Both Husserl (1927) and Heidegger (2005) postulate that the life-worlds of participants are fundamental to phenomenological research because they offer a clear view into the complex environment in which the phenomenon being researched exists. Lawrence-Lightfoot and Davis (1997) emphasise that the focus of phenomenological research is on the voices, or lived experiences, of participants.

This research, using a phenomenological design, makes use of participant profiles which create an image, or portrait⁵¹, of participants who availed themselves of this opportunity to take part in a research project. Information was combined from a variety of experiential sources: past experiences, educational status or beliefs, and experiences as Mathematics educators. Using participant profiles allowed me to obtain a deeper look into development of participants' lived experiences from initial interpretations to more established ones through the research period which is a practice of constitutive phenomenology (Spiegelberg, 1976) (paragraph 3.5.2).

Occasionally, researchers generate names for their participants according to their attributes or character traits. However to avoid any preconceived judgments of the participants, this was not done. Instead, participants were named using letters of the alphabet, namely A, B and C, which were assigned randomly to participants. The pseudonyms were given to participants randomly: the letters do not correspond to any characteristics or attributes of the participant identity. This safeguard ensured that ethical considerations remain intact, as specified in paragraph 3.9 (Yin, 2011).

4.3.1 Teacher A's Profile

Teacher A is a female educator who is near to retirement after teaching for forty-one years. Most of those years have been spent at the school where the research took place. She has taught the mothers and fathers of the current learners and in some cases the grandparents of these learners as well. She is currently teaching in grade six and has been there for the past three years but has spent most of her teaching career in grade five.

Due to a personal incident with the Western Cape Education Department (WCED), she states that she has lost hope in the ability of the WCED to manage and support its educators. She has been disillusioned with curriculum changes in the last decade and holds a negative opinion of the effectiveness of the current government in their educational management.

***Teacher A (Ii1: EE):** I can't for the life of me understand what goes on in these peoples' heads, ah, you know with all these changes and policies. First it is, uh, this OBE⁵² biesagheid and then it's no more OBE, then another one, now its*

⁵¹ The word portrait refers to the qualitative researchers' method of portraiture (Lawrence-Lightfoot, 1983; Quigley, 2013; Muccio, 2015). Refer to section 3.6.2.

⁵² OBE (Outcomes Based Education) referring to a previous South African national curriculum policy.

CAPS⁵³, CAPS! (Laughs). I really think they don't know that they doing so they change it all the time.

This experience has caused the teacher to lose faith in WCED-facilitated workshops and training. She is not willing to attend any of them. She believes that she has gained a lot of experience as an educator and does not benefit from WCED-facilitated workshops or training.

Teacher A (Ii1: EE): *I always say that you can only learn over time and these new things that these advisors come with, you can just throw away when you get into a classroom. That can't help you. These books en goet wat van die department kom is gemors.... I know how to teach anything, but this is only from years of experience and not from what anyone told me or said I must do in one of these workshops. There they only give you more notes to fill in and talk about, uh, crutches for the learners and, uh, this um, intervention biesagheid... they must come and show me then how they manage, and I promise you they will themselves struggle to teach these children how they want us to teach.*

She claims that she remains passionate about teaching and enjoys her interaction with the learners. She feels that because this school has been a part of her life for so many years that it is her home. She says that she is happy at the school. She enjoys the love the learners have for her which she says she does not think she would receive at another school. She has formed strong friendship bonds with her colleagues over the many years that they have worked together.

Teacher A's experience as a Mathematics teacher

Teacher A was not trained to teach Mathematics nor is she confident in the subject but was put in a position where she had to teach the subject. She says that she has learnt over the years through experience, reflection and trial and error and now feels that she is confident enough to assume her role as the grade six Mathematics teacher. She believes that experience gained through years of teaching is the most important factor in being a good teacher. She holds that the methods and theories learnt at teacher training institutions should be forgotten on entering the school in order to learn how to teach through hands-on experience.

Teacher A (Ii1: EE): *I always say this... (pause) I always tell the students when they come that they must forget this things that they learn at the colleges, cause you can only learn how to teach from experience.*

⁵³ CAPS (Curriculum and Assessment Policy Statement) referring to the current South African national curriculum policy.

Teacher A tries to provide her learners with excitement in her lessons and attempts to give them opportunities for practical application. She states that she will dance out movements of key words of the lessons and was eager during the early stages of the Community of Practice meetings to show videos on her phone which she has where her learners are making models of geometric objects. Examples of her learners' work can be seen in Figure 4:1 and Figure 4:2.

Teacher A (Gi5: EE): *Whenever I teach fractions I like to make it fun. You must always get them to have fun even if they laugh at you... I will always try to dance out something so they can remember it... to get them to remember the, uh, denominator I did that song now on, uh , (pause) it's all about the base bout the base (laughing and animating the dance).*



Figure 4:1 Example of teacher A's learners' work



Figure 4:2 Example of teacher A's learners' work

These two figures show examples of teacher A's learners work displayed in her classroom. These are the models of geometric objects which her learners made in the video she has on her phone. In these models learners used rolled paper and tape to create pyramids.

These two figures show examples of teacher A's learners work displayed in her classroom. These are the models of geometric objects which her learners made in the video she has on her phone. In these models learners used rolled paper and tape to create pyramids.

She asserts that learning should be fun yet that learners need to be structured in their learning (refer to Figure 4:3 and Figure 4:4 below). She does not see the need for what she terms mixed methods of instruction in the new curriculum by which learners are taught and allowed to use different procedures to calculate the same problem. She senses that learners should all learn one method which should be drilled into them so that they do not make mistakes when using it.

Teacher A (Gi3: EE): ... for all these years I see how the learners can't add and, uh, do the basic maths, uh, operations in grade six anymore. They need structure in the lessons. These things must be drilled into them so they don't make mistakes in tests. You can't just have them all doing different methods, you must have one method and they must learn it over and over until they get it right... This new thing of every child doing their own method is nonsense, this department is messing them up.

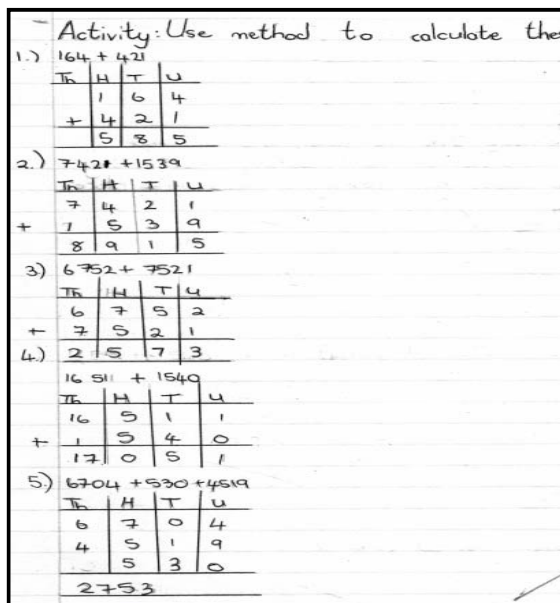


Figure 4:3 Teacher A's learner book 1 (09-02-2015)

This is an example of a learner book of teacher A. In this example she is teaching using one method for addition where the learner repeats the method as described in the extract from Gi3: EE above.

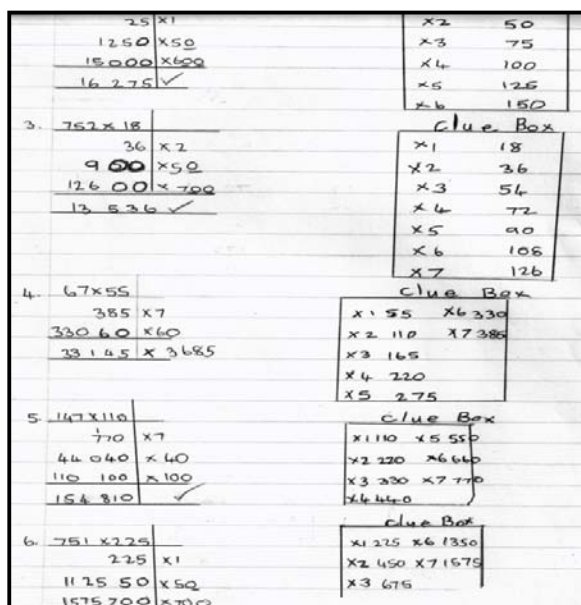


Figure 4:4 Teacher A's learner book (05-03-2015)

Teacher A begins every lesson reciting multiplication tables with her learners and says that she makes sure to provide learners with enough examples in their homework for them to practise from. According to her, this method has proven more successful in her teaching experience which she measures by learners' results achieved in their tests.

Her classroom walls have posters related to Mathematics; one being the multiplication tables (1 to 12) in the front of the class which evidence her learners' books (Figure 4:7). There are many examples of learners' work covering her walls. There are examples of learners' projects on naming and creating angles, as well as three-dimensional (3-D) objects which were made by her past and present learners (Figure 4:5. and Figure 4:6).

This example of one of teacher A's learner books where a multiplication activity is completed. Similarly this also compliments extract Gi3: EE above. These two images also illustrate what she describes as structured learning.



Figure 4:5 An example of learner's project on angles

These two figures depict the learners projects displayed on teacher A's classroom walls.

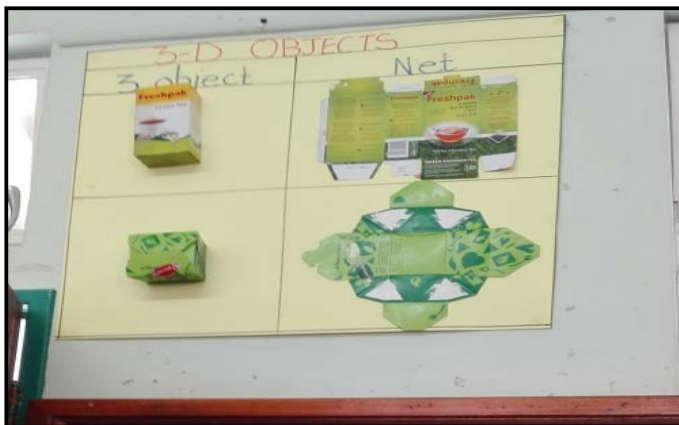


Figure 4:6 An example of learner's 3-D objects project

TIMES TABLES			
2 $1 \times 2 = 2$ $2 \times 2 = 4$ $3 \times 2 = 6$ $4 \times 2 = 8$ $5 \times 2 = 10$ $6 \times 2 = 12$ $7 \times 2 = 14$ $8 \times 2 = 16$ $9 \times 2 = 18$ $10 \times 2 = 20$ $11 \times 2 = 22$ $12 \times 2 = 24$	3 $1 \times 3 = 3$ $2 \times 3 = 6$ $3 \times 3 = 9$ $4 \times 3 = 12$ $5 \times 3 = 15$ $6 \times 3 = 18$ $7 \times 3 = 21$ $8 \times 3 = 24$ $9 \times 3 = 27$ $10 \times 3 = 30$ $11 \times 3 = 33$ $12 \times 3 = 36$	4 $1 \times 4 = 4$ $2 \times 4 = 8$ $3 \times 4 = 12$ $4 \times 4 = 16$ $5 \times 4 = 20$ $6 \times 4 = 24$ $7 \times 4 = 28$ $8 \times 4 = 32$ $9 \times 4 = 36$ $10 \times 4 = 40$ $11 \times 4 = 44$ $12 \times 4 = 48$	5 $1 \times 5 = 5$ $2 \times 5 = 10$ $3 \times 5 = 15$ $4 \times 5 = 20$ $5 \times 5 = 25$ $6 \times 5 = 30$ $7 \times 5 = 35$ $8 \times 5 = 40$ $9 \times 5 = 45$ $10 \times 5 = 50$ $11 \times 5 = 55$ $12 \times 5 = 60$
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Figure 4:7 Times tables printout in learner's book

This figure is an example of teacher A's learners book where a printout of the times tables are given to her learners.

Her room is dedicated to the teaching of Mathematics: she is the grade six Mathematics teacher for both classes (Figure 4:7.). Teacher A does not feel that she lacks resources: she finds ways to use what is available to her, such as printing her own posters (Figure 4:9), which is something she has learnt to do over her many years of teaching in a school with limited finances.

Teacher A (G11: EE): We don't have the resources we need to help these learners. We don't even get red pens anymore or dusters.

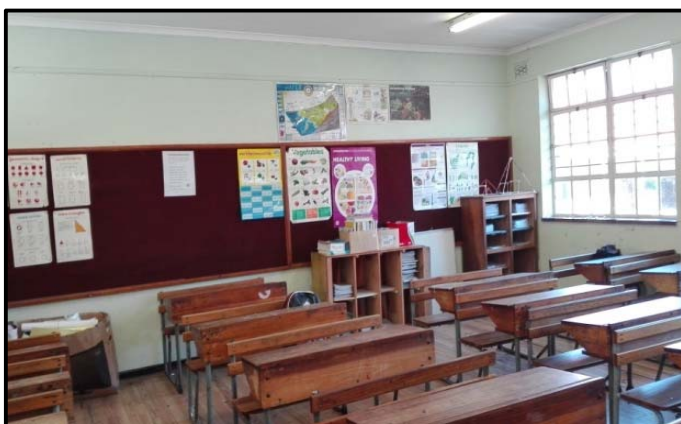


Figure 4:8 A wall in teacher A's classroom

This figure illustrates teacher A's classroom wall where the majority of her posters are related to Mathematics.



Figure 4:9 Example of teacher A's self-made poster resources

This figure shows examples of posters teacher A printed out and laminated at a printing shop.

4.3.2 Teacher B's Profile

Teacher B has been teaching for thirty-two years. Her last eighteen years have been spent at the current school where she has recently been teaching grade four after spending most of her time teaching in grade six. Although she is a class teacher who has always taught one class all their subjects, she enjoys teaching Mathematics and has made many efforts to attend training opportunities to learn more about the subject.

Teacher B (Ii1: EE): *You know, I can honestly say that I love Maths and I want my learners to, (pause), to feel the same way man, they must also love Maths... I always struggled with maths when I was at school, um, I studied and I studied and I made it, but I always struggled. Now I'm teaching but I always say to them that I am still learning...*

She is passionate about education and remains optimistic despite difficulties she faces as a teacher. She says that as the years go by it becomes more and more difficult to teach with the

increasing demands of administration and curriculum placed on teachers. She has her reservations about the WCED regarding the numerous changes in curriculum and policies but asserts that she does not let that get in the way of her practice. She always looks for the positive and does her best to impart that value to her learners.

Teacher B (Gi7: EE): *The department always makes empty promises man. We are still waiting on certificates for the training we did with them two years ago. I mean I did learn from it, I still use that methods in the class but the way the go about, uh conducting themselves and making all these promises like they going to give resources and certificates that never come, it leaves a sour taste in your mouth man.*

Teacher B (Ii1: NE): *We are now working together to fix things here. I don't know about the country again but maybe we can at least do something here in our school.*

She is concerned that there is always a large drop in learner performance when they move from grade three to grade four and that the number of learners needing support more than doubles.

Teacher B (Ii1: EE): *You know (pause) the children are very weak man. Every year I have more children who are, um who can't read man, and now they just get pushed onto grade 4 and I have to struggle with them. How can they just expect us to push these children on and do anything where we can help them?*

Teacher B (Ii1: EE): *I have so many learners on the intervention list. Almost half of my class are struggling. We need to make a way where we can assist these learners.*

Teacher B has always believed that the collaboration of Mathematics teachers to discuss continuity and methodology across the grades is necessary to address the lowering results. She states that she is constantly attempting to improve her own teaching practice. She believes that making a difference in her class first is what is needed.

Teacher B (Gi4: NE): *I am happy that we formed this group. Man, I have wanted to do this for long and I have been thinking that its better this way so we can share ideas and methods and learn from each other.*

Teacher B (Ii1: NE): *This here is how we make a difference in the school (Referring to the Community of Practice).*

Teacher B's experience as a Mathematics teacher

Teacher B strongly believes that lessons should be enjoyable and makes every effort to interest and animate learners; encouraging them to be visually and physically expressive when learning Mathematics. Teacher B injects excitement into the Mathematics class, counting aloud, shouting answers and showing actions, even if this means she is laughed at by the learners. She wants her learners to be active and involved in learning: so she spends less time teaching in front of the class and more time walking around assisting struggling learners in the class while learners are actively involved with work. This technique causes her lessons to become noisy: often learners become disruptive but she feels that this is her teaching style even though she admits she needs to work on organisation and learner discipline in her lessons. Figure 4:10 shows her description of this strategy in her reflective journal.

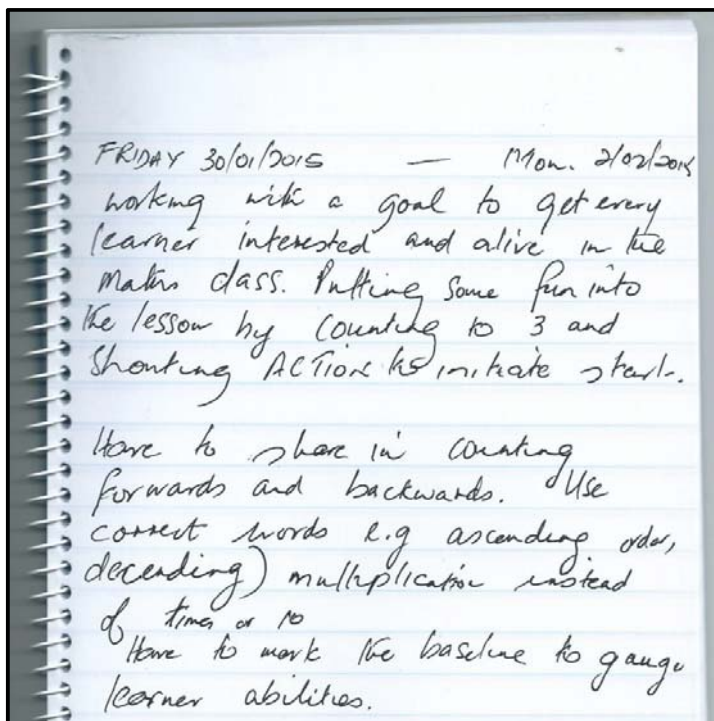


Figure 4:10 An extract from Teacher B's reflective journal

This extract from teacher B's reflective journal shows a diary entry where she describes a lesson taught. She describes how she attempted to make the lesson interesting and get every learner to be 'alive in the maths class.

She also describes the learners counting aloud and shouting actions. She also alludes to the organisation difficulties commenting on the baseline needing to be marked which was overdue on this date.

She admits that she has not been, and still is not, the best Mathematics teacher that she could be: she sometimes finds it difficult to understand the work and especially the methods which she is required to be teaching her learners.

Teacher B (Gi1: EE): *I feel that it's important that we share our knowledge because all our experience together is a lot. But if we were on our own, then for example I don't know a lot about this topic here (referring to place value) but if you know something like a new method then you can show me how to do it.*

Teacher B constantly asks for help from those teachers she believes to be more knowledgeable. Teacher B is always eager develop, however has lost her faith in WCED-run training opportunities which waste her time. She feels she has to attend them nevertheless.

Teacher B (Ii1: EE): *You know we always go on these department training and get nothing from it. The instructors are always just reading from pages or they are talking about new policies but it is never very useful man.*

Teacher B believes that learners' Mathematics books should be filled with notes and examples from which to study but she does not like learners to spend too much time writing off the board. According to her, learners are weak in their reading and writing: so that copying down notes from the board becomes time-consuming. Teacher B overcomes this difficulty by duplicating and pre-cutting notes daily so that the learners can paste in work (Figure 4:11). This work she admits does take up a lot of space in her class. She needs a lot of shelving and table space for the many copies of notes she makes. Second, she needs a lot of storage space for learner books because learners often need more than one Mathematics book for the year as a result of the many notes she gives them to paste into their books. Her classroom is filled with learners' books and notes. There is not much walking room between desks: something which she says often causes disruptions, especially during tests (Figure 4:12).

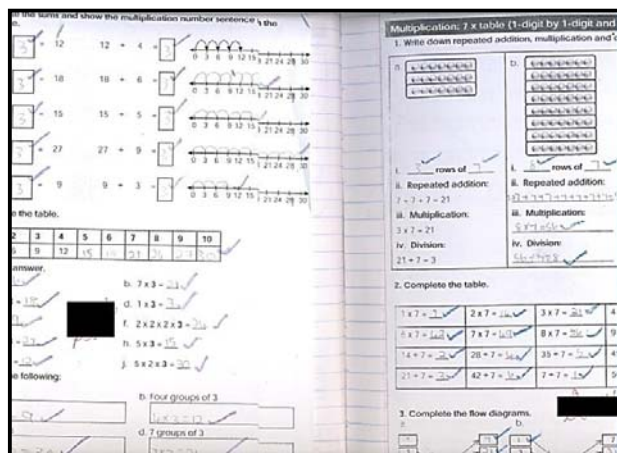


Figure 4:11 Figure 4:11: Example of teacher B's learner books (23-02-2015)

This figure shows an example of teacher learner's book in teacher B's class. As described by her, the learners' books contain a lot of printouts and worksheets pasted in. For confidentiality her signature has been blocked out.



Figure 4:12 Teacher B's classroom

This figure illustrates the classroom structure of teacher B. The space occupied by learners' books is evident in this figure.

To address these limitations of the classroom she attempts to make the environment pleasant to her learners by placing flower pots on the window sills and filling her walls with educational posters. Teacher B teaches all the subjects to her class and has filled the class with posters relating to the various subjects. The majority of her wall and board space has been dedicated to Mathematics posters. This arrangement can be seen in Figure 4:13, Figure 4:14 and Figure 4:15.



Figure 4:13 A wall in teacher B's classroom



Figure 4:14 Left side of teacher B's blackboard



Figure 4:15 Right side of teacher B's blackboard

These three figures depict teacher B's allocation of her classroom wall space to Mathematics posters and resources. Even though posters of other subjects are visible, it is evident that Mathematics posters and resources, especially around the blackboard, take preference.

4.3.3 Teacher C's Profile

Teacher C is in her third year of teaching and her first year at the current school. She is passionate to work in underprivileged areas and has learnt isiXhosa in order to be more effective as a teacher. She is reflective, often writing comments on her planning sheets, or writing notes in her notebook on how her lessons went (Figure 4:16).

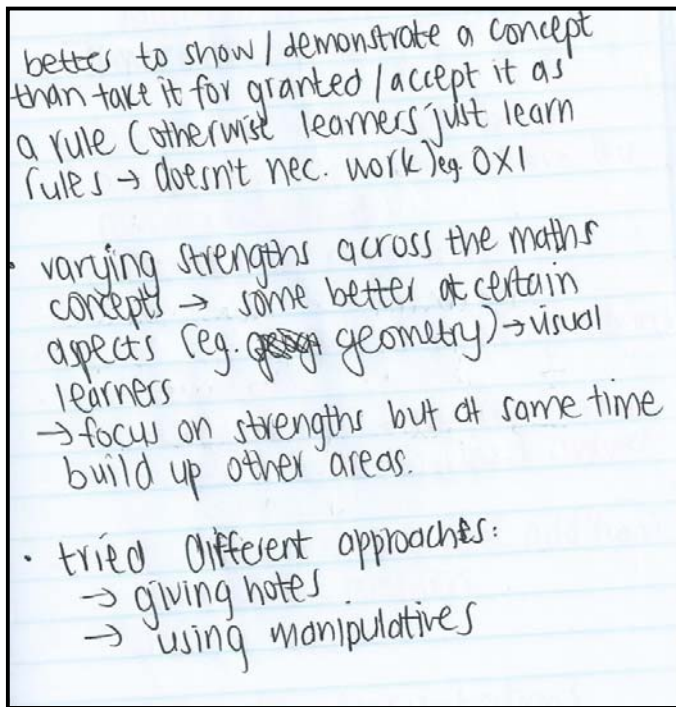


Figure 4:16 Extract from teacher C's reflective journal

This figure depicts an example of teachers C's reflections she writes on lessons taught. This extract was taken from her reflective journal where she documented her reflections during the research period as opposed to writing them in her notebook or on her planning sheets as per norm.

Teacher C asks herself, more experienced colleagues in the school and more often her mother whom she says is an accomplished teacher, how to improve her practice. She feels that learning should be interactive and that most of her lessons allow learners to be actively involved in the lesson through discussions, group work and practical tasks.

Teacher C (Gi4: NE): *I normally reflect on my lessons and think how I can improve but I find it more useful here because we're all reflecting together and it's also a good thing that I get an outsiders' opinion and not just my own.*

Being at a new school, Teacher C has found it difficult to adapt to the new management style and has had difficulties regarding learner discipline. However, she believes that through the implementation of new strategies in class, and by keeping open lines of communication with the school management staff, she has made progress and is settling in well. She feels that constant communication with her learners' parents/guardians is important for their learning and their discipline at school: Teacher C holds regular meetings with many parents who are willing to see her. She feels that such meetings have helped her gain insight into their situations at home, and given her insight about how to assist particular learners during her daily interactions.

Teacher C (Gi6: EE): *When I call parents in they are more interested in defending their child, saying that I'm the problem, but they not even interested in helping their child with their homework or even checking that the work gets done.*

Teacher C's experience as a Mathematics teacher

As a current grade four teacher she appears confident in teaching Mathematics for which she feels she received adequate training at university and in which she did well at school. Her goal as a Mathematics teacher is to ensure that no learner is left behind: meaning that they are not left with misconceptions, confused or struggling in any topic before continuing to the next section of work. She is constantly adapting her methodology through reflection and attempting to provide learning opportunities for the entire class to learn. She spends a large portion of her lessons with learners who are having difficulty with the subject or current concept. She tries to spend less time talking to the entire class and more time working with small groups of learners; giving more attention to struggling learners. She avers that this is time-consuming but she does not want to neglect any learner in her class.

Teacher C claims that she welcomes constructive criticism from colleagues, advice from more knowledgeable members of staff and experienced experts from outside the school. She regards such discussions as opportunities for growth and development. She believes that Mathematics is one of the most important subjects. She is willing to participate in all endeavours at the school regarding the growth and development of Mathematics teaching and learning. She has constantly attended training workshops offered by the education department and attended many training workshops and seminars offered by her trade union even if it meant paying for such sessions herself.

Teacher C (Ii1: NE): *I feel that I'm learning more as I teach and I can see where I need to develop. ... It's important that we have opportunities for professional development because we need to keep learning new methodology on how to improve our practice.*

Detailed lesson planning is of the utmost importance to her practice. Teacher C holds that it is an essential part of what makes a good Mathematics teacher. She claims that she applies this rule to all aspects of her lessons which she plans weeks in advance; preparing the necessary notes, worksheets, resources and activities (Figure 4:17 and Figure 4:18).

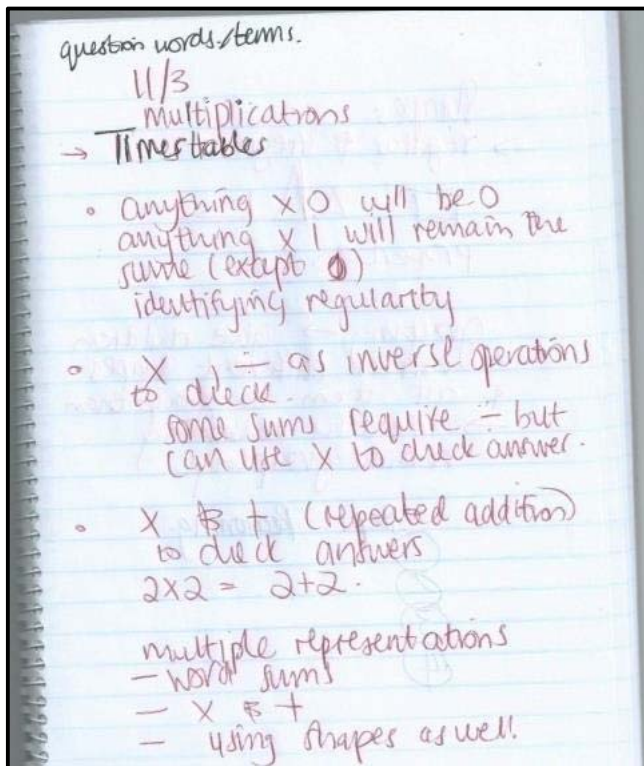


Figure 4:17 Extract from teacher C's reflective journal

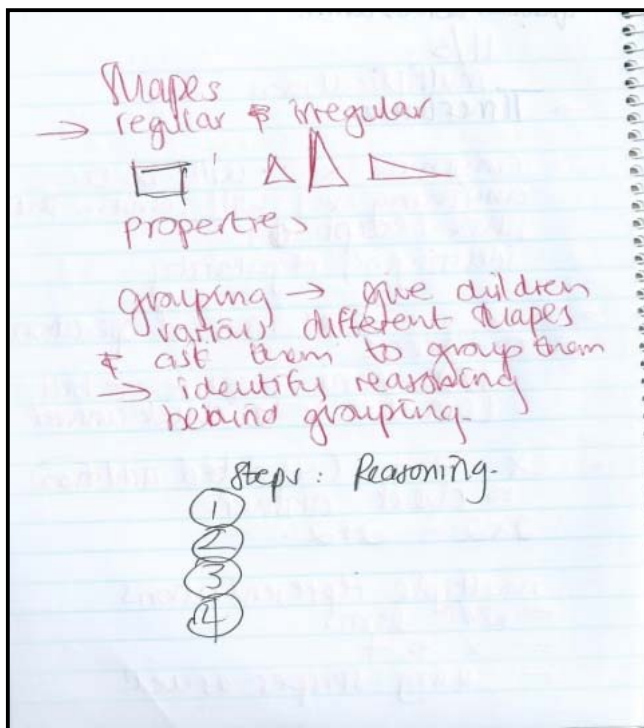


Figure 4:18 Extract from teacher C's reflective journal

These two figures have been taken from teacher C's reflective journal where she documented her reflections and lesson planning during the research period. Figure 4:17 and Figure 4:18 show examples of teacher C's notes written when preparing lessons implementing the Habits of Mind. In Figure 4:17 she is attempting to apply the 1st Habit, identify regularity.

Teacher C employs a wide range of teaching aids and resources in her lessons and often has to purchase the materials needed herself since the school does not always have the resources

she needs for her lessons (Figure 4:22: A section of teacher C's blackboard.. Her classroom has been meticulously structured to stimulate learning (Figure 4:19 and Figure 4:21).



Figure 4:19: Rear wall in teacher C's classroom



Figure 4:20 : Right hand side wall of teacher C's classroom

These figures depict the organisation of teacher C's classroom. Figure 4:19 shows a Mathematics term wall consisting of multiple terms and their definitions. Figure 4:20 shows the meticulous structuring of teacher C's classroom wall.

Teacher C has made a wide range of flashcards, in English, Afrikaans and isiXhosa, designed and made posters according to the needs of her lessons, and set up workstations for practical activities (Figure 4:21). Her classroom has been resourced for all the subjects she teaches, being the class teacher. She has placed more emphasis on Mathematics and Natural Science. She feels instruction in these subjects needs to be practical. Her table tops and window sills are filled with learners' experiments and Mathematics projects completed, or being completed, during this year.



Figure 4:21 Example of a workstation in teacher C's classroom

This figure shows an example of a workstation in teacher C's classroom. At this particular station learners use 3-D objects representing polygons, based on their faces, to discuss their properties through investigation.

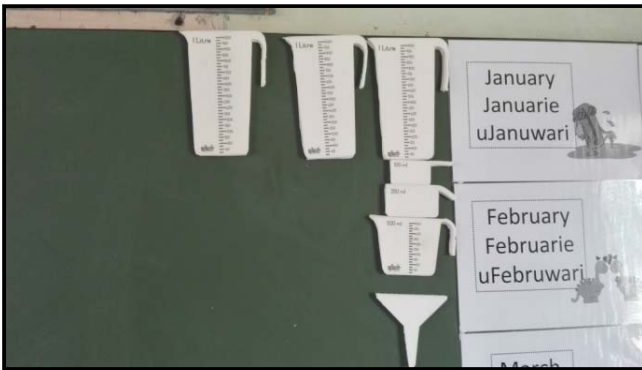


Figure 4:22 A section of teacher C's blackboard

This figure shows another work station where learners use magnetic representations of measuring jugs to practically investigate measurement tasks, which she has purchased herself. To the right of this there is an example of a multilingual flashcard created by teacher C.

4.4 Themes identified from the experiences of the teachers

The data collected were analysed using two models. The first is Giorgi's phenomenological model⁵⁴ (1975) and the second is the interconnected model of professional growth⁵⁵ (Clark & Hollingsworth, 2002). A combination of these models was used to provide a rich description of the data collected.

Whiting's (2002) adaptation of Giorgi's model (paragraph 3.8) was used to identify emergent themes in the data. In accordance with this model, four steps were used: (i) read through all the data as a whole, (ii) determine meanings expressed by participants, by reading and re-reading transcripts (identifying themes in the process), (iii) interrogate the themes according to the purpose of the study (placing themes into revelatory themes⁵⁶), and (iv) draft a descriptive statement of essential, non-redundant, themes. This section discusses the revelatory themes which were identified.

⁵⁴ Refer to paragraph 3.8.1.

⁵⁵ Refer to paragraph 3.8.2.

⁵⁶ A revelatory theme is a theme which is relevant in answering the research questions (Giorgi, 1975; Whiting, 2002).

After the themes were identified with their relevant natural units⁵⁷, as the extracts or quotations taken from the participants' interviews or reflective journals, the interconnected model of professional growth was used to map the interconnected patterns evident in these natural units. The interconnected patterns provided a deeper insight into the professional development of the participants evident in their interpretations of the phenomenon where Habits of Mind was introduced into teaching practice. These patterns are illustrated alongside the natural units and are discussed in paragraph 4.5.

The revelatory themes from all the data collected were: (1) perceptions of Relational Understanding, (2) perceptions of implementing Habits of Mind, and (3) experiences of being part of a Community of Practice. In addition to these themes, the data indicated the emergence of a pattern in the teachers' perceptions. This pattern indicated that their perceived experiences were two-fold. They had perceptions based on Existing Experiences (EE), their past experiences prior to the research period, and there were perceptions based on New Experiences (NE), the experiences they had during the research period. These two codes, EE and NE, were identified during thematic generation and are used to label participant quotations which aid in discussion of themes. Further coding information can be observed in Table 4:1 in paragraph 4.2 above. The quotations used in this section are written in the everyday vernacular of the participants. This style provides insight into the natural responses of the participants.

4.4.1 Perceptions of Relational Understanding

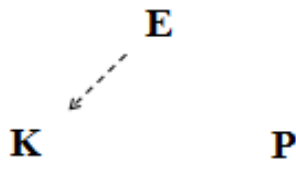
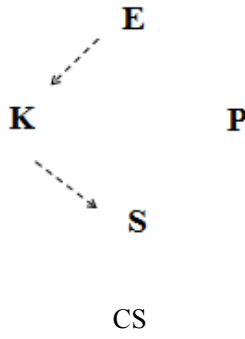
There were various perceptions of participants related to Relational Understanding evident in the data collected, as set out in paragraph 2.7.2. Relational Understanding refers to knowing what to do and why to do it (Skemp, 1976). Relational Understanding is an amalgamation of procedural fluency [the ability to know what procedures to use, how to use them accurately], and conceptual understanding [the ability to relate existing schemas to new knowledge which explains why specific procedures are used (Kilpatrick *et al.*, 2001; Pope, 2014)].

To discuss these various perceptions of participants, this section is divided into sub-themes: (A) Perceived benefits of Relational Understanding, and (B) Perceptions of Relational Understanding.

⁵⁷ Natural units is the term used by Giorgi (1975) to describe participants experiences in the form of units of meaning which are segregated from the rest of the transcribed text.

A. *Perceived benefits of Relational Understanding*

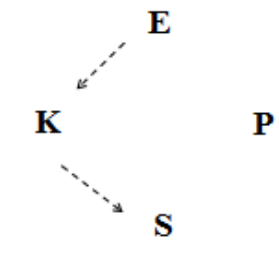
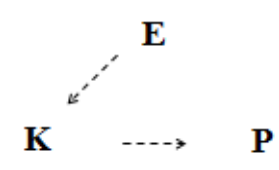
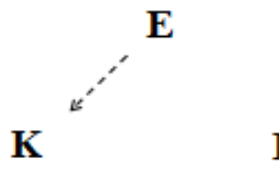
In their revelatory themes, all three participants made numerous comments on their perceived benefits of Relational Understanding. The initial benefits listed by teachers from their existing experiences (EE) were that Relational Understanding: is an important aspect of Mathematics teaching and learning; helps learners to apply their knowledge of Mathematics; and links topics relationally so lessening the need to re-learn work. All of these perceived benefits correspond to the benefits of Relational Understanding listed by Reason (2003). These can be seen in the natural units of the participants which follow:

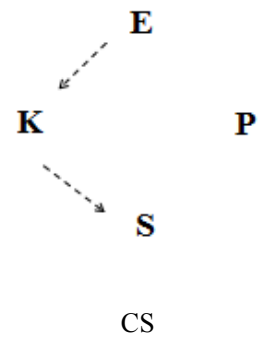
NATURAL UNIT	INTERCONNECTION ⁵⁸
Teacher A (Gi1, EE): I like this relation – ‘wat se goet?’ Ja that understanding. Why because I believe that ... (pause) it is important for the children that they must know how to use the Mathematics in real life.	 59
Teacher C (Gi1, EE): I think getting them to have a Relational Understanding will help them in life because they will be able to use all their Maths knowledge to solve problems.	

⁵⁸ Interconnections illustrated on the interconnected model of professional growth refer to paragraph 3.8.2, but will only be discussed later in paragraph 4.2 They were included in these tables to indicate the interconnected patterns in relation to the participants' natural units, which is necessary for the discussion in paragraph 4.2

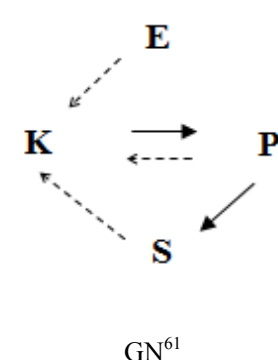
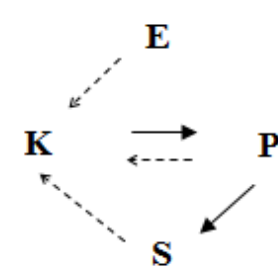
⁵⁹ Key: E – External Domain, K – Personal Domain, P – Domain of Practice, S – Domain of Consequence.

⁶⁰ CS - change sequence (refer to paragraphs 3.8.2 and 4.2 – an interconnected pattern where interconnections are not evident between domains of K and P, and therefore no lasting teacher professional development is evident (Clark & Hollingsworth, 2002).

NATURAL UNIT	INTERCONNECTION ⁵⁸
Teacher A (Gi7, EE): I have always taught with this focus in mind, where the learners learn the work so that they can understand and link the topics to the real world. I like what this um relational learning is saying but I have always taught with that in mind. So that the learners must understand and not just have to study the work all the time.	
Teacher C (Gi7, EE): I think that if we get them to relate the topics in Maths more I won't have such a problem when I teach a new topic and I have to constantly go back to remind them what we previously learned when they are required to use that knowledge in the new topic.	
Teacher A (Gi1, EE): You always have to keep going back and redoing the work over and over again. These children don't understand what they are learning so they don't see where there is links in the work or how they can um relate the work to each other. They expect that you as the teacher must now give them the links and they don't want to do it themselves. I always say that, um to them I tell them that if you just understand what I am teaching you and you study the old work and connect it to the work you are learning today in class then you will be able to pass any test easily.	

NATURAL UNIT	INTERCONNECTION ⁵⁸
Teacher B (Gi1, EE): You know, I keep saying that they must listen to teacher, and children you must keep in mind what I have taught you so that you can make reference to old work and make your own understanding that is unique to you. Then you will tell me again, but teacher I understand what I am doing. Understanding is the most important thing.	

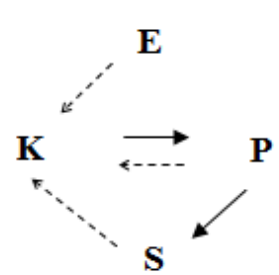
The natural units gathered from new experiences (NE) which list the perceived benefits of Relational Understanding were mentioned in the NE of Teacher C. Teacher C felt that when teaching to promote Relational Understanding her major benefit was that she had to repeat concepts less often:

NATURAL UNIT	INTERCONNECTION
Teacher C (Gi5, NE): I find that when I got them to relate their topics in this way (using the habits) they seemed to have a better understanding in the follow up lessons and I did not have to repeat myself as often.	
Teacher C (Ii1, NE): I find that when I did a topic like length, and I related it to decimals the learners were able to understand it more. Even though decimals were not part of the syllabus at the moment, by me teaching it and then relating it to length they had a better understanding and more importantly I did not have to repeat it over and over.	

⁶¹GN - Growth network (refer to paragraphs 3.8.2 and 4.2 - an interconnected pattern where interconnections are evident between domains of K and P, and therefore lasting teacher professional development is evident (Clark & Hollingsworth, 2002).

NATURAL UNIT	INTERCONNECTION
	GN

Another benefit mentioned in the new experiences of Teacher C can be seen in the second natural unit above where she felt that her learners had a better understanding of the concept she was teaching when she related it to a previous topic. Parallel to this, Teacher C mentions what she believes to be improvement in learner involvement and understanding as a result of Relational Understanding, stating that:

NATURAL UNIT	INTERCONNECTION
Teacher C (Gi4, NE): Now that I understand how to use the habits better and have planned strategies to get the learners to use them I find that they are more involved in the lessons and more of the struggling learners are understanding the work.	 GN

B. *Perceptions of Relational Understanding*

Having discussed participants' perceived benefits of Relational Understanding evident in the data collected, it is important to note that, when comparing their natural units on Relational Understanding, it was apparent that participants had varied perceptions of what comprises Relational Understanding⁶². Relational Understanding, according to Skemp (1976), refers to learners' ability to relate new concepts in Mathematics to previously learned schemas. This ability refers not only to learners' understanding of one single aspect, or concept, in Mathematics. Relational Understanding refers to the ability to understand mathematical concepts in the context of their relation to other concepts in Mathematics. Relational Understanding assists the learner to gain a broader, relational view, or understanding, of Mathematics as a whole. Surmising the simplest definition of Relational Understanding as described by Skemp (1976) and Pope (2014), Relational Understanding indicates procedural fluency; knowing which mathematical procedures to use and having the conceptual

⁶² In reiteration, the meanings Relational Understanding, Habits of Mind and Communities of Practice were explained to the participants prior to the research period (refer to paragraph 3.6.1).

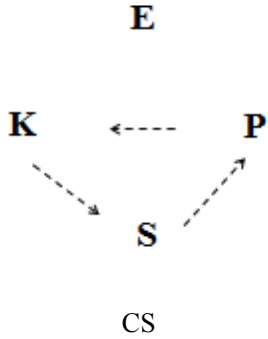
understanding⁶³ to know why certain procedures are used. This was the perception of Relational Understanding used in the context with this research. The data collected revealed that this was not always the perception that participants had of Relational Understanding, evident in their natural units.

From all of Teacher C’s natural units, it was evident her perception of Relational Understanding corresponded with that of the research. She comments on linking new and previously learnt concepts which concurs with the explanations of Skemp (1976).

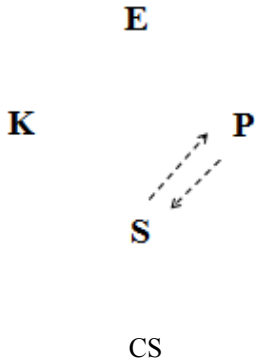
NATURAL UNIT	INTERCONNECTION
Teacher C (Ii2, NE): It came to me when I was planning the lessons for the week and trying to think how to use the habits, thinking of what questions I could ask and what the responses might be. This was when I really had to keep in mind that I am trying to teach for Relational Understanding so I had to plan my lessons so that there was time for, opportunities for them to link the previous lessons to this lesson. It was difficult trying to think of how to get some of them, especially the struggling learners to be part of the discussion but I later realised that these types of lessons, where they made connections between the different topics excited them because they understood the work.	<pre> graph TD E((E)) -.-> K((K)) K --> P((P)) P -.-> S((S)) S --> K </pre> GN

Similar perceptions were present in some of the natural units of Teacher A and Teacher B where they commented on the linking of concepts and its benefits in the application of Mathematics.

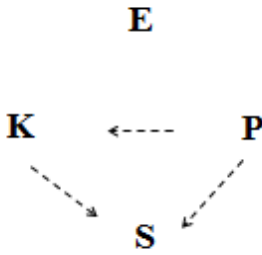
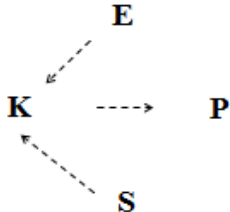
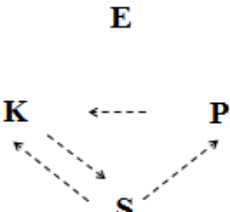
⁶³ Terms conceptual understanding and procedural fluency taken from Kilpatrick *et al.* (2001).

NATURAL UNIT	INTERCONNECTION
Teacher A (Gi1, EE): You always have to keep going back and redoing the work over and over again. These children don't understand what they are learning so they don't see where there is links in the work or how they can um relate the work to each other. They expect that you as the teacher must now give them the links and they don't want to do it themselves. I always say that, um to them I tell them that if you just understand what I am teaching you and you study the old work and connect it to the work you are learning today in class then you will be able to pass any test easily.	 <pre> graph TD E --- K E --- P K --- S P --- S </pre>

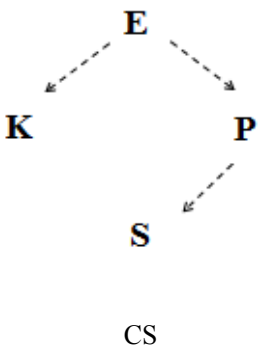
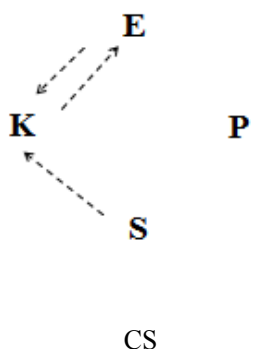
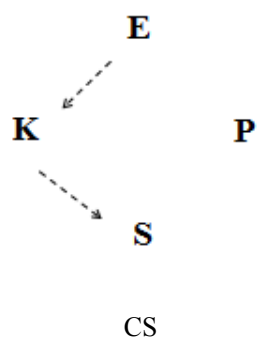
In the natural unit above Teacher A makes reference to the linking of concepts, referring to it as Relational Understanding. Likewise Teacher B makes reference to this in her natural units saying that:

NATURAL UNIT	INTERCONNECTION
Teacher B (Li1, EE): We have to improve their understanding of the work and show them how to use Maths. They sometimes don't even see where you can use it in the other subjects... they need to understand the work so that they can relate it to other situations where they can use it there also.	 <pre> graph TD E --- K E --- P K --- S S --- P </pre>

However, in the natural units from Teacher B and Teacher A they did not make reference to Relational Understanding from this perception of linking concepts. In Teacher B's natural units she more often referred to Relational Understanding as a technique which helped learners to appreciate Mathematics as a worthwhile and useful discipline.

NATURAL UNIT	INTERCONNECTION
Teacher B (Gi5, EE): You know what, we as teachers we always using different things and methods to try to get the learners to not just umm remember the work but also understand what and why they are doing it. We sometimes do these things without even realizing what we are doing. We just teach man, and we try our best to get them to understand.	 CS
Teacher B (Li2, EE): You know, (pause) I feel that they don't see why I am teaching them. You know it's almost like they don't care, and it's because they can't see the importance of knowing the work. I keep telling them, you know what? You cannot do anything without Mathematics. But I think it's also that they can't see the value of it. They don't use it at home. So they can see why they are learning it. What for? This is why I believe in allowing them to understand the work, like what we have been trying to do. Have Relational Understanding like we said.	 CS
Teacher B (Li1, EE): I find that words like ascending, descending, factors, multiples, um product, difference, the sum of two numbers, um you know is very important 'hey?', it's part of the Mathematical literacy. So um for me the literacy part is very important, and also the way the child phrases and answers a question, and then also concepts. For me concepts are very important and I also like to use literacy, cause I also like stories but I also like to use realistic things cause they must be able to explain the Maths in real life so they can understand. Like now with length for example, children use length daily, they deal with money daily, they deal with um (pause), I mean like they must have the literacy to explain the Maths so that they can see it in the real world and make that link.	 CS

Similarly Teacher A’s natural units have analogous perceptions as seen below:

NATURAL UNIT	INTERCONNECTION
Teacher A (Gi7, EE): I have always taught with this focus in mind, where the learners learn the work so that they can understand and link the topics to the real world.	
Teacher A (Li2, EE): What I always feel is that the learners need to know the value of Mathematics, or else they won’t remember it. They need to have that understanding. <i>Wat’s die goet nou weer? Re- Re, uh... Ja,</i> Relational Understanding. That’s it yes. They must have that so they can understand why it is important for them to be at school. Because you know, er, Maths is not something you use every day. Or not the Maths they are doing now days in school. So they must have this Relational Understanding to see the value of the work, in maybe their future if they want to do jobs like...	
Teacher A (Gi1, EE): I like this relation – ‘<i>wat se goet?</i>’, Ja that understanding. Why because I believe that (pause) it is important for the children that they must know how to use the Mathematics in real life. When they go out and look for jobs they need to have matric Maths, but they don’t understand that now. That is why we and their parents need to give them this understanding <i>goetes</i> (referring to Relational Understanding) so that they see the importance of working and studying their Maths now.	

In the above descriptions, examples were given of how Teacher A and Teacher B perceive Relational Understanding as enhancing learners’ ability to see Mathematics as worthwhile and useful. These perceptions of Relational Understanding regarding its influence on

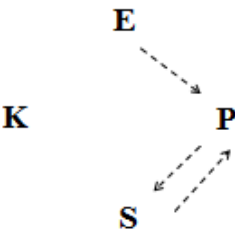
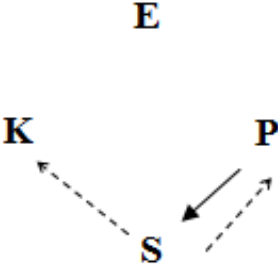
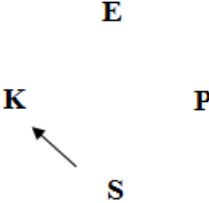
learners' ability to value Mathematics are not a foreign concept. In fact it is associated with the benefits of Relational Understanding. This is evident when Murphy and Carlisle (2008) describe agency as a benefit of Relational Understanding of Mathematics; explaining that it increases enjoyment of the subject and generates confidence in using Mathematics in various contextual situations: real-life problem solving opportunities. Reason (2003) adds to this optimism with another benefit associated with Relational Understanding. Reason claims that, as schemas grow, learners' awareness of their possibilities in Mathematics enlarges which makes it easier to draw connections. These benefits show that positive implications, in learners' awareness of both the value of Mathematics and its implications in real-world problem solving, can be associated with Relational Understanding.

Kilpatrick *et al.* (2001: pp. 115–116) describe five strands of Mathematics proficiency: (1) conceptual understanding, (2) procedural fluency, (3) strategic competence, (4) adaptive reasoning and (5) productive disposition. The first two strands, conceptual understanding and procedural fluency, were discussed in paragraph 2.7.2 where Pope (2014) related Relational Understanding to these two strands. The fifth strand described by Kilpatrick *et al.* (2001, p. 116), productive disposition, is explained as being the “*habitual inclination to see Mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy*”.

Teacher A and Teacher B's perception of Relational Understanding as a skill that facilitates learners ability to make connect Mathematics with its real world value and application are therefore not a divergent perception but one which has its place in both learners' mathematical understanding and proficiency. However, in light of Relational Understanding this is not its definition but a benefit of having a Relational Understanding. Since this perception was the dominant perception in Teacher B's natural units and frequently arose in Teacher A's natural units, it suggests that their perception of Relational Understanding leaned more towards one aspect, or benefit, of Relational Understanding. Their perception of Relational Understanding might not have been a complete description of the concept. To have a more complete understanding of the concept of Relational Understanding as stipulated in the literature review, participants are encouraged to perceive that Relational Understanding occurs where learners are able to relate new concepts in Mathematics to previously learnt schemas which allow learners to know what procedures to follow and why (Skemp, 1978; Pope, 2014). Having a complete understanding of this concept encourages these two

participants to categorise the view of Mathematics as worthwhile and useful: a product of their learners having a Relational Understanding of Mathematics (Reason, 2001; Murphy & Carlisle, 2008).

Teacher A frequently shared this dominant perception of Teacher B, relating Relational Understanding to learners’ view of Mathematics being worthwhile and useful, yet her most recurring perception was that Relational Understanding refers to learners’ ability to remember or memorise Mathematics terminology and methods or procedures for doing calculations. This is evident in the following natural units:

NATURAL UNIT	INTERCONNECTION
Teacher A (Ii1, EE): We can’t just always focus on this understanding ‘<i>besigheid</i>’ (business) because they need to know their basics. We have to also drill the basics into them so that they know it...if they remember how I showed them to do the sum in the class then they will understand it when they see it again in the tests or homework.	 CS
Teacher A (Gi2, EE): But what I’m saying is what I teach; I make sure that, that child understand before I continue to my next step. Sometimes this means I must go over and over the work again, and get them to stand and repeat it over and over. But until they memorise the definitions they won’t understand and so I cannot continue on.	 CS
Teacher A (Ii2, EE): What I have learnt in all the years I have been a teacher. From my experience, (pause), I believe that learners will not truly understand unless they learn the basic skills, firstly the basic skills. Secondly they must memorise the terms. So if I say difference they must straight away know to subtract, and so on. <i>Hulle moet weet. En</i>, uh, number three they must know the methods we use. This is how they understand,	 CS

NATURAL UNIT	INTERCONNECTION
through practice, practice, practice. They must drill these things into their memory so when the tests come they won't make mistakes. So they must understand.	

This perception of understanding does have its place in mathematical proficiency: Kilpatrick *et al.* (2001, p. 116) refer to it as procedural fluency, defining it as the “*skill in carrying out procedures flexibly, accurately, effectively, and appropriately*”. However this understanding cannot be learnt in isolation. Pope (2014) concurs with this standpoint, stating that the ideological valuing of procedural learning tends to promote mathematical learning with little Relational Understanding. Skemp (1976 p. 21) suggests that teaching solely with the aim of developing learners’ abilities in memorising and using procedures accurately as instrumental understanding, is the same as learning *rules without reasons*. Procedural fluency is a necessary aspect of Relational Understanding, but if it is learnt in isolation, it resembles what Skemp (1976) describes as instrumental understanding and is contradictory to the concept of Relational Understanding (Pope, 2014). Teacher A’s perception regarding Relational Understanding is not consistent with the concept as understood by literature used in this research: the ability to know which procedures to use and to know why these procedures are being used (Skemp, 1978; Pope, 2014).

All three teachers agree that Relational Understanding is beneficial in teaching but they have varied perceptions of what Relational Understanding is. Teacher C’s dominant perception remains true to Skemp’s (1976) and Pope’s (2014) concept of Relational Understanding as to where learners are able to relate new concepts in Mathematics to previously learnt schemas, allowing learners to know what procedures to use and why (Skemp, 1978; Pope, 2014). A frequent perception of Teacher A, and Teacher B’s dominant perception remains true of this concept of Relational Understanding: although limited in one aspect. A benefit of Relational Understanding is that learners are able to see Mathematics as worthwhile and useful. Their perception of Relational Understanding seems not to fully describe it as the research perceived it to be (Reason, 2001; Murphy & Carlisle, 2008). Teacher A’s dominant perception is more relevant to that of instrumental understanding where the focus is on memorising and using procedures accurately: something which contradicts the concept of Relational Understanding (Skemp, 1976). To refer to the subsidiary questions of this research ‘*what were their perceptions of promoting Relational Understanding?*’ it is evident from the

data collected that, even though they have varied perceptions of Relational Understanding, the teachers agree with the promotion of Relational Understanding because they feel that it is beneficial. The relevance of some of their views regarding its benefits are validated by their perceptions which are not completely in line with that of what Relational Understanding is perceived to be by this research and therefore could be misleading.

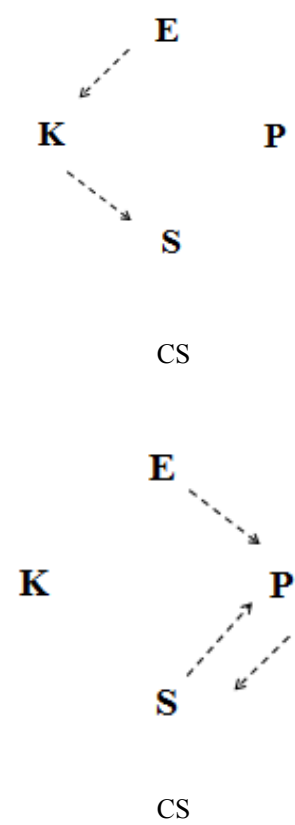
4.4.2 Perceptions of implementing Habits of Mind

The use of specifically chosen Habits of Mind as a tool that promotes learners’ Relational Understanding was explained in paragraph 2.8. From the revelatory themes associated with the participants’ perceptions of the implementation of Habits of Mind in their practice, two sub-themes emerged: (A) Perceptions of Habits of Mind, and (2) Implementing Habits of Mind.

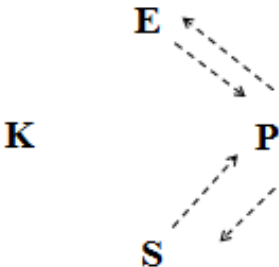
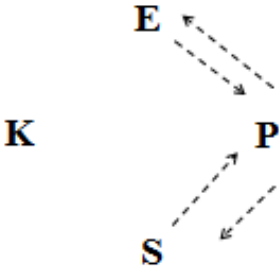
A. Perceptions of Habits of Mind

The initial participant responses to the idea of promoting Habits of Mind in their lessons were positive and optimistic. They perceived that it would be beneficial to their classroom practice. This was evident in the natural units of the participants’ existing experiences (EE) early into the research period.

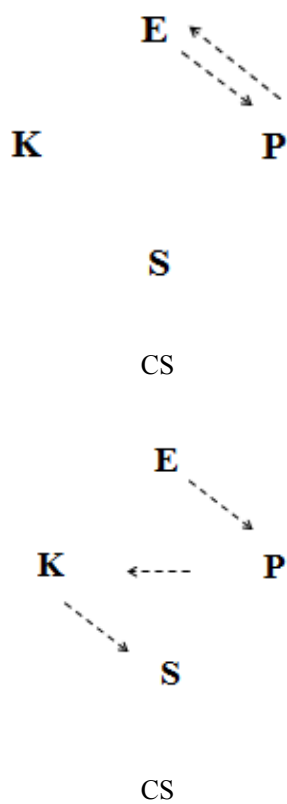
NATURAL UNIT	INTERCONNECTION
Teacher A (Gi1, EE): I like these Habits of Mind. I always feel that it is good for them to have good habits; like I try to get them do these steps when I say do this first then do this so they can be more organized in their learning. I like these habits.	<pre> graph TD E[E] -.-> K[K] E[E] -.-> P[P] K[K] -.-> P[P] S[S] CS[CS] </pre>

NATURAL UNIT	INTERCONNECTION
Teacher B (Gi1, NE): You know I actually like these habits because it will help them to be more focused on how they can learn the work. They can learn more for understanding man and not just sit and write and do activities. With this they can be more active man. Teacher A (Ii1, EE): You know habits are things we use all the time and I always try to get the learners to develop good, good habits. Now you come with these habits but I feel yes it's good to have them. Because why, the learners need structure. They lack the skills and basic, uh skills to study or complete, uh solve problems using Maths so to get them to have these habits will help them structure themselves better.	 The top diagram shows a network of four nodes: E (top), K (middle-left), P (middle-right), and S (bottom). Dashed arrows indicate connections from E to K, K to S, and E to P. The bottom diagram shows a similar network of four nodes: E (top), K (middle-left), P (middle-right), and S (bottom). Dashed arrows indicate connections from E to P, K to P, and S to P. Both diagrams have the label 'CS' centered below the nodes.

From their natural units it was evident that participants had different interpretations as to what Habits of Mind were. According to the literature referred to in Chapter 2. Habits of Mind are regarded as being specific ways of thinking about and doing Mathematics (Selden & Selden, 2005). Four specific Habits of Mind were chosen for this research: those Habits of Mind that could promote Relational Understanding in the thinking about and doing of Mathematics (paragraph 2.9.) When looking at data collected from Teacher B and Teacher C, it was evident that they generally perceived Habits of Mind in the same terms as those explained in the literature review and in accordance with the research aim where Habits of Mind were to be used as a tool that promotes Relational Understanding of Mathematics.

NATURAL UNIT	INTERCONNECTION
Teacher B (Ii1, NE): When I teach I like to teach the children, uh, ways or um little things man I can get to the word now but things like these Habits of Mind were they have now a, uh, set of things to do. Man you know what I'm trying to say it's like you give them methods so that they can think about the Mathematics more and not just do. So now we using these Habits now, these four Habits, <i>ja</i>. Now when they don't have me around or they go to the next grade then they take these things with them and use them, and you know like we been trying to do all the time this methodology is continuing to the next teacher so they see the link in the work so they don't just forget it. Teacher C (Ii2, NE): Trying intervention methods like using these Habits of Mind is very important in what we are trying to do here as Maths teachers. Because we are trying to keep the same methodology from grade to grade if we all use the Habits of Mind in our lessons the learners will get used to using them and have a better holistic understanding of Mathematics. We won't have to start over each year and they will always use these four steps when doing any new work in Maths. I think methods like this is what we should be doing more.	 CS  CS

In the data collected from Teacher A however, it was evident that she did not share the same interpretation of what Habits of Mind are. As evident in her two previous natural units seen in this section, she refers to Habits of Mind as '*good habits*' (Gi1, EE) and as '*things we use all the time*' (Ii1, EE). This is evident in those natural units and is an interpretation of Habits of Mind which she uses on many occasions during the research period.

NATURAL UNIT	INTERCONNECTION
Teacher A (Ii2, NE): What I have been saying all this time is that we as teachers, experienced teachers, we have always done these things where we get them to follows steps or develop habits, like studying and going home and doing homework or their tables every day. <i>Dis mos die selfde goed.</i> Teacher A (Ii1, NE): I like these Habits cause it's something that I believe in when I have been teaching. The same way I have my good and bad habits so I want to get them to have these good habits when doing Maths and they must have lots of good habits cos it helps them remember the work.	 The diagrams illustrate interconnected concepts. The top diagram shows E at the top, K to the left, and P to the right, with dashed arrows from E to K and E to P. Below this is S, then CS. The bottom diagram shows E at the top, K to the left, and P to the right, with dashed arrows from E to K, E to P, and K to S. Below this is S, then CS.

These natural units of Teacher A reveal that she interprets Habits of Mind as good general Habits of Mind and not as specialised Habits of Mind selected for this research. Cuoco *et al.* (1996, p. 3) differentiate between these interpretations; stating that “*general Habits of Mind are not the sole province of Mathematics – the research historian, the house-builder, and the mechanic who correctly diagnoses what ails your car all use them.*”. They specify that Habits of Mind specific to a particular subject and/or purpose, such as the ones selected for this research, differ from general Habits of Mind which are techniques used to allow students to think of Mathematics as mathematicians do. Habits of Mind are specific ways of thinking about and doing Mathematics, promoting Relational Understanding when doing so, which is the interpretation of Habits of Mind used in this research. Whereas Teacher B and Teacher C more often had a perception of Habits of Mind which was analogous to that of this research, Teacher A more often perceived Habits of Mind as being general habits.

B. *Implementing Habits of Mind*

Data collected later in the research period revealed participants' perceptions of the implementation of Habits of Mind in their classroom practice. These perceptions were more prominent in their new experiences (NE). One of the most-often recurring perceptions was their perceived difficulties in implementing Habits of Mind due to time constraints in their classroom practice. These time constraints were revealed in their natural units which limited time caused by demands of the content in the curriculum and administrative demands of teaching. Participants attribute their inability to implement the use of Habits of Mind to a lack of teaching time, and felt that using Habits of Mind in their teaching lengthens the lessons in an already time-limited situation.

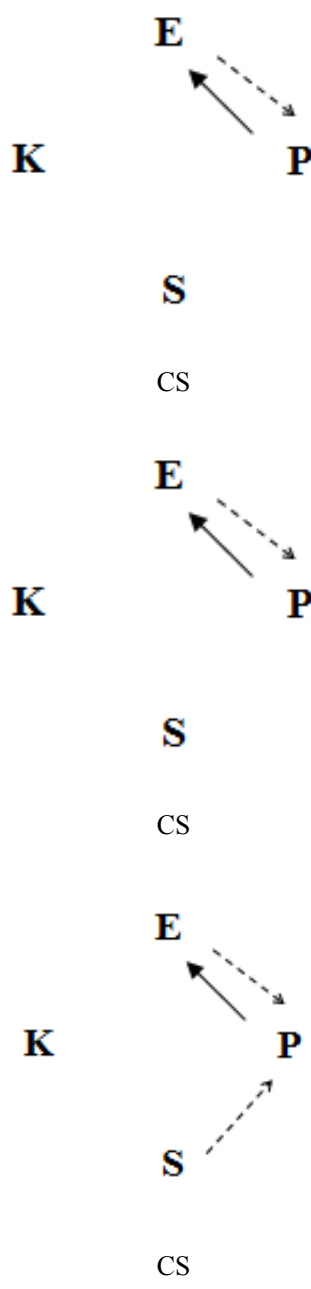
These feelings were consistent among the new experiences (NE) of participants' natural units and were evident in some of their existing experiences (EE). Reasons identified in the data for the time constraints of the participants, as they perceived them, were mainly related to the demands of the Department of Basic Education (DBE) on educators, and the demands of the National Curriculum Statement, which currently is the Curriculum and Assessment Policy Statement (CAPS). The following natural units illustrate these perceptions:

NATURAL UNIT	INTERCONNECTION
Teacher C (Gi2, NE): Marking the DBE book takes up a lot of time and I can't keep carrying all these books home all the time. Having to use the textbook, their workbook and DBE book is a hang of a lot of work for us and them.	The diagram for Teacher C shows a vertical arrangement of concepts. At the top is 'E'. Below it, 'K' is on the left and 'P' is on the right. Below 'K' and 'P' is 'S'. At the bottom is 'CS'. A dashed double-headed arrow connects 'K' and 'P'. A solid arrow points from 'S' to 'P'.
Teacher A (Gi6, EE): It is a bit, I don't know how you find it teachers but I feel that the curriculum is (pause), the content is too much.	The diagram for Teacher A shows a vertical arrangement of concepts. At the top is 'E'. Below it, 'K' is on the left and 'P' is on the right. Below 'K' and 'P' is 'S'. At the bottom is 'CS'. A solid arrow points from 'S' to 'P'.

NATURAL UNIT	INTERCONNECTION
Teacher B (Gi3, NE): We spend so much of our learning, um teaching time on following this CAPS, CAPS, CAPS and DBE book, DBE book that we don't have time for intervention or to get the children to understand the work.	

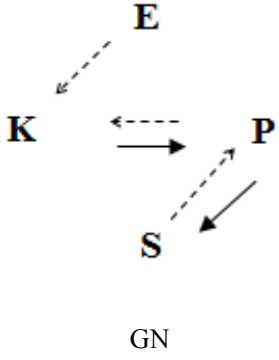
Consequences of the time constraints are evident in the natural units above from Teacher B when she mentions not having enough time for intervention strategies, ultimately limiting the implementation of using Habits of Mind in her lessons. This experience was common amongst the participants: they felt that the time constraints limited their ability to use the Habits of Mind in their lessons.

NATURAL UNIT	INTERCONNECTION
Teacher A (Gi4, NE): I always say that this department wants us to just be busy. Non-stop busy. This is why we can't have the time to do these Habits of Mind now.	
Teacher B (Gi4, NE): No man I now didn't have the time this weeks, I'll be honest. This CAPS curriculum just overwhelms the children and I have to repeat, repeat, repeat things all the time and don't have time to try this (referring to the Habits of Mind).	

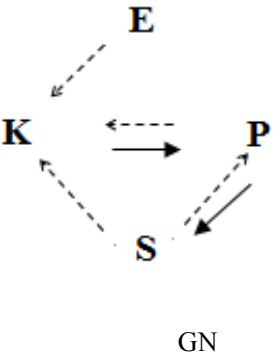
NATURAL UNIT	INTERCONNECTION
Teacher C (Gi2, NE): I haven't had much time to implement the Habits of Mind. It's difficult because with teaching all the subjects the content is so much that there is not much time for anything else. Teacher A (Gi3, EE): ... and I always say that this government don't know what they are doing by giving us so much things to teach our learners. We are so busy with blue books and (pause) ah keeping up with the curriculum that we don't have time to try these, um habits. Teacher A (Gi2, NE): I'm sorry but I couldn't find the time to do it (referring to the Habits of Mind) this week. I'm actually behind with this CAPS work cause I have been ill and now I must catch them up. But I also find that we can't even take sick, uh, leave cause we fall so quickly behind. There is no time for anything.	 The diagrams illustrate interconnectedness. Each diagram shows a central node 'E' connected to 'K' and 'P' by solid arrows, and to 'S' by a dashed arrow. The first two diagrams are identical and show 'S' above 'CS'. The third diagram shows 'S' below 'CS' with an additional dashed arrow from 'S' to 'P'.

These natural units from the participants depict the perceived difficulties they encountered when attempting to implement Habits of Mind into their teaching as a result of being overburdened by the Department of Basic Education (DBE) and the Curriculum and Assessment Policy Statement (CAPS) curriculum. Participants' natural units revealed that they experienced additional stress in an already time-limited situation where the Habits of Mind

lengthened their lessons. This difficulty can be seen in teacher C’s natural units where she states:

NATURAL UNIT	INTERCONNECTION
Teacher C (Gi3, NE): I find that if I plan these habits into my lessons they often take longer because there is more discussion so I could fall behind in CAPS... But I get better feedback from more of the class especially the weak ones.	

Similarly in her natural units Teacher B says that:

NATURAL UNIT	INTERCONNECTION
Teacher B (Ii2, NE): You know the times I tried to use the habits I felt that my lessons were engaging yes, but I feel that it took up a lot of time man. We don’t always have the time for this. Yes I would love to have them speak and discuss all the time but you know time is always a problem and um these types of lessons where you do things like this, like what we do with these habits, there just isn’t time for it.	

In addition to time constraints, participants’ natural units describe difficulties learners had when attempting to use the Habits of Mind. From the participants’ descriptions, learners had the most difficulty with the literacy demands of the Habits of Mind. Both Habits 2 (Discuss the regularity) and 4 (Justify)⁶⁴ require learners to use language to describe, discuss, compare and justify the Mathematical concepts of the lessons. The participants described this exercise as challenging for their learners. During her Individual Interview 1, Teacher B commented on her struggling learners:

⁶⁴ Refer to paragraph 2.9.

NATURAL UNIT	INTERCONNECTION
Teacher B (Ii1, EE): I have so many learners on the intervention list. Almost half of my class are struggling. We need to make a way where we can assist these learners.	<pre> graph LR K --- E K --- S S -.-> P CS </pre>

Later in the same interview she was more specific, speaking directly on their literacy abilities:

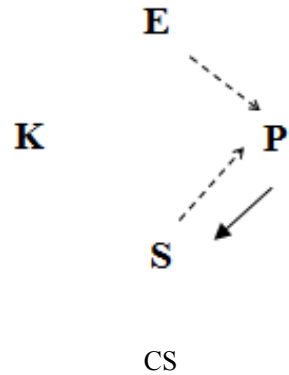
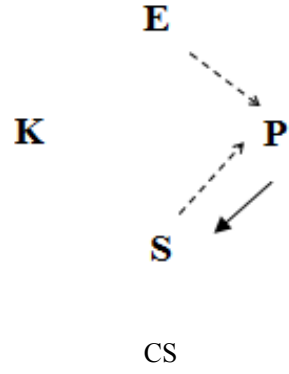
NATURAL UNIT	INTERCONNECTION
Teacher B (Ii1, EE): You know (pause) the children are very weak man. Every year I have more children who are, um who can't read man, and now they just get pushed onto grade 4 and I have to struggle with them. How can they just expect us to push these children on and do anything where we can help them?	<pre> graph LR K --- E K --- S S -.-> P CS </pre>

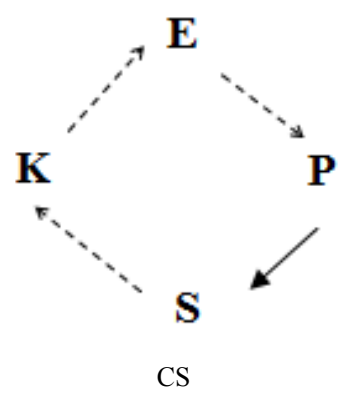
In her Individual Interview 1 Teacher C was vocal about the literacy difficulties she faces in her classroom:

NATURAL UNIT	INTERCONNECTION
Teacher C (Ii1, EE): I knew it was bad but I never knew how bad it was until I started teaching. Here we at least have most of the learners able to speak or understand English or Afrikaans at a level where you can teach them something like Mathematics for example. But the school I was at most of the learners could only understand isiXhosa and even their isiXhosa was not very good. How	<pre> graph LR K --- E K -.-> P S -.-> K CS </pre>

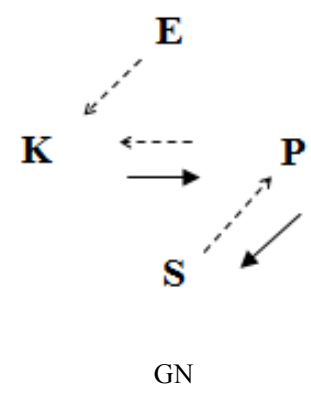
NATURAL UNIT	INTERCONNECTION
still are they meant to learn out of English textbooks or write tests written in English? Not to mention they struggle to comprehend Mathematics concepts.	

This point corresponds to what Fleisch (2013) describes when naming the patterns of under achievement in both Literacy and Mathematics as major contributors to the South African education crisis. The importance of reflecting on the role of learners' literacy abilities when implementing new tools in classroom practice, such as the Habits of Mind, is emphasised in Fleisch's (2013) research as well as participants' natural units emerging from the data collected. In the data collected from the participants, it is evident that learners' literacy ability, and difficulties associated with it, is a contributing factor to the difficulties participants had when implementing Habits of Mind. This aspect can be identified in the following natural units:

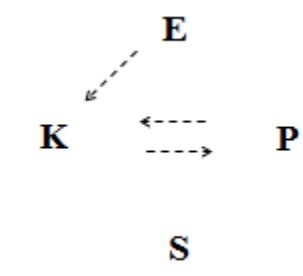
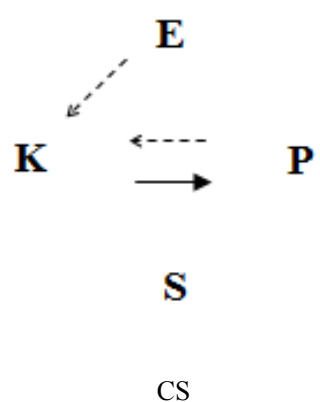
NATURAL UNIT	INTERCONNECTION
Teacher A (Gi2, NE): I find it difficult to get them to use these habits. They already struggle with the work and they don't like to talk and uh be involved, they want me to use the habits for them.	
Teacher B (Ii2, NE): You know hey that they struggle to explain themselves. When I ask them to talk about the patterns or when I say, right it time now for you to stand and tell the class, and prove what you have been discussing, the majority of them can even put one sentence together. They can't speak, they can read, they can't write. And its most of them. That's why I said we struggled with these Habits because it took so long to do it.	

NATURAL UNIT	INTERCONNECTION
Teacher A (Ii2, EE): I can tell you this when I first read the um Habits that was on the poster for the class I knew already that they would struggle with this. Why, firstly it meant they will have to speak a lot and I know they struggle with it. So when we did the Habits and they struggled it was nothing new to me. They can't speak about what they are thinking. They don't have the, uh, (pause). Their language skills are not there. You see it always in the Maths lessons, especially now with these, ah, Habits because they need to speak a lot when they use it.	

In addition to perceived difficulties as a result of time constraints and learner literacy challenges, Teacher A's natural units reveal her own personal difficulties with using Habits of Mind. This weakness can be seen in her natural unit below:

NATURAL UNIT	INTERCONNECTION
Teacher A (Ii2, NE): To be honest I found these habits difficult to use. Why, because getting learners to discuss and look for patterns <i>en so aan</i> takes a lot of time in the lessons. The children love doing this but we don't have enough time to always do things like this. And for me also I myself sometimes find it difficult to do these things. I am always learning, I always say that, but when I try these habits myself then I also struggle with them. I take long to do it, <i>hoe sal dit wees as die kinders dit probeer?</i> We just simply don't have the time for it.	

Teacher A was not the only one to mention personal difficulties when attempting to use the Habits of Mind. Teachers B and C mentioned this aspect as well:

NATURAL UNIT	INTERCONNECTION
Teacher B (Gi2, NE): I struggle so see where I can use these habits in the lessons ... I sometimes can't find the ways to use them myself. Um how must I get them to use it if I struggle with it myself and then I want them to use it? I need to practice it more and I need your help also to say where and how I must use it.	
Teacher C (Ii2, NE): When I began to use the Habits I struggled a bit in the planning because I could not always see how to use it.	

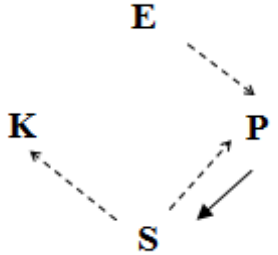
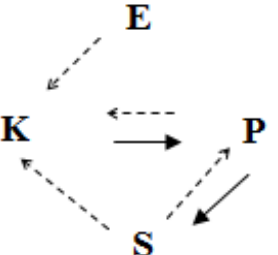
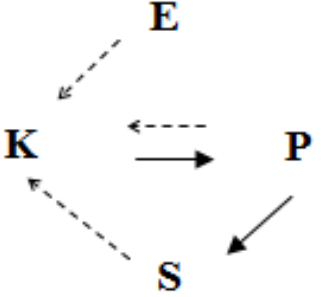
These are insightful perceptions which allow for a deeper understanding of why the participants experienced challenges in implementing these Habits of Mind, over and above their difficulties with teaching time and learners' difficulties and literacy constraints. Constraints on teaching time and learners' literacy, even though relevant to their perceived challenges in implementation, are more general challenges in the participants' classroom practice: whereas their personal difficulties with using the Habits of Mind themselves is a unique challenge to this phenomenon. Attempting to implement the Habits of Mind allowed participants to reflect on their practice and identify what hindered their attempts to adjust their practice. Despite the perceived difficulties which participants experienced when implementing the Habits of Mind, the attempt itself required them to reflect on their practice and identify what they felt were difficulties hindering their implementation of Habits of Mind. Dewey (1933) encourages this involvement of teachers: to be the subject of educational research, reflectively gaining knowledge of what they are doing. Winch, Oancea and Orchard (2015) emphasise the reflective teacher's role in current educational research,

identifying that along with situated understanding and technical knowledge, critical reflection is an aspect of teachers’ professional development. Evidence of this amalgam of skills is seen in Teacher C’s natural units:

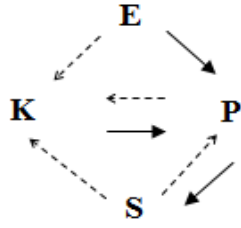
NATURAL UNIT	INTERCONNECTION
Teacher C (Ii2, NE): (Continuation of previous quote) But as I continued to use it I became more used to it and I started to use it better. It became easier as I used it more.	

Teacher C mentions this more than once during the research period. When looking at data collected in the group interviews that reflect Teacher C’s new experiences (NE), there was a progression in her confidence in using the Habits of Mind in her teaching. This increased self-confidence led to perceived improvements in her learners’ use of, and confidence in using, the Habits of Mind.

NATURAL UNIT	INTERCONNECTION
Teacher C (Gi2, NE): I have had some difficulty to get them to see the patterns in the work. They struggle with speaking and most of the time when I have a lesson where they can discuss then the disruptive ones always ruin the lesson.	

NATURAL UNIT	INTERCONNECTION
Teacher C (Gi3, NE): I find that if I plan these habits into my lessons they often take longer because there is more discussion so I could fall behind in CAPS... But I get better feedback from more of the class especially the weak ones.	 CS
Teacher C (Gi5, NE): The more I use them the more confident I am becoming... The learners are more willing to engage in the lesson and I find that the habits help them structure the way they give feedback... They follow the steps like first looking for the pattern, then discussing and then while they are busy doing that I have time to move around the class or help the weaker ones.	 GN
Teacher C (Gi6, NE): Now that I understand how to use the habits better and have planned strategies to get the learners to use them I find that they are more involved in the lessons and more of the struggling learners are understanding the work.	 GN

In these natural units Teacher C shows a change in her perception of using Habits of Mind in her teaching. She felt that the more she used the Habits of Mind and planned such use into her lessons, the more proficient she and her learners became in their use of them. Her final perceptions of this familiarity with the material can be seen in her concluding interview of the data collection period, individual interview 2.

NATURAL UNIT	INTERCONNECTION
Teacher C (Ii2, NE): I am still using the Habits of Mind when I teach. I'm not being so rigid in planning it into the lessons formally but I do always keep them in mind, they are still up on my wall. So we still refer to them when we discuss and it helps make the lessons move faster. Because they are now used to them they automatically begin using them and I find that I can leave them to work and don't have to waste time with explaining over and over... ...they are also writing down their own definitions from what they discuss and I feel that I am repeating less because they remember the work more now... ...I don't struggle with time as much as I did earlier this year. I think it's mostly because I'm more settled but I feel that them using the habits also allows them to work more independently so I get time back there.	 GN

Teacher C suggested that her new strategy resulted in less repetition of work which consequently aided in time management. Less repetition benefits teaching. Reason (2003) associates lower repetition with a Relational Understanding of Mathematics. In this interaction, Teacher C's personal experiences of implementing Habits of Mind are evident: she went through a process of struggling and 'mastering' her use of Habits of Mind and later passed her mastery on to the learners. The process of scaffolding is evident here as described in constructivist theories which elucidate Vygotsky's (1978) Zone of Proximal Development⁶⁵. Kiruthika (2014, pp. 1–2) describes this process of scaffolding as the teacher providing the appropriate guidance for the learners. Scaffolding assists learners in mastering a task or concept. In this light, scaffolding is explained as the teacher assisting learners in progressing from not being able to do a task on their own, to being able to do it with assistance, and eventually to the *mastery level* where they can perform the task unassisted. This progression is evident in the natural unit above where Teacher C states: "Because they are now used to them they automatically begin using them and I find that I can leave them to work ... also allows them to work more independently" (Ii2, NE). Warren (2009) describes the teacher's role in the scaffolding process as that of the more knowledgeable other. Warren

⁶⁵ Refer to paragraph 2.7.1.

(2009) implies that the teachers themselves need to have mastered the task or concept before being able to scaffold the learner into doing the same. This requirement corresponds to the emphasis that Venkatakrishnan and Spaul (2014) place on the development of teachers' Specialised Content Knowledge (SCK). SCK is explained by Ball *et al.* (2008, p. 389) as knowledge and skills unique to the work of teaching Mathematics⁶⁶. A change, and possible development, of Teacher C's SCK is evident in the progression of her implementation of Habits of Mind to what Kiruthika (2014, p. 2) describes as a *mastery level* which promoted her learners' progression towards their mastery of the Habits of Mind as evident in her perceptions depicted in the natural unit above (Ii2, NE).

In summary, data identified that although participants initially felt that Habits of Mind were beneficial to learners, they had difficulty implementing them in their lessons. These difficulties were perceived because implementing Habits of Mind demanded more time in an already time-limited situation. Second, the emphasis and demands placed on learners' literacy ability by the Habits of Mind proved challenging for learners. Participants perceived that this challenge originated from learner difficulties in literacy which affects Mathematics learning. Third, more reflective perceptions of participants revealed that they themselves had difficulty using the Habits of Mind. From these perceptions, it was evident that in attempting to implement Habits of Mind into their lessons, participants were required to reflect on their practice which is argued to be a beneficial practice of teachers (Dewey, 1933; Winch *et al.*, 2015). Teacher C, however, felt that the benefits of Habits of Mind, once established, relieved some of the pressure of limited time, allowing learners to be more independent once they mastered Habits of Mind (Kiruthika, 2014).

4.4.3 Experiences of being part of a Community of Practice

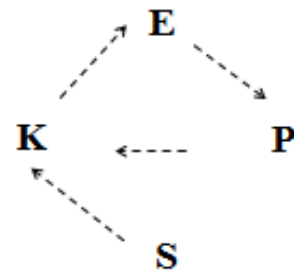
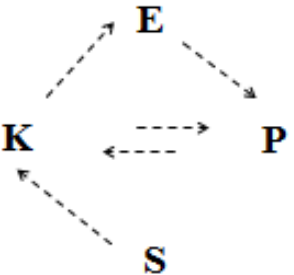
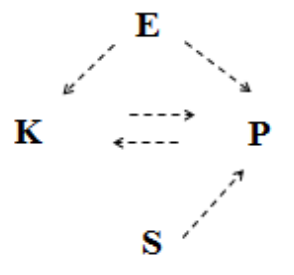
During the research period, participants were part of a Community of Practice which Lave and Wenger (1991) define as a professional learning community in which there is a collaboration of individuals towards shared knowledge. Natural units refer to the participants' experiences while being part of a Community of Practice and were all positive in nature. The natural units of the participants consistently mentioned what they perceived to be benefits of being part of a Community of Practice which remained consistent across existing experiences (EE) and new experiences (NE).

⁶⁶ Refer to paragraph section 2.5.1.

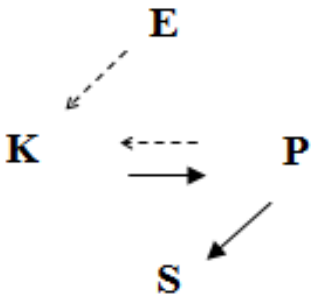
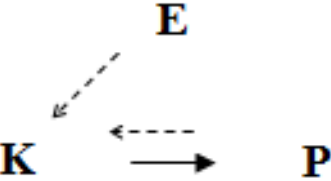
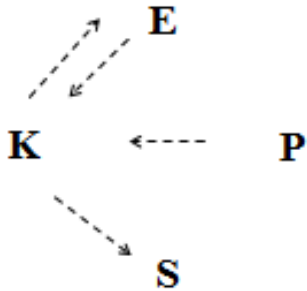
Data collected from existing experiences (EE) of participants revealed that the establishment of a Community of Practice was an activity which they previously envisioned for the school.

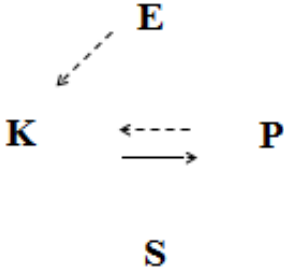
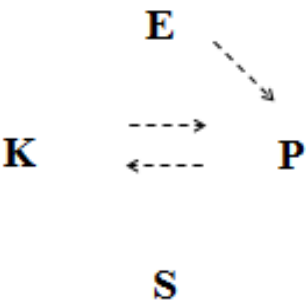
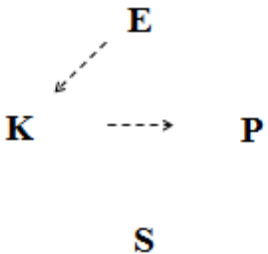
NATURAL UNIT	INTERCONNECTION
Teacher B (Gi4, EE): I am happy that we formed this group. Man, I have wanted to do this for long and I have been thinking that its better this way so we can share ideas and methods and learn from each other.	The diagram for Teacher B shows a vertical sequence of nodes: E at the top, followed by K, P, S, and CS at the bottom. A horizontal dashed arrow points from P to K.
Teacher A (Gi1, EE): This, um group here is what we have been wanting to establish in this school for long. We all have our own things we can learn from each other and we all know things that we can share. I have been doing things for years but I can always learn something from you new people because you have energy to try new things. It is important that we share what we are doing in our classrooms.	The diagram for Teacher A shows a vertical sequence of nodes: E at the top, followed by K, P, S, and CS at the bottom. A dashed arrow points from E down to K, and another dashed arrow points from K to P.

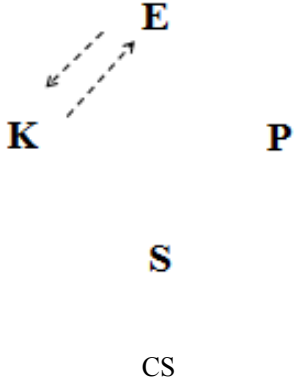
In the above natural units these participants felt that operating in a community of Mathematics teachers was beneficial through sharing experiences and classroom practice. In Teacher A’s natural unit, she recognised their (participants) need for support and for collaboration. There were perceptions in the natural units where participants mentioned their need to share methodology and classroom practice. They felt that they could synchronise these areas and assist learners as they progress from one grade to the next.

NATURAL UNIT	INTERCONNECTION
Teacher C (Gi1) NE: I think that it's actually good to have this kind of group as we have the chance to see what each other is doing so that we teach the same way. It's confusing if the learners are taught a certain way of doing things in one grade and they get taught something else in the next grade.	 CS
Teacher B (Gi1) EE: (responding to the previous comment) I agree, you know when you teach one thing and then the next teacher teaches something different then it's almost like the child must learn the work from overs again. It is time consuming. And you know we have been saying for long that we must sit together as teachers to discuss methods so that we all teach the same man.	 CS
Teacher A (Gi3) EE: When I teach then notice they always forget what they learned in the previous grade. But I think it's not that they forget. It's because the way you explain is not the way I explain so they don't understand it's the same thing. You see they get use to the teacher's voice. But I feel something like this (referring to the Community of Practice) is what we need so that we on the same, um, so like for instance I show them how to do this sum this way or you show them a way and then when they come to me I do the same thing so they can see it's the same.	 CS

In the natural unit of Teacher B, (Gi1), are the benefits of the Community of Practice experienced by the teachers. Data collected from the participants' new experiences (NE) suggested that they felt they had gained a great deal by sharing their individual ideas related to the teaching of Mathematics. This gain was achieved by sharing experiences with each other within the Community of Practice. The following natural units describe the feelings of participants:

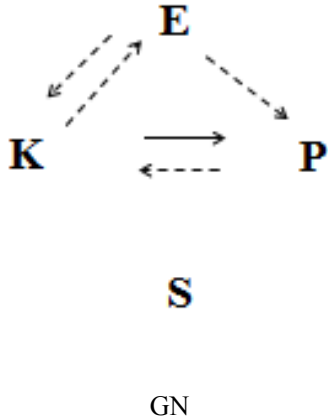
NATURAL UNIT	INTERCONNECTION
Teacher C (Gi7, NE): I've learnt quite a bit from these meetings... it makes sense the way you explained this method and I found that they struggle a lot with multiplication. Like the way you break it down where they can see the times tables is the same understanding as the methods they show in the textbooks but its more broken down so they can make the link easier.	 GN
Teacher B (Gi5, NE): I find that I get a lot out of these meetings, and um I feel like I learn something new every time. You never too old to learn something new. I always tell my class that and I say teacher also learnt something new today. I'm actually going to try that with looking for patterns in the shapes first before I give the names and then I can give them the note on shapes with all the information on it.	 GN
Teacher A (Gi7, NE): We can only improve like this. I appreciate the input I get here and a feel that I go away with something afterwards. It's always good to see what is happening in the other classrooms because then I know what your struggles are and I can also see that we struggle with the same things and I can see how you manage to deal with it or I can even help you... and also I can tell you what they must know in grade 6 then you can teach knowing that in grade 4 so that we don't confuse the learner by saying two different things when they go from grade to grade.	 CS

NATURAL UNIT	INTERCONNECTION
Teacher B (Gi7, NE): You know when I am teaching now I always think of how we spoke about certain things in this group and then I think how will you people think about how I'm teaching this now. Then I somehow have a meeting in my head and think of how I can improve this lesson... I think it's a good thing hey.	 GN
Teacher C (Gi4, NE): I normally reflect on my lessons and think how I can improve but I find it more useful here because we all reflecting together and it's also a good thing that I get an outsiders opinion and not just my own.	 CS
Teacher B (Gi7, NE): It's actually strange how quickly the time goes, <i>times flies when you having fun</i>. But I feel that it's because we so passionate about what we are doing and we all get so much out of it when we share the same passion and I feel that it motivates me now to want to do better. Sometimes all the problems demotivate a person man, but ja this encourages me to want to do better.	 CS

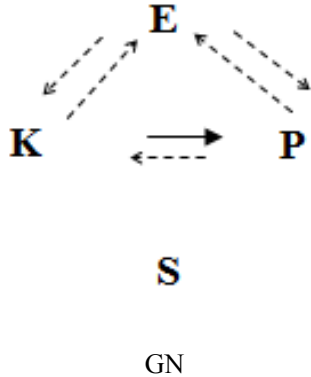
NATURAL UNIT	INTERCONNECTION
Teacher A (Gi2, NE): Like what I said in the previous meeting, use your peers knowledge cause if you don't understand something then sometimes the other person understand more and can help you at your level.	 <pre> graph TD K <-.-> E E --- P S --- P CS --- S </pre>

The above natural units describe participants' perceived benefits of the Community of Practice. They commented on the value of learning through sharing of experiences between members of a learning community. These descriptions resonate with the research of Jita and Ndlalane (2009) who credit community-based approaches with promoting collaboration between individuals, as well as the construction and sharing of teachers' subject content knowledge (CK) and pedagogical content knowledge (PCK) in a meaningful way. Hill *et al.* (2008) encompass both CK and PSK in their description of mathematical knowledge for teaching (MKfT)⁶⁷. This inclusion is important when keeping in mind the emphasis placed on developing MKfT in relevant local research concerned with teacher professional development. Taylor and Taylor (2013), Venkatakrishan and Spaul (2014), and Jita and Ndlalane (2009), are referred to in paragraph 2.5.1. Mkhawanazi (2014) sheds light on a shift of interventions assisting the promotion of what Hill *et al.* (2008) describe as MKfT in South Africa, but states that this remains an elusive target. The natural units of participants in this research project suggest that participating teachers find their Community of Practice to be beneficial in the promotion of developing MKfT. These perceptions are valuable and provide insight into the promotion of teacher professional development which is needed in South Africa (Mkhawanazi, 2014). The natural unit of Teacher B below reveals a clear influence on her practice as a result of the Community of Practice:

⁶⁷ Refer to paragraph 2.5.1

NATURAL UNIT	INTERCONNECTION
Teacher B (Gi7, NE): You know when I am teaching now I always think of how we spoke about certain things in this group and then I think how will you people think about how I'm teaching this now. Then I somehow have a meeting in my head and think of how I can improve this lesson.	 <pre> graph TD K <--> P K -.-> E E -.-> P E --> S S --> GN </pre>

This reflective experience was nearly identical to the new experience (NE) of Teacher C described in her second individual interview.

NATURAL UNIT	INTERCONNECTION
Teacher C (Ii2, NE): The group has really formed part of me. I find myself questioning my lesson plans as I am writing them as if I was presenting the lesson to the group in one of our meetings. I try to think of what feedback I would get. I normally would ask my mom for advice when I'm planning but now I feel that I have grown enough in the group that I can do it myself. I feel like I have gained experience without having to teach for years to get it.	 <pre> graph TD K <--> P K -.-> E E -.-> P E --> S S --> GN </pre>

These participant experiences are closely related to descriptions of DuFour (2004) who emphasises that Communities of Practice can encourage educators to reflect critically and sustain the community's existence, allowing for it to become deeply rooted in the school's culture. Similar findings of teachers' interpreted experiences of continuous professional development endeavours are confirmed in a South African pilot study conducted by Kaino, Dhlamini, Phoshoko, Jojo, Paulsen and Ngoepe (2015) which reveals that teachers emphasised development of teacher content knowledge and teacher collaboration. This emphasis is common to that of the perceived benefits of participants in this research.

In summary, data collected shows that participants were in favour of the establishment of a Community of Practice. Once it was established, they felt that it had improved their practice through sharing of experiences and teacher knowledge, as well as collaborative reflection of practices emphasised in the research of DuFour (2004) and Kaino *et al.* (2015). The perceptions of these participants regarding their experience of being in a Community of Practice are valuable: they provide insight into a current need for effective intervention teacher professional development in South Africa (Mkhawanazi, 2014). The need for development of teacher knowledge is emphasised in local literature: Taylor & Taylor, 2013; Venkatakrishan & Spaul, 2014; Jita & Ndlangane, 2009 adding to the value of the insights of these participants' perceptions where they describe the advantages of being part of a Community of Practice.

4.5 Interconnected patterns

In the previous paragraph, 4.4 interconnected patterns evident in participants' natural units were indicated alongside the natural units. Clarke and Hollingsworth (2002) credit the use of the interconnected model (Figure 4:23) in mapping patterns in interconnected pathways of teachers' interpreted experiences in their professional development through changes in their professional practice. These interconnections, reiterated from paragraph 3.8.2 are explained through the interceding processes of reflection and enactment between the four domains of professional growth (Clarke and Hollingsworth, 2002).

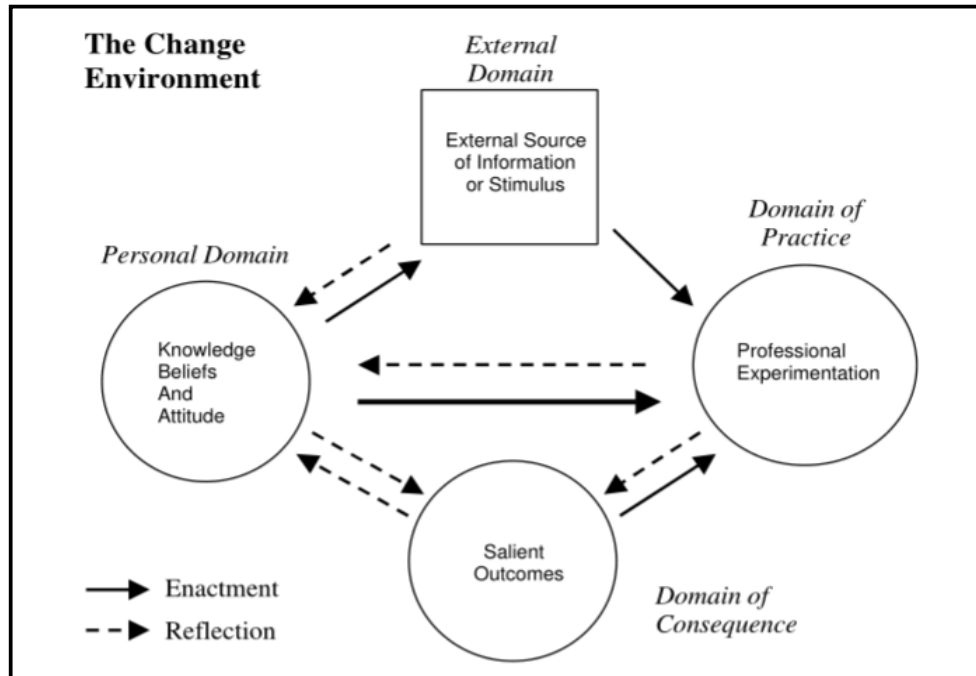
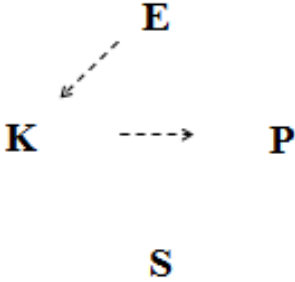
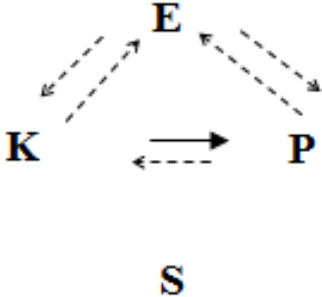


Figure 4:23 The interconnected model of professional growth (Clarke & Hollingsworth, 2002: 951)

Clarke and Hollingsworth (2002 p. 958) describe two types of teacher professional development which can be identified through mapping interconnected patterns in the interconnected model of teacher growth. The first pattern they refer to as “*change sequences*” which describes empirical evidence of interconnections made between two or more domains on the interconnected model. The change as a result of enactment and/ or reflection in the teachers’ domains of growth seen in change sequences, however, does not translate into lasting professional development (Clarke and Hollingsworth, 2002; Hollingsworth, 1999). The second type of teacher professional development identified through mapping interconnected patterns Clarke and Hollingsworth (2002, p. 958) is referred to as “*growth networks*”. Growth networks differ from change sequences primarily in relation to the induced change of the teacher’s personal domain (K) and domain of practice (P). Growth networks are more complex in their interconnected patterns. As a result, growth networks are reflective of lasting change in professional development of teachers. The interconnected model has assisted me in this research to differentiate between short-lived change in participants’ practice and long-term professional development. Using this model aids in the practice of constitutive phenomenology which is concerned with the advancement of participants’ experiences from initial impressions to broader and more established perspectives of what has been experienced (Spiegelberg, 1975). Examples of change

sequences and growth networks can be seen in Table 4:2 below. The codes used in this section are illustrated in Table 4:1, paragraph 4.2

Table 4:2 Example of change sequences and growth networks evident in the participants’ natural units

CHANGE SEQUENCE	GROWTH NETWORK
Teacher B (Gi7, NE): 	Teacher C (Ii2, NE): 

The interconnected model was used for the following three functions in this research, as listed by Clark and Hollingsworth (2002 pp. 957–958): (1) as an analytical tool to categorise the identified patterns of teacher change through interconnections made between domains of professional growth as explained in the previous paragraph, (2) as a predictive tool to identify interconnected patterns and use them to suggest possible avenues or mechanisms for promoting teacher development , and (3) as an interrogatory tool by which the researcher can outline specific research questions in the data collected; which, in turn, aids in answering research questions. The insight provided by the interconnected patterns on the professional development of participants is separated (irrespectively⁶⁸) into three sections: (1) Participants’ interconnected patterns, (2) Interconnected patterns related to the research themes, and (3) Evident mechanisms for promoting professional development.

4.5.1 Participants’ interconnected patterns

This section outlines the most common interconnected patterns evident in the natural units of the individual participants. It forms part of what Clark and Hollingsworth (2002, p. 957) describe as the analytical function of the interconnected model and serves to provide insight into any professional development as participants’ progress through the research period.

⁶⁸ Irrespectively: the word is placed here to emphasis that the three functions listed by Clark and Hollingsworth (2002: 957-958) will not be employed in the same order as they describe it, i.e. not respectively used.

A. *Teacher A's interconnected patterns*

When examining Teacher A's interconnected patterns associated with her natural units relevant to the revelatory themes of this research, it appears she experienced slight change in her professional development over the research period. This stasis could be related to her natural units being mostly those of existing experiences (EE). The interconnected model of professional growth is associated with Guskey's (2002) premise that the goal of examining professional development is to identify teachers' change in classroom practices, beliefs and attitudes, as well as the change of learners' outcomes as experienced by the teachers (Clarke & Hollingsworth, 2002). Growth networks are described by Clarke and Hollingsworth (2002) as more complex interconnected patterns in which change in the personal domain and domain of practice is induced. Growth networks require reflection upon existing experiences (EE) and enactment leading to professional growth: evident in new experiences (NE). The situatedness⁶⁹ of Teacher A's natural units in her existing experiences limits the presence of enactment between domains, especially in the domain of practice, which could restrict the formation of interconnected growth networks.

Further support for this inference is evident in Teacher A's individual interview 2 (Ii2) in which a growth network (GN) was evident in her natural unit and which she described as her implementation of Habits of Mind:

⁶⁹ Situatedness: Referring to the contextual influences where knowledge is formed (Derry, 2013: 24), refer to paragraph 2.4.

Location

Theme: Perceptions of implementing Habits of Mind

Subtheme: Implementing Habits of Mind

NATURAL UNIT	INTERCONNECTION
Teacher A (Ii2, NE): To be honest I found these habits difficult to use. Why, because getting learners to discuss and look for patterns <i>en so aan</i> takes a lot of time in the lessons. The children love doing this but we don't have enough time to always do things like this. And for me also I myself sometimes find it difficult to do these things. I am always learning, I always say that, but when I try these habits myself then I also struggle with them. I take long to do it, <i>hoe sal dit wees as die kinders dit probeer?</i> We just simply don't have the time for it.	GN

Examining this growth network in relation to the context provided in the natural unit, it is evident that the introduction of Habits of Mind in the external domain (E), led to changes in the personal domain (K) and domain of practice (P). The process of reflection from the enactment of implementing Habits of Mind indicated negative results (Teacher A experienced difficulties in its implementation) but the interconnected pattern depicts the formation of a growth network. The formation of growth networks in Teacher A's interconnected patterns were rare in relation to the emergent themes of the research.

B. Teacher B's interconnected patterns

The interconnected patterns associated with Teacher B's natural units revealed that lasting professional development evident in the form of growth networks was limited to her experiences as perceived in two of the three revelatory themes. As explained in Teacher A's interconnected patterns, growth networks (GN), as defined by Clarke and Hollingsworth, (2002) require reflection and enactment which can lead to professional growth and exist generally in new experiences (NE). Teacher B's natural units related to her perception of Relational Understanding, the first theme⁷⁰, were those of existing experiences (EE). No long-lasting change in her domains of professional growth was apparent in these

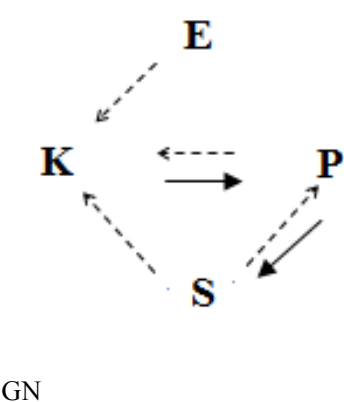
⁷⁰ Section 4.4.1

interconnected patterns. This lack of change was in contrast with her natural units in the other two themes: perceptions of implementing Habits of Mind⁷¹ and experiences as part of a Community of Practice⁷². In these themes, interconnected patterns relating to the natural units of Teacher B indicated change in the domains through the interceding processes of both reflection and enactment from new experiences. This degree of change created growth networks as shown in the interconnected model shown below:

Location

Theme: Perceptions of implementing Habits of Mind

Subtheme: Implementing Habits of Mind

NATURAL UNIT	INTERCONNECTION
Teacher B (Ii2, NE): You know the times I tried to use the habits I felt that my lessons were engaging yes, but I feel that it took up a lot of time man. We don't always have the time for this. Yes I would love to have them speak and discuss all the time but you know time is always a problem and um these types of lessons where you do things like this, like what we do with these habits, there just isn't time for it.	

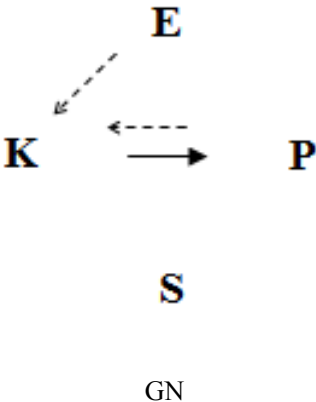
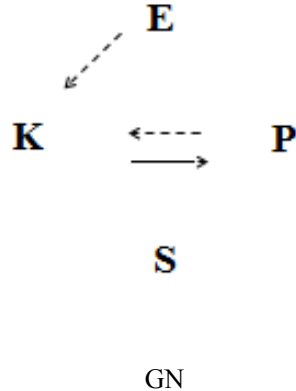
From this growth network, related to the natural unit in her individual interview 2, seen above, the interceding process of reflection reveals the interconnected change in the external domain (E) and personal domain (K). From the description related to her perceptions of the event, her natural unit, this change is associated with the introduction of using Habits of Mind in her teaching practice. The change in her personal domain led to change in her domain of practice (P) through the interceding process of enactment: Teacher B acted on the new knowledge in her personal domain through experimentation of implementing Habits of Mind in her teaching in her domain of practice (Clarke & Hollingsworth, 2002). The change in her domain of practice, through enactment, led to change in the domain of consequence (S), after which change was experienced in the domain of practice and personal domain through the

⁷¹ Section 4.4.2
⁷² Section 4.4.3

interceding process of reflection. Teacher B’s perceived outcomes of introducing Habits of Mind in her classroom practice indicated that she experienced challenges associated with time constraints, yet the interconnected pattern depicted the formation of a growth network in this new experience. Emergence of growth networks associated with Teacher B’s natural units can be observed below:

Location

Theme: Experiences of being part of a Community of Practice⁷³

NATURAL UNIT	INTERCONNECTION
Teacher B (Gi5, NE): I find that I get a lot out of these meetings, and um I feel like I learn something new every time. You never too old to learn something new. I always tell my class that and I say teacher also learnt something new today. I’m actually going to try that with looking for patterns in the shapes first before I give the names and then I can give them the note on shapes with all the information on it.	 The diagram shows four nodes: E at the top, K on the left, P on the right, and S at the bottom. A dashed arrow points from E to K. A solid arrow points from K to P. A dashed arrow points from P to S. The label 'GN' is centered below the nodes.
Teacher B (Gi7, NE): You know when I am teaching now I always think of how we spoke about certain things in this group and then I think how will you people think about how I’m teaching this now. Then I somehow have a meeting in my head and think of how I can improve this lesson... I think it’s a good thing hey.	 The diagram shows four nodes: E at the top, K on the left, P on the right, and S at the bottom. A dashed arrow points from E to K. A solid arrow points from K to P. A dashed arrow points from P to S. The label 'GN' is centered below the nodes.

The two new experiences of Teacher B described in these natural units above depict the same interconnected pattern and are both associated with her experiences of being part of a Community of Practice. The two experiences of Teacher B indicate that the change originated in the external domain (E) where the Community of Practice is acting as the external source

⁷³ Section 4.4.3

of information or stimuli (Clarke & Hollingsworth, 2002). This change, through reflective interconnections, led to changes in her teacher knowledge located in her personal domain (K), resulting in change through enactment in her domain of practice (P).

Insight gained from using the analytical function of the interconnected model indicates that Teacher B experienced lasting changes in her professional development when implementing Habits of Mind in her practice and when being part of a Community of Practice which is where growth networks emerged in her natural units (Clarke and Hollingsworth, 2002).

C. Teacher C’s interconnected patterns

The interconnected patterns which emerged from Teacher C’s natural units depict formation of multiple growth networks representing lasting professional growth. Reiterating once more the relation between growth network (GN) formation as explained by Clark and Hollingsworth (2002) and teachers’ new experiences (NE), it is evident that the multiple growth patterns emerging in Teacher C’s natural units are related to her experiences as mainly new experiences.

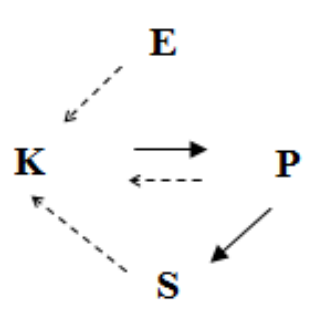
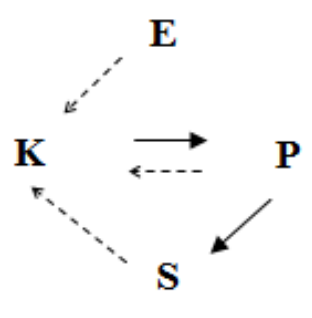
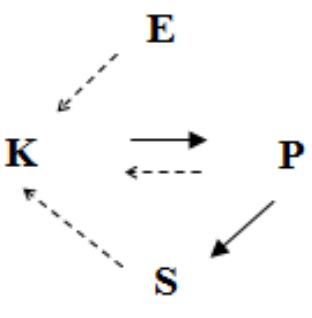
The first three growth networks evident in Teacher C’s interconnected patterns emerged from her natural units associated with the revelatory theme perceptions of Relational Understanding.

Location

Theme: Perceptions of Relational Understanding

Subtheme: Perceived benefits of Relational Understanding

NATURAL UNIT	INTERCONNECTION
Teacher C (Gi5, NE): I find that when I got them to relate their topics in this way (using the habits) they seemed to have a better understanding in the follow up lessons and I did not have to repeat myself as often.	<pre> graph TD K((K)) -- solid --> E((E)) E -.-> K K -- solid --> P((P)) P -.-> K P -- solid --> S((S)) S -.-> K </pre>

NATURAL UNIT	INTERCONNECTION
Teacher C (Ii1, NE): I find that when I did a topic like length, and I related it to decimals the learners were able to understand it more. Even though decimals were not part of the syllabus at the moment, by me teaching it and then relating it to length they had a better understanding and more importantly I did not have to repeat it over and over.	GN⁷⁴ 
Teacher C (Gi4, NE): Now that I understand how to use the habits better and have planned strategies to get the learners to use them I find that they are more involved in the lessons and more of the struggling learners are understanding the work.	GN 
Teacher C (Ii2, NE): It came to me when I was planning the lessons for the week and trying to think how to use the habits, thinking of what questions I could ask and what the responses might be. This was when I really had to keep in mind that I am trying to teach for Relational Understanding so I had to plan my lessons so that there was time for, opportunities for them to link the previous lessons to this lesson. It was difficult trying to think of how to get some of them, especially the struggling learners to be part of the discussion but I later realized that these types of lessons, where they made connections between the different topics excited them because they understood the work.	GN  GN

⁷⁴GN: Growth network (refer to sections 3.8.2 and 4.2)

These three growth networks depict an analogous interconnected pattern by which the interceding processes of reflection and enactment reflect change emerging in the external domain (E) and progressing to the personal domain (K), domain of practice (P) and domain of consequence (S). The experiences of Teacher C, described in these natural units, are new experiences describing her perception of Relational Understanding which emanated from having implemented Habits of Mind in her classroom practice. The structure of these three interconnected patterns mirrors patterns described by Clarke and Hollingsworth (2002) as linear patterns which they associate with Guskey’s (2002) alternative model of professional growth: they state that “the practitioner makes informed modifications to practice, monitors the consequences of the new practice, reflects on the significance on those consequences, makes further modifications to practice, and so ad infinitum” (Clarke and Hollingsworth, 2002: 960). Despite inferring that this linear pattern is naïve, they associate it with the formulation of learning progression essential to teacher professional development. Further evidence of lasting professional development is evident in growth networks related to Teacher C’s natural units which were found in the emergent theme perceptions of implementing Habits of Mind⁷⁵.

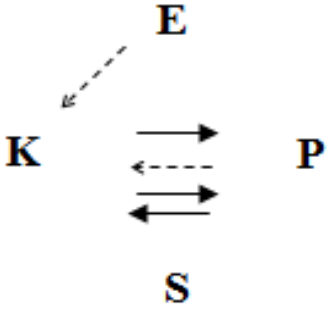
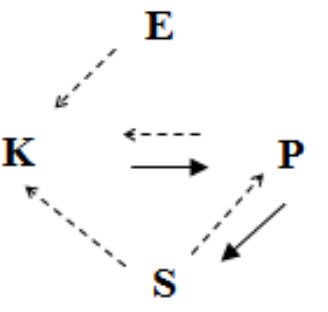
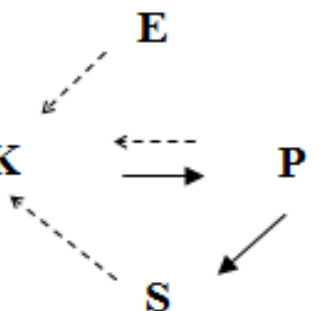
Location

Theme: Perceptions of implementing Habits of Mind

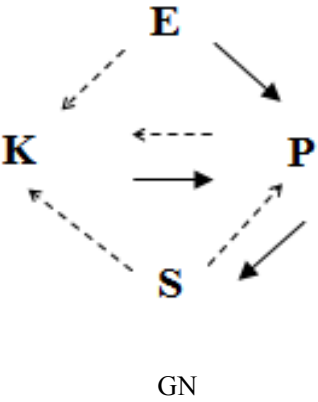
Subtheme: Implementing Habits of Mind

NATURAL UNIT	INTERCONNECTION
Teacher C (Gi3, NE): I find that if I plan these habits into my lessons they often take longer because there is more discussion so I could fall behind in CAPS... But I get better feedback from more of the class especially the weak ones.	GN

⁷⁵ Section 4.4.2

NATURAL UNIT	INTERCONNECTION
Teacher C (Ii2, NE): (Continuation of previous quote) But as I continued to use it I became more used to it and I started to use it better. It became easier as I used it more.	 GN⁷⁶
Teacher C (Gi5, NE): The more I use them the more confident I am becoming... The learners are more willing to engage in the lesson and I find that the habits help them structure the way they give feedback... They follow the steps like first looking for the pattern, then discussing and then while they are busy doing that I have time to move around the class or help the weaker ones.	 GN
Teacher C (Gi6, NE): Now that I understand how to use the habits better and have planned strategies to get the learners to use them I find that they are more involved in the lessons and more of the struggling learners are understanding the work.	 GN

⁷⁶ The multiple arrows between domain P and K in this interconnected pattern indicates repetition of the process of enactment and reflection between these domains.

NATURAL UNIT	INTERCONNECTION
Teacher C (Ii2, NE): I am still using the Habits of Mind when I teach. I'm not being so rigid in planning it into the lessons formally but I do always keep them in mind, they are still up on my wall. So we still refer to them when we discuss and it helps make the lessons move faster. Because they are now used to them they automatically begin using them and I find that I can leave them to work and don't have to waste time with explaining over and over... ...they are also writing down their own definitions from what they discuss and I feel that I am repeating less because they remember the work more now... ...I don't struggle with time as much as I did earlier this year. I think it's mostly because I'm more settled but I feel that them using the habits also allows them to work more independently so I get time back there.	 GN

These growth networks are consistent with the natural units of Teacher C as she progressed from initial experimentation with the implementation of Habits of Mind in her teaching practice to a mastery of this practice (Kiruthika, 2014). The growth networks indicate lasting professional development. Such development induced change in her personal domain (K). This change was related to her change in knowledge attitudes and beliefs of using Habits of Mind in her practice. Such growth led to change in her domain of practice (P), relating to the enactment of experimenting with Habits of Mind in her classroom practice. Hollingsworth (1999) identifies growth patterns in particular teachers' professional development. There is a cycle of enactment and reflection between the domain of practice and personal domain before reflection of salient outcomes in the domain of consequences was evident. This growth pattern resembles that of Teacher C's. Both Hollingsworth (1999) and Clarke and Hollingsworth (2002) describe this phenomenon as evidence of a teacher's learning style. This particular learning style of Teacher C suggests that she postpones the consideration of salient outcomes first to change her beliefs subsequent to the extensive refinement and mastery of a new instructional technique such as implementing Habits of Mind.

This learning style of Teacher C is evident in the growth networks below which are related to her natural units and which are present in the revelatory theme experiences and part of a Community of Practice.

Location

Theme: Experiences being part of a Community of Practice

NATURAL UNIT	INTERCONNECTION
Teacher C (Gi7, NE): I’ve learnt quite a bit from these meetings... it makes sense the way you explained this method and I found that they struggle a lot with multiplication. Like the way you break it down where they can see the times tables is the same understanding as the methods they show in the textbooks but its more broken down so they can make the link easier.	GN
Teacher C (li2, NE): The group has really formed part of me. I find myself questioning my lesson plans as I am writing them as if I was presenting the lesson to the group in one of our meetings. I try to think of what feedback I would get. I normally would ask my mom for advice when I’m planning but now I feel that I have grown enough in the group that I can do it myself. I feel like I have gained experience without having to teach for years to get it.	GN

These final two growth networks are associated with Teacher C’s perceptions of developing her teacher knowledge through collaboration and sharing of practices within the Community of Practice. The interconnected patterns indicate professional development through interconnected changes within Teacher C’s personal domain (K). Such patterns concern changes in teacher knowledge and domain of practice (P); referring to her reflective practice, originating from change in the external domain (E) and relating to the influences of the Community of Practice. Influences of Communities of Practice in teachers’ professional

development in terms of growing teacher knowledge and improving reflective practice as depicted in Teacher C's growth networks are supported by analogous findings in related research⁷⁷ (Jita & Ndlalane, 2009; Kaino *et al.*, 2014).

Teacher C's interconnected patterns indicate multiple occurrences of lasting professional growth evident in emergent growth patterns related to her natural units.

4.5.2 Interconnected patterns related to the research themes

After examining participants' individual, interconnected patterns of professional growth, I now discuss the combination of these patterns in relation to their natural units related to the revelatory themes of the research. This discussion forms part of the interrogatory function of the interconnected model of professional growth. Clarke and Hollingsworth (2002, p. 598) associate this function with facilitating the research questions: something which takes place by examining the role played by specific processes introduced to the environments of teachers. These introduced processes refer to the participants' implementation of Habits of Mind which promote Mathematics learners' Relational Understanding in their teaching, while operating within a Community of Practice.

Three subsidiary questions were posed in this research: (1) what were the teachers' perceptions of how Habits of Mind influenced their practice, (2) what were their experiences as part of a Community of Practice, and (3) what were their perceptions of promoting Relational Understanding? When analysing the data collected, Whiting's (2002) adaptation of Giorgi's (1975) phenomenological model was used to identify emergent themes from participants' experiences (paragraph 3.8.1. In the third step of this model (interrogation of themes according to the purpose of the study) the themes identified were interrogated in accordance with the research questions: identifying revelatory themes relevant to the aim of the research and research questions. These revelatory themes were discussed previously in paragraph 4.4. It is appropriate to apply the interrogatory function of the interconnected model to participants' interconnected patterns evident in each revelatory theme. As elucidated by Clark and Hollingsworth (2002, p. 598) I am enquiring about the roles' specific processes which were introduced to the participants' environments.

⁷⁷ Refer to section 4.4.3

A. *Perceptions of Relational Understanding*

The process introduced to the participants' environment and related to this revelatory theme, was the promotion of learners' Relational Understanding of Mathematics. The participants' descriptions in their natural units related to this theme revealed that all of them reflected on the possible salient outcomes (in the domain of consequence - S) agreeing that promoting Relational Understanding in their practice would be beneficial. This conclusion was evident based on the interconnected model by which the interceding process of reflection (indicated by a broken arrow) was manifest between the domains (Figure 4:24).

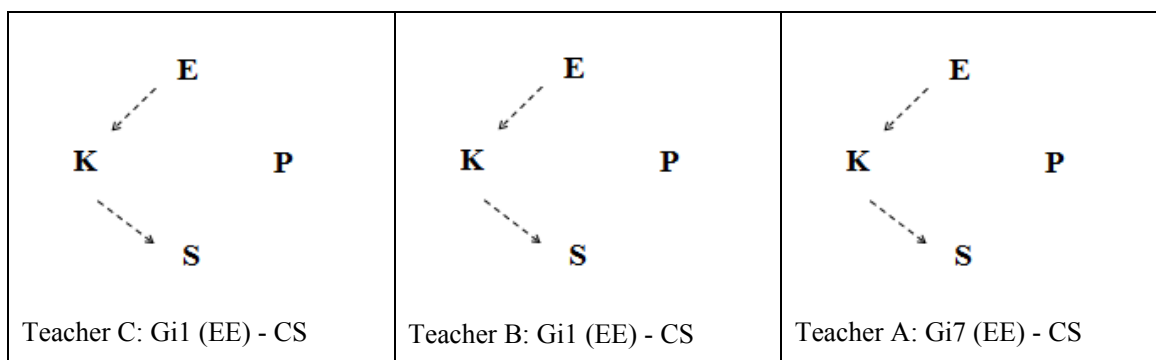


Figure 4:24 Change sequences related participants' perceptions of Relational Understanding

This schema did not indicate lasting professional development: participants' interconnected patterns were for the most part those of change sequences (CS). Conversely, Teacher C's perceptions of Relational Understanding revealed lasting professional development evident in growth networks (GN) emerging from her natural units (Figure 4:25). These growth networks were related to her perceived benefits of Relational Understanding: the difference being that these reflections were not on possible salient outcomes but on observed salient outcomes.

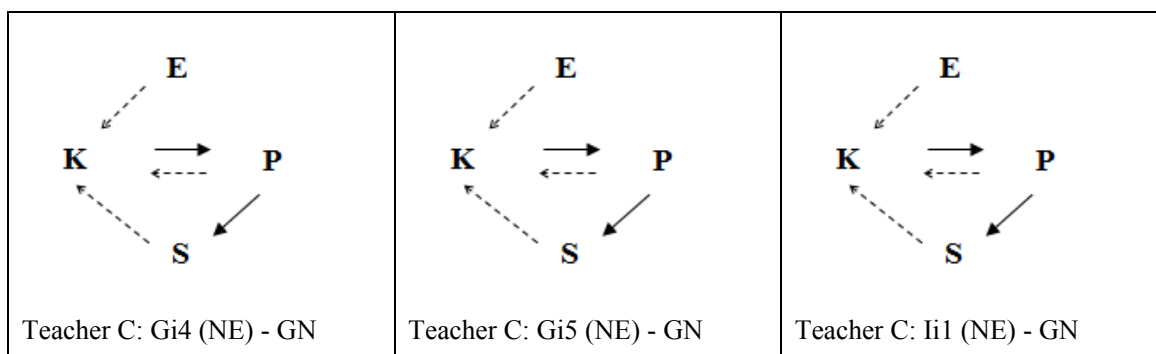


Figure 4:25 Teacher C's growth networks related to her perceptions of Relational Understanding

By examining the growth networks of Teacher C, it is evident that the process which played a role in teacher professional development related to participants' perceptions of Habits of Mind was not their perceived benefits of Relational Understanding. Instead professional development was related to perceptions of observed change in the domain of consequence where Teacher C reported to have observed changes in the salient outcomes⁷⁸ of her learners' performance.

B. Perceptions of implementing Habits of Mind

The process introduced into participants' environment and related to this theme was the implementation of Habits of Mind which promotes learners' Relational Understanding into their practice. Participants agreed that Habits of Mind are beneficial to their practice as revealed in their reflections of possible salient outcomes (in the domain of consequence - S) and reflected on possible implications for their practice (in the domain of practice – P). These reflections, however, did not lead to lasting change; revealed in the interconnected model as change sequences (Figure 426).

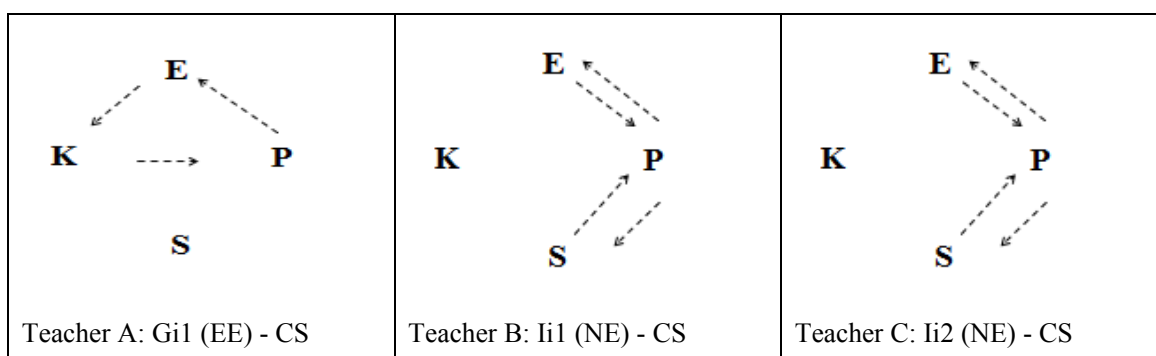


Figure 4:26 Participants' change sequences related to their perceptions of implementing Habits of Mind

All three participants experienced lasting professional development in relation to this theme: evident in the growth networks emerging from their natural experiences (Figure 4:27). These growth networks indicate professional development resulting from the process of participants' enactment (indicated by a solid arrow), relating to their attempts to implement Habits of Mind in their practice. From this enactment, subsequent reflections on practice (P) and salient outcomes (S) were observed in these growth networks. Participants did not perceive reflections of possible change occurring. Participants observed changes in reflections as was evident in their growth networks.

⁷⁸ Salient: what teachers perceive to be prominent, relevant or significant outcomes

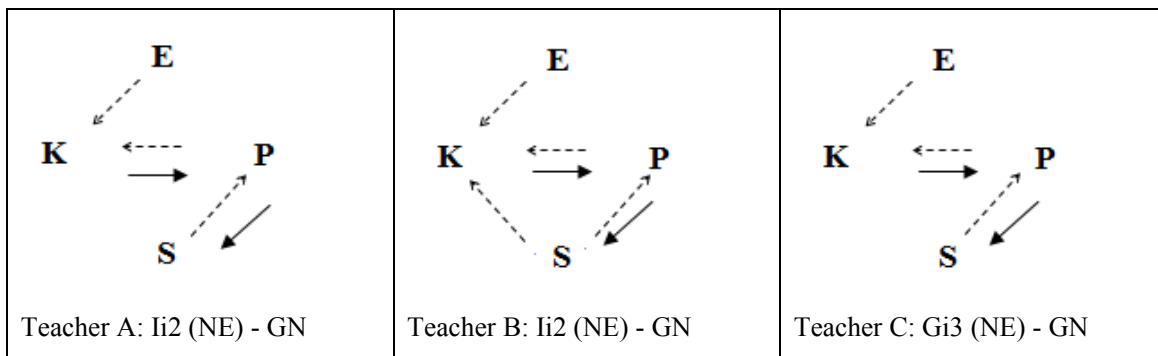


Figure 4:27 : Participants' growth networks related to their perceptions of implementing Habits of Mind

The process of participant enactment of Habits of Mind and subsequent reflections on observed changes in the domain of practice (P) and perceived changes in salient outcomes in the domain of consequence (S) played a role in participants' professional development as indicated in their growth networks.

C. *Experiences of being part of a Community of Practice*

The change sequences (CS) of participants' natural units related to the introduction of the process of being part of a Community of Practice and indicated similar perceptions to those of the other two themes (Figure 4:28). Participants perceived this process to be beneficial. This perception was related to their reflections of possible changes in their domains of practice (P) and consequence (S), and in the personal domain (K).

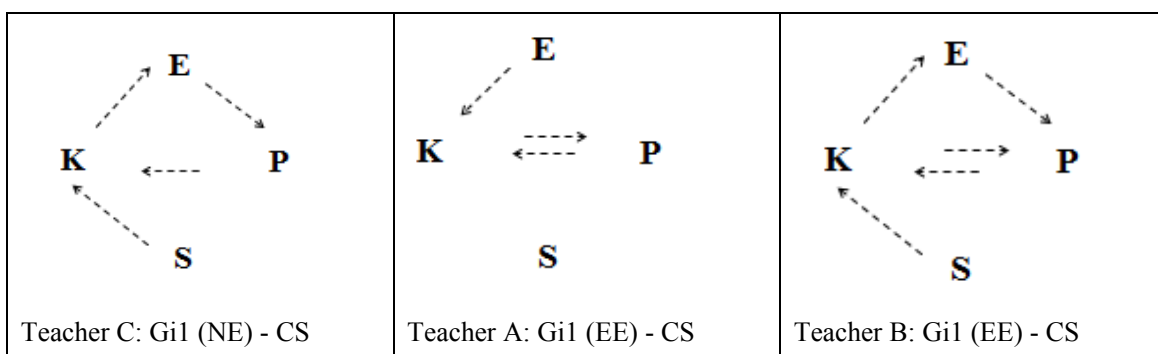


Figure 4:28 Participants' change sequences related to their experiences being part of a Community of Practice

It was evident in the previous two processes that reflections on enactment played a role in professional growth. Growth networks related to participants' experiences as part of a Community of Practice revealed enactment induced by reflections and played a role in participants' professional growth (Figure 4:29).

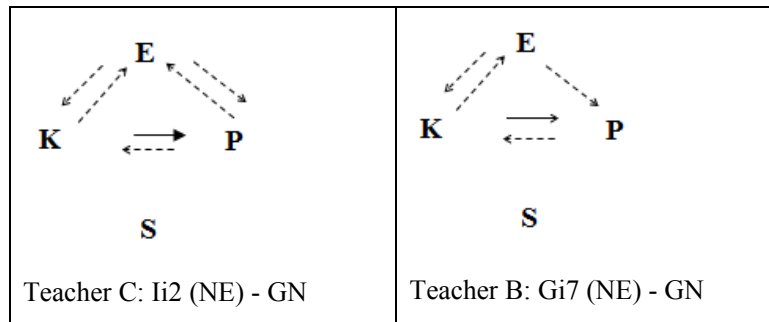


Figure 4:29 Participants' growth networks related to their experiences being part of a Community of Practice

The growth networks of Teacher B and Teacher C in Figure 4:29 are explained in their natural units as change in their domain of practice (P) through the interceding process of enactment, subsequent to the motivation of domain changes as a result of the interceding process of reflection. The role played by the introduction of the participants as part of a Community of Practice was shown in the succeeding participants' reflections leading to enactment and lasting change in professional development.

4.5.3 Mechanisms which promote professional development

This section summarises which mechanisms were active during the research period, based on participants' interconnected patterns and which promoted the professional development of participants. Identification of such mechanisms relates to Clarke and Hollingsworth's (2002, p. 597) predictive function of the interconnected model of professional growth. Two mechanisms were evident after examining participants' interconnected patterns: (a) Reflection and (b) Collaboration.

A. Reflection

The growth networks of participants revealed in the descriptions of the related natural units that lasting professional development occurred in accordance with teachers' reflective practice. This professional development was not, however, a constituent of all moments of reflection. Teacher reflection on existing experiences, as depicted in teacher B's natural units below, did not lead to lasting change in her interconnected domains.

NATURAL UNIT	INTERCONNECTION
Teacher B (Gi4, EE): I am happy that we formed this group. Man, I have wanted to do this for long and I have been thinking that its better this way so we can share ideas and methods and learn from each other.	<pre> graph TD E --- K E --- P K -.-> P K --- S P --- S S --- CS </pre>

Yet, the interconnected pattern of Teacher B below does indicate the emergence of a growth network symbolising lasting professional development.

NATURAL UNIT	INTERCONNECTION
Teacher B (Gi7, NE): You know when I am teaching now I always think of how we spoke about certain things in this group and then I think how will you people think about how I'm teaching this now. Then I somehow have a meeting in my head and think of how I can improve this lesson... I think it's a good thing hey.	<pre> graph TD E -.-> K K --> P K --- S P --- S S --- GN </pre>

The difference between these two interconnected patterns is discernible in the interconnected pathways of reflection (broken arrow) and enactment (solid arrow) which indicate teacher change in the domain of practice (P) and personal domain (K). Reiterating what was discussed in paragraph 4.5.1 the interconnected model of professional growth is closely associated with Guskey's (2002) premise that the goal of examining professional development is to identify teachers' change in classroom practices, beliefs and attitudes, as well as change of learner outcomes as experienced by teachers (Clarke & Hollingsworth, 2002). Clarke and Hollingsworth (2002) describe growth networks as complex interconnected patterns by which teacher change in the personal domain and domain of practice is induced. Growth networks require reflection of existing experiences and enactment leading to professional growth which takes the form of new experiences. This need

for growth networks was consistent in the growth networks emerging from all three participants' natural units. Two relations, between reflection and enactment, emerged in the growth networks when applying the interrogatory function of the interconnected model of professional growth (Clarke & Hollingsworth, 2002). The first was evident in the revelatory themes: 'perceptions of Relational Understanding' and 'perceptions of implementing Habits of Mind' in which an interceding process of enactment between the domains led to reflection. The second was the reversal of this pattern as seen in the third revelatory theme 'experiences being part of a Community of Practice': the interceding process of reflection led to enactment (refer to paragraph 3.5.2). Despite differences in relation of enactment and reflection in these growth networks, it was evident that enactment and reflection were present as required by Clarke and Hollingsworth (2002). Schön (1983) emphasises the role of action (enactment) in reflective practice. Smolarek and Hora (2016) summarise Schön's (1983, p. 3) concept of reflection as "the cyclical act of thinking about what one is doing, during or following the action, to facilitate the learning process". Smolarek and Hora (2016) place reflective practice at the core of teacher education: stating that engagement in reflective process is central to ongoing professional development. They allude to Schön's (1983) premise that competent practitioners, or teachers, utilise knowledge in action, a form of tacit⁷⁹ teacher knowledge, which becomes an automated response in their practice. Schön (1983) explains that when moments in practice arise, where this form of knowledge is insufficient, the competent practitioner reflects in the moment (reflection-in-action) or after the moment (reflection-on-practice). Smolarek and Hora (2016, pp. 3-4) credit these two forms of reflection, namely reflection-in-action and reflection-on-practice, with allowing practitioners to adjust their practice accordingly.

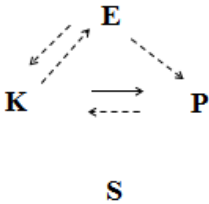
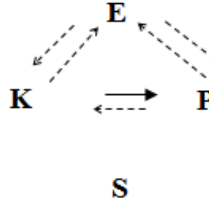
The précis of reflective practice (and its implications for the lasting professional development of participants in this research, as evident in growth networks on the interconnected model) emphasises the importance of a marriage between reflection and enactment. This marriage is indistinguishable from the description of Schön (1991) who defines reflection in action as associated with critically thinking about practice while acting in the practice reflected upon: symbiosis of reflection and action, becoming constant reflective practice. The mechanism of reflection evident in the participants' interconnected patterns reveals that reflection-in-action

⁷⁹ Tacit (implicit) knowledge is knowledge of an individual which is difficult to articulate or write down, and is often referred to as unspoken knowledge.

(Schön, 1991), being a combination of reflective and enactive processes, was conducive to teacher professional development in this research.

B. Collaboration

The second mechanism, evident in the interconnected patterns, which promoted participants’ professional development, was their collaboration when being part of a Community of Practice. In the revelatory theme ‘experiences as part of a Community of Practice’, growth networks revealed that collaboration of participants led to their individual professional development. This can be seen in the natural units and corresponding interconnected patterns of Teacher B and Teacher C below.

NATURAL UNIT	INTERCONNECTION
Teacher B (Gi7, NE): You know when I am teaching now I always think of how we spoke about certain things in this group and then I think how will you people think about how I’m teaching this now. Then I somehow have a meeting in my head and think of how I can improve this lesson.	 GN
Teacher C (Ii2, NE): The group has really formed part of me. I find myself questioning my lesson plans as I am writing them as if I was presenting the lesson to the group in one of our meetings. I try to think of what feedback I would get. I normally would ask my mom for advice when I’m planning but now I feel that I have grown enough in the group that I can do it myself. I feel like I have gained experience without having to teach for years to get it.	 GN

These two natural units which reveal formation of growth networks indicating lasting professional development of the participants, express a change in these participants’ reflective practice, more appropriately reflection-in-action (Schön, 1991). Smolarek and Hora (2016) explain, (regarding Schön’s 1983 premise) that when teachers, as competent practitioners, find tacit knowledge is insufficient, they adjust this lacking through reflective practice. Taylor (2007) refers to tacit knowledge as something that individuals instinctively understand but which cannot be written down or recorded, referring to Polanyi’s (1966, p. 61)

phrase “we can know more than we can tell”. Polanyi (1966) establishes the existence of tacit, implicit, knowledge: he explains it can be deduced from the practical outcomes of its application that knowledge exists in an individual’s mind but which they cannot articulate. Taylor (2007, p. 68) alludes to the existence of collective tacit knowledge, differentiating between the existence of collected explicit knowledge and implicit, tacit, collective knowledge. Collective explicit knowledge is referred to as knowledge held in common repositories and which is readily accessible to all members of the group. Implicit⁸⁰, tacit, collective knowledge refers to knowledge residing in general practices and relations between unwritten formal and informal procedures of the group. Implicit collective knowledge encompasses individual group members’ explicit and implicit knowledge because most of the individual’s knowledge of the group, collective tacit knowledge, can be articulated by an individual. This knowledge, although capable of being articulated, has not been formally captured or recorded: Taylor (2007, p. 68) claims that it remains implicit, tacit, collective knowledge. Pyrko (2016) refers to Polanyi (1962) when discussing the fundamental practice in Communities of Practice: thinking together as a collaborative learning process. Polanyi’s (1962) notion of indwelling is used as a conceptual base for the collaborative process of thinking together. Pyrko (2016, p. 2) explains indwelling as occurring when individuals in a community are able to “guide each other through their understanding of a mutually recognized real-life problem, and in this way indirectly ‘share’ tacit knowledge”.

Both implicit and explicit individual knowledge are defined by Ernest (1999). He defines implicit knowledge as encompassing the individual’s understanding of the subject: Mathematics. Hill *et al.* (2008) describe this form of knowledge when referring to teacher subject matter knowledge. Hill *et al.* (2008) differentiate between two types of teacher knowledge: subject matter knowledge (SMK), which can be related to Ernest’s (1999) description of implicit knowledge, and pedagogical content knowledge (PCK). Ball *et al.* (2008, p. 394) define PCK as “knowledge in and for teaching rather than on the teachers themselves”: claiming it encompasses the teacher knowledge of how to teach Mathematics. This is analogous to Ernest’s (1999) definition of explicit knowledge as the teacher’s knowledge related to their ability in guiding a learner in developing their Mathematics. Venkatakrishnan and Spaul (2014) use the work of Ball *et al.* (2008) regarding mathematical knowledge for teaching (MKfT) on which to base their arguments: they emphasise the importance of, and need for, the development of MKfT (which encompasses both SMK and

⁸⁰ Taylor (2007) and Polanyi (1966) use the terms implicit and tacit interchangeably.

PCK). As the relation was made between teachers' SMK and implicit knowledge, as well as PCK and explicit knowledge, development of implicit and explicit knowledge in this research should provide insight into development of mathematical knowledge for teaching (MKfT). Re-iterating Taylors's (2007) description of collective tacit knowledge as the shared individual implicit and explicit knowledge of members of a community which can be articulated and therefore reflected on, it can be concluded that the mechanism of collaboration evident in participants' descriptions could be relevant to professional development of their MKfT.

CHAPTER 5

CONCLUSION

5.1 Introduction

This chapter revisits the background and aim of this research. The revelatory themes⁸¹ from Chapter 4 are discussed and related to the research questions. I describe my own researcher reflections and discuss the limitations of this research. Last, I discuss the insights this research have revealed into teacher professional development and conclude, suggesting recommendations for future research.

5.2 Research Background

This research project focuses on the need for education reform in Mathematics; with special reference to the professional development of teachers. This need was identified and confirmed by means of a thorough review of relevant literature (Taylor & Taylor, 2013; Hill *et al.*, 2005). Statistics released from the Department of Basic Education (DBE) (2014), in which learners' results from annual standardised national testing in Mathematics are analysed, demonstrate that the majority of South African learners did not achieve a 50% pass percentage. Fleisch (2013) argues that South Africa is falling behind its counterparts worldwide. Over the past decade there has been no change in overall progress. Fleisch (2013) identifies patterns of underachievement in Mathematics; informing us that learner achievement in most areas of this subject is weak. Spaul and Kotze (2015) express the urgency of educational reform and suggest that learners who fall behind in their schooling are likely to fall further and further behind until there is no learning taking place. In the search for a possible way to improve learner performance, an analysis conducted by Venkatakrishnan and Spaul (2014) was consulted: the dire state of South African Mathematics teachers' mathematical knowledge for teaching (MKfT) (Hill *et al.*, 2008) was exposed: research indicated that 79% of grade six Mathematics teachers did not have the MKfT to understand the subject on the grade level at which they teach. Taylor and Taylor (2013) emphasize that they found many South African educators' MKfT is insufficient to provide learners with a coherent understanding of the subject: they recommend the promotion of teachers' MKfT through both pre- and in-service education. This recommendation is supported by Jita and Ndlalane (2009) and Mkhwanazi (2014) who emphasise the need for

⁸¹ A revelatory theme is a theme which is relevant in answering the research questions (Giorgi, 1975; Whiting, 2002).

promoting teacher professional development in South African education reform. These recommendations are substantiated by the findings of this research project which are that teacher professional development is a beneficial intervention in advancing teachers' knowledge of mathematics and how to teach it effectively.

5.3 Research Aim

Prompted by statistical evidence of the South African education crisis (Fleisch, 2013; Taylor, 2011; Spaull & Kotze, 2015) which reveal the need for effective professional development of teachers (Taylor & Taylor, 2013; Venkatakrishnan & Spaull, 2014), this research provides an in-depth description of how teachers take the initiative to provide self-initiated teacher professional development (Gaible & Burns, 2005). This research provides insight into teacher professional development and answers the primary research question: *'How do teachers experience implementing Habits of Mind as a tool which promotes Mathematics learners' Relational Understanding, while operating within a Community of Practice?'* The following subsidiary questions were used to guide the answering of the primary question: (1) *What were the teachers' perceptions of how Habits of Mind influenced their practice*, (2) *What were their experiences being part of a Community of Practice*, and (3) *What were their perceptions of promoting Relational Understanding?* The intention of this research is to inspire similar endeavours by South African teachers who may be inspired by initiatives of teachers chronicled in this research.

5.4 Discussion of research questions

This section discusses the revelatory themes which have emerged in the data and relates them to the research questions. This discussion took place in Chapter 4 where the revelatory themes were discussed at length. This section summarises what has been discussed in Chapter 4, focussing on answering the three subsidiary research questions.

5.4.1 What were teachers' perceptions of how Habits of Mind influenced their practice?

When examining revelatory themes, three conclusions emerged which were relevant to this subsidiary question. First, (A) it was evident that participants had varied interpretations of what comprises Habits of Mind. Second, (B) participants found it challenging to implement the Habits of Mind due to a number of difficulties they face. Third, (C) implementing Habits of Mind required participants to become more reflective in their lesson preparation. These

conclusions are set out, related to relevant research and discussed in the conclusion to this section in relation to the subsidiary questions.

A. *Varied Interpretations of Habits of Mind*

Two of the three participants, Teacher B and Teacher C, interpreted the concept of Habits of Mind as described in the literature review. This interpretation is that the Habits of Mind referred to in this research are specifically chosen habits, regarded as specific ways of thinking about and doing Mathematics (Selden & Selden, 2005), that were used as a tool for promoting Relational Understanding. Teacher A, however, referred to Habits of Mind as general Habits of Mind. This interpretation of Habits of Mind as good general habits is not congruent with the definition adopted in this research (Cuoco *et al.*, 1996). Judged from her natural units,⁸² Teacher A promotes sound, general Habits of Mind in her teaching of Mathematics. Implementing Habits of Mind, as stipulated in this research, has influenced her practice. Teachers B and C felt that implementation of Habits of Mind influenced their practice: it allowed them to synchronise their classroom practice. This advantage benefitted learners moving from grade to grade. The teacher, one grade up, being one of the participants in this research, could use these Habits of Mind in the Mathematics lessons and so create a chain of good practice for teachers.

B. *Challenges of implementing Habits of Mind*

All three participants regularly commented on the challenges they faced when implementing Habits of Mind in their lessons. These challenges can be divided into three aspects: (i) constraints, (ii) teacher difficulties, and (iii) learner difficulties.

i. *Constraints*

Participants felt that they faced many constraints when attempting to implement Habits of Mind in their lessons. These constraints originated partly from the demands of the DBE which stipulated using more than one Mathematics work book: this requirement increased administrative demands. Teachers felt that the demands of the over-saturated Mathematics syllabus outlined in the CAPS curriculum placed added constraints on teaching time. These constraints restricted the time for their lessons and limited implementation of Habits of Mind in lessons. This difficulty limited the influence of Habits of Mind in practice: Habits of Mind

⁸² Natural units is the term used by Giorgi (1975) to describe participants experiences in the form of units of meaning which are segregated from the rest of the transcribed text.

lengthened lessons. Later into the research period, Teacher C's perception changed slightly: she still felt that she was limited by these constraints. Teacher C planned carefully for implementation of Habits of Mind in her lessons: she considered that the main advantage of this implementation was that it lessened the need to repeat content and eased the time constraints imposed upon her. This experience of Teacher C is discussed in paragraph 3.6.1.

ii. *Teacher difficulties*

Participants admitted to having difficulty implementing Habits of Mind. All three participants experienced difficulty when attempting to use Habits of Mind in their lessons at first: they struggled to use and understand the Habits. Teacher C later commented on her improved ability to use and understand Habits of Mind. She sensed that the more she applied them in her lessons, the more proficient she became in applying them herself. Teacher A, however, did not fully understand what Habits of Mind were: she perceived them to be general habits (Cuoco *et al.*, 1996). This misunderstanding may have added to her difficulty in implementation.

iii. *Learner difficulties*

All three participants experienced that, when implementing Habits of Mind in their lessons, learners had difficulty comprehending them. Habits of Mind, especially the second habit, '*discuss the regularity*', require learners to articulate mental reflections upon the concepts being taught, and call on learners to be involved in communication of the concept to others through diagrammes, pictures, mathematical models, writing or word of mouth (Carpenter & Lehrer, 2009). Participants felt that learners were not ready to participate in using the Habits of Mind because they had difficulty speaking about it. This challenge corresponded to concerns highlighted by Fleisch (2013) regarding poor achievement in both Mathematics and Literacy of South African learners.

C. *Habits of Mind require reflection*

The challenges experienced by participants when attempting to implement Habits of Mind could be interpreted as factors that limited the benefit of Habits of Mind in participant practice. On further examination of the data, it was evident that attempting to use the Habits of Mind in teaching required participants to reflect on their experience and identify difficulties. Examination of data regarding participants' involvement in the Community of Practice revealed reflection in the form of articulation. Carpenter and Lehrer (2009, p. 22)

state that “Articulation requires reflection, and, in fact, articulation can be thought of as a public form of reflection”. The reflection occurring in this situation in which participants identify difficulties in the implementation of Habits of Mind, can be identified within Van Manen’s (1977) proposed levels of reflection. Van Manen suggests three ascending levels to critical reflection: (1) the first level of reflection is focussed on the practical means of reflections, rather than the ends, (2) this higher level of reflection is focussed on analysing and clarifying experiences associated with it, and (3) the highest level of reflection includes questioning pre-established knowledge, experiences and conventions through reflection (Parkes & Kajder, 2010). The initial stage of reflection, at which participants identify challenges when implementing Habits of Mind, corresponds with the first level proposed by Van Manen (1977, p. 226): “*When the nature of the constraint is recognised, the need for a higher level of deliberative rationality becomes apparent*”.

In conclusion, when asking the question: “*What were the teachers’ perceptions of how Habits of Mind influenced their practice?*” the revelatory themes reveal that teachers perceived difficulties in implementing the Habits of Mind in their teaching and had varied perceptions of what Habits of Mind were. Through a deeper examination of their natural units, it was evident that implementation of Habits of Mind required participants to be reflective. Teacher reflection is encouraged by Dewey (1933) and critical reflection⁸³ is identified by Winch *et al.* (2015) as an aspect of teacher professional development. An intended outcome of this research is to provide an example of how teachers instigate and undergo professional development through a self-directed professional development model which correlates with the research aim of providing insight into teacher professional development. Serafini (2002) emphasises the value of reflection; its potential to refine classroom practice and improve the quality of the teaching-learning process. By implementing Habits of Mind in their practice, participants were obliged to reflect on their practice; something which advanced their professional development.

5.4.2 What were teachers’ experiences of being part of a Community of Practice?

The revelatory themes which emerged from the data collected relating to this subsidiary question depict positive experiences of those participants who became part of a Community

⁸³ Critical reflection is often used interchangeably with the term reflective practice but is more appropriate in describing practitioners’ ability to gain insight into their professional development by reflecting on their experiences (Lucas, 2012).

of Practice. Three conclusions can be identified: (A) The Community of Practice was envisioned by participants, (B) The Community of Practice is beneficial, and (C) The Community of Practice encourages reflection. These three conclusions are elaborated upon, related to relevant research below and then discussed in the conclusion to this section.

A. *The Community of Practice was envisioned by the participants*

Data was collected which related to experiences of participants in a Community of Practice. This data revealed in the early stages of the research period that, prior to this research project, teachers envisioned this type of community-based support structure, or collaborative practice, for the school. It was evident in their natural units that they recognised their need for support and felt that sharing experiences, regarding areas of their MKfT in which they had both difficulties and success in, would be beneficial to their practice. They commented on the need to share and synchronise MKfT with each other to support the progress of learners from grade to grade. Wenger and Snyder (2000, p. 140) confirm this notion by identifying Communities of Practice as an important knowledge management strategy which they believe could contribute towards an organisation's strategic direction. This confirmation corresponds with McDermott (2000, p. 4) who states: "As they share ideas and experiences, community members often develop a shared way of doing things, a set of common practices ...". Brodie's (2014) research concludes with similar findings relating to teachers sharing experiences with the goal of solving problems related to their practice.

B. *The Community of Practice is beneficial*

Natural units from all three participants revealed experiences where they felt they benefitted from being part of the Community of Practice. The benefits described by participants were that they were able to: (1) share teaching methods, ideas, knowledge and experience, (2) sequence or synchronise the teaching and learning of Mathematics between grades, (3) motivate and support one another. The benefits described by participants relate to literature detailing similar benefits of Communities of Practice. Stewart (1996) defines Communities of Practice as collaborative groups which empower individuals and allow them to access new knowledge and skills. Lesser and Everest (2001) credit Communities of Practice with encouraging contribution, and sharing of ideas and knowledge. Wenger *et al.* (2000) debate the ability of Communities of Practice to enable the transference, or sharing, of expertise between members. McDermott (2000, p. 2) maintains that Communities of Practice add value to members' professional lives because they focus on common interests and "practical

aspects of a particular practice, everyday problems, new tools, developments in the field, and things that do and do not work”. Owen (2014) finds that debates between members of a Community of Practice regarding differences in practice, ideas and varied experiences promote professional growth. This conclusion supports the findings of this section on the beneficial nature of Communities of Practice and prepares for the next section on the encouragements of reflection. This assessment of Communities of Practice correlates with Wenger’s (2000, pp. 227-228) modes of belonging in so far as they relate to *engagement* and refer to collaboration between members which benefits them and deeply shapes their personal/professional identity and lived experiences.

C. ***The Community of Practice encourages reflection***

It was evident from participants’ experiences that reflection and reflective practice occurred as a result of being part of a Community of Practice. Allard, Goldbatt, Kemball, Kendrick, Millen and Smith (2007, p. 311) identify that participants in a Community of Practice developed a “Deepened reflection on the relationship between personal and professional practice”. Yang (2009) refers to Leo (1990, p. 12) to explain the capabilities of Communities of Practice as a reflective platform for its members:

“Given that reflective practice is ‘the relationship between an individual’s thoughts and action and the relationship between an individual teacher and his or her membership in a larger collective called society’ (Leo, 1990 p. 204), a Community of Practice could be an alternative avenue for reflective practice among teachers”.

In Community of Practice meetings held during the research period, participants were involved in sharing ideas, practices and experiences through discussion as a form of articulation; which is defined by Carpenter and Lehrer (2009, p. 22) as requiring reflection and can be described as a *public form of reflection*⁸⁴. Lucas (2012) discusses reflective practice; referring to its interchangeable use in literature where it is often defined as equivalent to reflexivity, reflective thinking and critical reflection. Lucas (2012) singles out critical reflection, advocating it as more appropriate in teacher professional development because it allows practitioners to gain insight into their professional development through reflecting on their own experiences. Fook (2007) associates reflective practice with critical reflection; explaining that critical reflection is a sub-set of reflective practice which, when used specifically to improve professional practice, is reflective practice focused on bringing

⁸⁴ Refer to paragraph 2.9.

about change. Fook (2007, p. 442) states: “critical reflection should function to improve the way we live and relate as human beings, and in the process also improve on our professional practice”. Lucas (2012, p. 4) endorses the use of critical reflection in co-operative learning environments such as that of a Community of Practice, stating that it “increases the chances of learning being relevant and meaningful”. Brookfield (1995) proposes four lenses describing teacher engagement in the process of critical reflection: (1) autobiographical, self-reflective (2) student-centred, student feedback, (3) colleagues’ experiences, engagement with other teachers, and (4) theoretical literature, researching, presenting and publishing scholarly literature. Sharing experiences through collaboration of teachers in a Community of Practice embodies the third lens, as proposed by Brookfield (1995). Benefits of engaging within this lens are: increased collegiality and improved teacher motivation as a result of being in a Community of Practice (see paragraph 5.4.2 B).

Being a community member led to collaborative teacher reflection and individual reflection. These benefits were evident in participants’ experiences when they affirmed that even when separated from the Community of Practice, they continued reflecting on the shared views of the community through internal dialogue. This advance shows an engagement of the first lens proposed by Brookfield (1995), the foundation to critical reflection; revealing pedagogical aspects which need adjustment or strengthening. Bourdieu (1987) describes a related process: he explains how cultural reproduction can occur, allowing an individual to forge a distinct identity in relation to others, and to evaluate and appreciate his or her own work.

When asking the subsidiary question “*What were their experiences being part of a community of practice?*” it was evident in participants’ existing experiences (EE) that they felt being part of a Community of Practice would benefit their professional development. Their new experiences (NE) revealed what they felt were benefits of being part of the Community of Practice. Participants benefitted from existing and new experiences. Collaboration between individuals which participants found beneficial in their teaching was promoted as part of a Community of Practice. Examination of participants’ experiences was similar to their perceptions when describing implementation of Habits of Mind: something which revealed that being part of a Community of Practice promoted reflective practice, and, more specifically, critical reflection. Their critical reflection was present in two lenses listed by Brookfield (1995): autobiographical and colleagues’ experiences. The importance of reflection in teacher professional development is supported in literature (Winch *et al.*, 2015; Bourdieu, 1987; Fook, 2007; Lucas, 2012; Brookfield, 1995) and has been a recurring

mechanism in this research relating to insights into the professional development of participants. Further insights, related to reflective practice, its promotion within a Community of Practice and its relevance in developing teacher knowledge, are discussed in paragraph 5.6.

5.4.3 What were teachers' perceptions of promoting Relational Understanding?

Data related to participants' perceptions of promoting Relational Understanding revealed that they unanimously agreed that promoting Relational Understanding was beneficial. The benefits associated with Relational Understanding by participants were that it aids learners to: (1) see real-life applications of Mathematics and its value, (2) link mathematical knowledge to solve problems, and (3) remember the work better so that less time is wasted in re-teaching.

These benefits echo the writing of several mathematics researchers. Kilpatrick *et al.* (2001) make reference to seeing the real-world value of Mathematics. Murphy and Carlisle (2008) indicate the benefit of being able to make connections more easily and find ways of getting to the answer more quickly. Skemp (1976) claims that Relational Understanding allows learners to remember work more easily by linking new and old knowledge which results in less need to learn by rote and re-learn work off by heart. This last benefit is linked to a difficulty which surfaced many times in the data; participants are limited by time constraints and the need to repeat work. Teacher C had success in this regard: when consistently using the Habits of Mind that promote learners' Relational Understanding she found that as they related their mathematical concepts, they remembered the work better. She found that learners had what she perceived to be a better understanding of the work. The class became more involved in the lessons. Murphy and Carlisle (2008) credit Relational Understanding with development of learners' agency for learning the subject. They state that Relational Understanding generates confidence and leads to enjoyment of Mathematics, developing agency for the subject which was experienced by Teacher C in her natural units.

Reflection upon data related to Relational Understanding revealed that participants had varied perceptions of the concept of Relational Understanding. Three emergent perspectives of teachers were evident. (1) Teacher C's perception was consistent with that of the research: she described Relational Understanding as learners' ability to relate new concepts to old concepts in Mathematics, allowing learners to know what to do and know why they do it (Skemp, 1976). (2) Teacher B's perception related to what Kilpatrick *et al.* (2001, p. 5) name *habitual inclination* which refers to learners' ability to see the real world value of

Mathematics and which is a benefit of Relational Understanding (Reason, 2003; Murphy & Carlisle, 2008): not the concept Relational Understanding in its entirety as perceived by the research. (3) Teacher A's dominant perception of Relational Understanding was what Kilpatrick *et al.* (2001, p. 5) term *procedural fluency*, that is learner ability to carry out Mathematical procedures and calculations accurately, appropriately and effectively. Procedural fluency is related to Relational Understanding (Pope, 2014). When learnt in isolation, as described in Teacher A's natural units, relational understanding is regarded as instrumental understanding which Skemp (1976, p. 2) defines as *rules without reasons*: it is considered to be contradictory to Relational Understanding. The theme of varied perceptions of participants regarding their perceptions of Relational Understanding and Habits of Mind is a recurring theme in this research project which is discussed in paragraph 5.5.1 where the researcher reflects on the limitations of the research.

Data related to participants' varied perceptions of Relational Understanding are relevant when answering the subsidiary question: '*What were their perceptions of promoting Relational Understanding?*' Teachers' perceptions were that Relational Understanding is beneficial. Some of the relevance of their perceptions could be limited by their perceptions of the concept of Relational Understanding which did not accord with the concept as defined in this research project.

5.5 Researcher Reflections

In this section, limitations of the research are discussed. During the research period, in data collection and data analysis phases, reflection played a large role and led me to literature dealing with reflective practice in research procedures. Bourke (2014) quotes England (1994, p. 82): "Research is a process not a product". Bourke (2014) uses this quotation to argue the role of continuous reflection in research: pointing to the fact that research should not end, once findings are disseminated. Bourke (2014) discusses the importance of positionality in research and the effects it has on the research itself. Schön (1991) distinguishes between two forms of conscious reflection aimed at interpreting experiences, actions, feelings and responses for self-learning and self-development: reflection-in-action and reflection-on-practice. Reflection on practice occurs after the practice has taken place and involves the individual thinking back on the actions of self and others involved in the practice in order to determine the success of the actions and how to improve the outcomes in the same or similar situation.

Grayling (2010) refers to Rowling (2000) who identifies that reflection involves identifying emergent patterns in experience of a specific event, or in learning situations. Three patterns emerged regarding limitations. The first limitation was that participants had varied perceptions of concepts within this study. Second, there were challenges and limitations in my conduct of a phenomenological design of enquiry. Third, since this research relied on participants' descriptions, the truthfulness of their descriptions could be seen as a limitation. These three limitations are discussed in paragraphs 5.5.1, 5.5.2 and 5.5.3 which follows.

5.5.1 Varied perceptions of teachers

The revelatory themes identified during the data analysis phase of the research revealed that participants had varied perceptions of Habits of Mind and Relational Understanding. Reflecting on these findings, it could be concluded that my positionality⁸⁵ may have played a role in the emphasis of the findings. Smith (1999) considers positionality to be linked directly to situated knowledge theories because positionality speaks to the researcher's identity in the situated context of the research. Smith (1999) emphasises the personal nature of fieldwork; explaining that biography and positionality of the researcher play an essential role in the research process during fieldwork and final text stages. When entering upon this research environment, I did so with recent experience of the concept of Relational Understanding and was familiar with Habits of Mind (see paragraph 3.7.4). This knowledge formed part of my researcher positionality which was not shared with the participants who, prior to the commencement of this research, did not have as much experience of these two concepts. There was a period prior to embarking on the study in which participants were introduced to these concepts and had an opportunity to form an understanding of them: yet they had varied perceptions of these concepts which became evident during the data analysis.

Reflecting on this fact, the possibility arose that varied perceptions could be a result of my positionality as a researcher. This effect could have been created because I did not fully understand the position of the participants who needed more time or discussion around these concepts to form a common understanding. In comparable research findings, in which pivotal characteristics of professional learning communities, such as Communities of Practice, were identified, Owen (2014) provides insight into leadership and its role in the establishment of these communities. In listing the elements of Communities of Practice, Wenger (2000, pp.

⁸⁵ Positionality: Smith (1999) stipulates this is referring to the researcher's class, gender, race, education etc. (Refer to paragraph 3.7.4.)

230-232) refers to the role of leadership and its essential value in co-ordinating the community. My positionality might have affected the leadership of the Community of Practice which resulted in heterogeneous interpretations of concepts. Being able to identify the role of positionality in leadership is a vital part of reflection within Communities of Practice: such identification or self-awareness can reduce and limit any bias caused by positionality. Wenger (2000, p 230) states that without the ability to reflect, a Community of Practice becomes a hostage to its own history.

5.5.2 Reflections on using phenomenology

Reflection, in practice and on practice, is an important aspect of phenomenological research. Van Manen (2007, p. 12) states that “Phenomenology is a project of sober reflection on the lived experiences of human existence...”. Phenomenological research required me to limit personal bias by bracketing preconceived ideas, or outcomes. I had to acquire the habit of constant reflection⁸⁶ in order to practise reductive phenomenology; as explained in paragraph 3.5.2.

Reductive phenomenology is one of five dimensions in phenomenological research listed by Spiegelberg (1976): it minimizes the researcher’s subjectivity during the research process by means of bracketing preconceived ideas related to the research. My positionality is associated with this theoretical framework: Freire (2000 p. 50) describes the existence of a dialectic relation between objectivity and subjectivity in a researcher’s positionality. This correspondence suggests that a researcher’s complete objectivity is impossible. Yet Bourke (2014) avers that a high degree of impartiality can be obtained if the researcher acknowledges who he or she is; in terms of being mindful of subjective blind spots such as cultural, religious or political bias. Bourke (2014 p. 3) claims that a researcher can attain a high degree of objectivity by being aware of subjective aspects: “such as positionality”. Streubert-Speziale *et al.* (2003) believe that a successful method for achieving self-awareness is for the researcher to delay reading the data or revisiting literature until the end of the data collection period. This method was practised during the initial research period. I was present during the interviews where the data was being recorded. I refrained from transcribing and reading any data although I was already exposed to the data during its collection. I had to be reflective in practice: avoid the temptation to ask leading questions, or lead the interviews in any way that

⁸⁶ This type of reflection would relate to Schön’s (1991) reflection in action.

would impose my preconceived ideas on the findings. Koopman (2015, p. 3) reflects on his introductory journey into phenomenological research:

“From this I learned that what is required from a phenomenologist in the field is to behave like someone who is watching and enjoying a film, without analysing its aesthetic, sociological and technical aspects. When the film is finished, the analyses must be carried out objectively and independently, of any emotional involvement and unsubstantiated criticism”.

Conducting the research in this way required considerable reflection from myself as a phenomenological researcher. Constant reflection in and on practice was required in order to bracket prior assumptions which threatened to skew the outcomes of the research. This vigilance over prejudices was a challenge at first but became easier as the research continued. Phenomenological reduction was maintained throughout the research period.

Further reflection⁸⁷ on this research revealed a limitation related to the hybrid phenomenological design used in this research which I refer to as a hybrid design. Two models were used for data analysis: Giorgi's (1975) phenomenological model and the interconnected model of professional growth (Clarke & Hollingsworth, 2002) which is not definitively a phenomenological model. This research provides insight into teacher professional development and uses the descriptions of three participants. The small size of the sample was a limitation. To compensate for this shortcoming, the findings had to be scrupulously thorough and rich in data. The interconnected model assisted me in providing ways to analyse participants' experiences; deepening insights provided in this research into their professional development. Clarke and Hollingsworth (2002, p. 597) define a predictive function of the interconnected model of professional growth: the mechanisms they identified promoted teacher professional development by providing a rich description of participants' experiences specifically related to lasting change in their professional development. The hybrid phenomenological design I refer to as *précis* is a combination of Giorgi's (1975) phenomenological model used to identify revelatory themes in participant experience and the interconnected model of professional growth (Clarke & Hollingsworth, 2002) used to examine the professional growth evident in participants' experiences; as related to the revelatory themes identified. This hybrid model provided a rich description of insights drawn from this research into teacher professional development.

⁸⁷ This type of reflection would relate to Schön's (1991) reflection on practice

5.5.3 Trustworthiness of participant descriptions

Trustworthiness is routinely criticised in qualitative research. Yet there are many longstanding frameworks deployed by qualitative researchers to acquire academic rigour (Shenton, 2004). In this research I relied on the participants to describe their experiences during group and individual interviews. This reliance could be seen as a limitation since participants may not be completely truthful in their descriptions. Shenton (2004) lists Guba's (1981, p. 64) four constructs for evaluating trustworthiness in research: credibility (in preference to internal validity), transferability (in preference to external validity/generalisability), dependability (in preference to reliability), and conformability (in preference to objectivity). The limitation of the trustworthiness of participants' descriptions could relate to credibility as described by Guba (1981). Shenton (2004) suggests nine provisions be made by researchers to promote confidence and ensure that they have accurately accounted for credibility in their research: (1) adoption of well-established research methods (i.e. models for analysis such as Giorgi's (1975, pp. 64–69) phenomenological model and the interconnected model of professional growth), (2) triangulation of data, (3) allowing participants to examine the researcher's descriptions of what they have articulated, (4) allowing participants the opportunity to refuse to participate in the research; which promotes their honesty when contributing data, (5) using interactive questioning; present in semi-structured interviews, (6) allowing peers, colleagues or more experienced supervisors to scrutinise and provide feedback of analyses and findings, (7) researcher's reflective commentary where the researcher evaluates the research through reflection-in-practice, (8) providing a thick and detailed description of what is being researched, and (9) examining related research findings in order to assess the degree to which the research results are similar to those of other studies. All of these above-mentioned provisions have been adhered to throughout the collection, analysis and description phases of this research project to ensure the trustworthiness of participants' descriptions.

5.6 Insights into teacher professional development

The aim of this research was to provide insight into the professional development of mathematics teachers. This aim was achieved by describing how such teachers set about improving their knowledge of Mathematics and tuition skills in order to tackle, on a small scale and in a limited yet realistic manner, the large-scale crisis in South African education. After comparing the revelatory themes which emerged in the data in light of the research aim,

the following conclusions can be drawn: (1) Teachers had varied perceptions of the concepts of Habits of Mind and Relational Understanding, (2) Teachers faced challenges implementing Habits of Mind, and (3) Habits of Mind and Communities of Practice encourage reflective practice. These three conclusions are discussed below in the sections: (1) Mathematical knowledge for teaching (MKfT), (2) Challenges implementing intervention strategies, and (3) Reflective practice.

5.6.1 Mathematical Knowledge for Teaching (MKfT)

The importance of mathematical knowledge for teaching (MKfT) and its growth in professional development, have been regularly referred to in relevant research literature throughout this research project (Hill *et al.*, 2008). Relevant literature emphasised that South African teacher content knowledge is unsatisfactory in general (Taylor & Taylor, 2013). Teachers are encouraged to undertake professional development to gain knowledge in their own subject area (SMK) as well as pedagogical content knowledge (PCK) (Venkatakrishnan & Spaul, 2014; Jita & Ndlalane, 2009). Hill *et al.* (2008) refer to MKfT which they describe as a combination of SMK and PCK. Insight into the development of MKfT provides understanding of teacher professional development: the aim of this research project.

The mechanism of collaboration through which teacher professional development occurs was identified in paragraph 4.5.3 (Clarke & Hollingsworth, 2002). Collaboration between participants was promoted through membership of a Community of Practice and reflective practice was encouraged among participants (see discussions in paragraph 4.5.3). Reflective practice was related to the ability of competent practitioners to reflect on and adjust their tacit knowledge⁸⁸ (Smolarek & Hora, 2016). Taylor (2007) reveals that collective tacit knowledge, unlike individual tacit knowledge, can be articulated by members of a community. Pyrko (2016, p. 2) explains that individuals in a community are able to “guide each other through their understanding of a mutually recognized real-life problem: in this way they indirectly ‘share’ tacit knowledge”. Taylor’s (2007) explanation of collective tacit knowledge, referred to by Pyrko (2016), is an amalgamation of individuals’ implicit and explicit knowledge shared in a community. Ernest’s (1999) explanation of implicit mathematical knowledge is similar to what Hill *et al.* (2008, p. 73) refer to as SMK: an individual’s understanding of a certain subject. Ernest (1999, p. 80) refers to explicit knowledge as the teacher’s ability to

⁸⁸ Knowledge which is instinctively understood by individuals but cannot be articulated or written down and is often referred to as implicit knowledge (Taylor, 2007).

guide a learner in developing his or her knowledge of Mathematics: something which could be associated with the explanation of PCK made by Hills *et al.* (2008). The combination of SMK and PCK is explained by Hill *et al.* (2008) as MKfT (Hurrell, 2013, p. 57). Development in these areas impacts directly on MKfT.

Insights from this research reveal that collaboration of individuals in a Community of Practice encourages reflective practice on the community's collective tacit knowledge. Reflection and adjustment to the community's collective tacit knowledge influences an individual member's implicit and explicit knowledge which can be associated with mathematical knowledge for teaching (MKfT); affecting in turn teacher professional development.

5.6.2 Challenges implementing intervention strategies

During the research period, participants attempted to use Habits of Mind as an intervention tool to promote learners' Relational Understanding of Mathematics. When implementing this tool, participants experienced difficulties in terms of time constraints and challenges applying Habits of Mind. Such problems in implementation correspond with Fleisch's (2013) report into the South African education crisis which emphasises the need for reform in Mathematics and Literacy. O'Connor and Geiger (2009) found that similar challenges face primary school educators in the Western Cape. O'Connor and Geiger focused on English second language education and not on Mathematics; yet the similarities between the results are remarkable. In this research, participants found that learners had difficulties in articulating the terms of Habits of Mind (Carpenter and Lehrer, 2009). O'Connor and Geiger (2009) described literacy challenges of learners. Both projects were located in schools where learners were required to converse in English as the language of learning and instruction; the majority of learners were English Second Language speakers. O'Connor and Geiger (2009, p. 266) state that "educators participating in this study were frustrated by a considerable workload...". This degree of frustration amongst educators existed primarily because of time constraints which were the result of excessive workloads in the curriculum.

Challenges, experienced by participants in this research, are relevant to the South African teaching profession in general. Similar results manifested themselves in related studies (O'Connor & Geiger, 2009; Fleisch, 2013). This correlation suggests that research enquiries focused on the South African education crisis should allow for learner difficulties in both Mathematics and Language. The fact that participants felt constrained in their teaching due to

excessive workloads supports the recommendation of O'Connor and Geiger (2009, p. 226): "This knowledge could also initiate further research leading to possible policy changes to meet educators' needs".

5.6.3 Reflective practice

In much of the literature referred to in this research project, reflective practice has been an important aspect of teacher professional development and practice. Reflective practice has proven to be a vital aspect of Communities of Practice: in maintaining the community and as a benefit of it (Wenger, 1998 & 2000). These aspects of reflection are replicated in the research into participants' experiences of the Community of Practice studied in this research. The data indicated that all three participants at some level engaged in reflection as a result of belonging to a Community of Practice. This engagement was relevant whether reflection took place on an individual level, when preparing for lessons, through articulation when discussing lived experiences within the community, or through the reflection of shared experiences of the community during group interviews. Aligning this insight with Wenger's (1998, pp. 73-82)) dimensions which define the competence of Communities of Practice, the dimension of *shared repertoire* adequately expresses the reflection indicated in the data collected. This dimension describes deeper self-awareness in the community: developing self-consciousness among members through reflection, broadening of community understanding and the emergence of multiple perspectives.

Using Habits of Mind to promote learners' Relational Understanding demanded reflection from the teachers. It was evident in the data collected that, by attempting to use Habits of Mind, teachers were obliged to reflect on their practice prior to the research period and their practice during the research period. This reflection corresponds to elements identified by Wenger (2000, pp. 230 – 232): with which a Community of Practice interacts in continuously re-designing itself. Using Habits of Mind refers to the element of *artefacts* which a community develops over time. Such artefacts are used, maintained, developed, retained or discarded by the community as it evolves through reflection. Habits of Mind do not necessarily encourage reflection in themselves but the use of them functions as an artefact within the Community of Practice. Maintaining, and reflecting on, artefacts within a Community of Practice are important practices for development and growth.

By reflecting on their experiences, and guided by Wenger's (2000, pp. 227–228) *modes of belonging*, it is possible to identify areas in which improvement was made within this

community. This community is situated more in the *engagement mode* as explained by Wenger (2000): members are collaborating and sharing experiences. This joint experience suggests that members may lack a sense of belonging within *imagination*: they are not fully able to place themselves and their identity within the community; and within *alignment*, relating to them not being able to manage their activities towards the shared goal of the community. The evidence of this shortcoming can be deduced from the varied perceptions of the concept of Relational Understanding as well as Habits of Mind among participants: a fact which resulted in their activities not being guided by the same perception and limiting their *alignment*. Limitations they felt were placed on them as a result of workload demands so that they were not always able to implement the Habits of Mind fully in their lessons. This lack of full implementation limited their *alignment* and their *imagination*: they were unable to realise the concept of teaching fully by using Habits of Mind to promote Relational Understanding. This phenomenon denotes that there was a sense of both modes of belonging: (*alignment* and *imagination*) within this community. Wenger (1998, pp. 173-181) explains that identifying the limitations of these modes of belonging through reflection enables the community to fine-tune alignment between these modes so that the ultimate goal of the community can be realised. This explanation emphasises the importance, relevance and promotion of reflective practice; especially within Communities of Practice: it informs individual professional practice and development of identity, and guides the community. Smolarek and Hora (2016) position reflective practice at the heart of teacher education, emphasising teacher engagement in reflective processes and part of continuous professional development.

5.7 Conclusion

In conclusion, the primary aim of this research was to appraise how mathematics teachers experienced professional development when endeavouring to raise their subject content knowledge and tuition skills. This aim was prompted by an awareness of the severe education crisis facing South Africa (Taylor & Taylor, 2013; Hill *et al.*, 2005; Fleisch, 2013; Spaul & Kotze, 2015; Venkatakrishnan & Spaul, 2014; Jita & Ndlangane, 2009; Mkhwanazi, 2014). From the data collected, this research provided insight into the professional development of teachers and revealed three key findings.

Implementation of Habits of Mind illustrated the need for engagement with *artefacts*⁸⁹ within a Community of Practice (Wenger, 2000). This engagement with artefacts stimulated reflection and collaboration within the Community of Practice which were the two mechanisms of professional development evident in this research (Clarke & Hollingsworth, 2002).

The second finding was that teachers felt challenged when implementing intervention strategies such as Habits of Mind. This challenge was the result of: (1) learners' poor language skills which compromised their ability to articulate mathematical concepts, and (2) teachers being overwhelmed by the workload demands of the current curriculum (CAPS) which places severe and undue pressure on the time they have for intervention strategies. Since the participants so often referred to their challenges in terms of workload, this research supports the recommendation of O'Connor and Geiger (2009, p. 226) who suggest the initiation of "further research leading to possible policy changes to meet educators' needs".

The third finding is that reflective practice is an important aspect of teacher professional development which allows teachers to reflect on their professional practice as well as the practice of others as shown through their lived experiences in a Community of Practice (Allard *et al.*, 2007). This shared reflection influences their teacher knowledge and professional growth (Winch *et al.*, 2015; Bourdieu, 1987; Fook, 2007; Lucas, 2012; Brookfield, 1995; Smolarek & Hora, 2016). Use of the interconnected model of professional growth indicated collaboration and reflection to be mechanisms of professional development in this research (Clarke & Hollingsworth, 2002). These two mechanisms allowed participants to form collective tacit knowledge within the Community of Practice, enabling participants to reflect on their own implicit and explicit knowledge which modified their subject matter knowledge (SMK) and pedagogical content knowledge (PCK) (Smolarek & Hora, 2016; Taylor, 2007; Pyrko, 2016; Ernest, 1999; Hill *et al.*, 2008). Hill *et al.* (2008) describe the existence of mathematical knowledge for teaching (MKfT) and explain it to be the amalgamation of SMK and PCK. Communities of Practice provide opportunities for teachers' professional development: these communities encourage and stimulate reflective practice of teachers which result in the development of their MKfT.

⁸⁹ The *artefact* being referred to here is the Habits of Mind which was used as a tool to promote Relational Understanding.

5.8 Recommendations for future research

It can be recommended from the insights gained in this research that more longitudinal inquiries be undertaken into the development of MKfT through collaboration and reflection promoted by Communities of Practice. The aim of this research was to provide insight into the professional development of mathematics teachers by describing how such teachers set about improving their own knowledge of mathematics and tuition skills. From the insights gained deeper studies into the relationship between Communities of Practice and the promotion of reflection could be conducted, continuing to provide further insight into teacher professional development. This correlates to recommendations of recent research discussing “continuing professional development” of educators (Ferreira & Bertotti, 2016, p. 1427). Ferreira and Bertotti (20016) describe a professional development design which considered education as a continuum, similarly to Smolarek and Hora’s (2016) stance where reflective practice is positioned at the centre of teacher continuous professional development.

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APPENDIX A: Letter of consent (Principal)

Dear Mr/Miss/Mrs.....

19 January 2015

Request to conduct research at your school

My name is Byron Abrahams and I am currently registered and studying to complete my Master's degree in Education at the Cape Peninsular University of Technology. As part of my studies I am conducting research and would like to ask if I could conduct this research at your school.

The research entails the involvement of three of your educators who will be providing data through audio recorded grouped interviews, written reflective journals and lesson observations. All data collection will be conducted on the school premises. The names of the teachers, learners and school will be kept strictly confidential and at no time will the names be disclosed in this research paper. All audio recordings will not be published in any form.

I require that you, the principal, complete this consent form so that you provide informed consent. This arrangement can be terminated at any time if any of the parties feel the need to.

Once completed, the assignment will be made available to any member partaking to view. If there are any questions regarding this request or if any questions arise during the research period feel free to call me:, or email me on

Yours sincerely

Byron Abrahams

I Mr/Miss/Mrs.....(Principal) give permission for the above mentioned to conduct research at (School name).....

Signed :

Date:

APPENDIX B: Letter of consent (Teacher)

Dear Mr/Miss/Mrs.....

19 January 2015

Consent form for involvement in research

My name is Byron Abrahams and I am currently registered and studying to complete my Masters degree in Education at the Cape Peninsular University of Technology. As part of my studies I am conducting research and would like to request your involvement in said research.

The research entails the involvement of four educators, you included, who will be providing data through audio recorded grouped interviews, written reflective journals and lesson observations. All data collection will be conducted on the school premises. The names of the teachers, learners and school will be kept strictly confidential and at no time will the names be disclosed in this research paper. All audio recordings will not be published in any form.

I require that you complete this consent form so that you provide informed consent. This arrangement can be terminated at any time if any of the parties feel the need to.

Once completed, the assignment will be made available to any member partaking to view. If there are any questions regarding this request or if any questions arise during the research period feel free to call me:, or email me on

Yours sincerely

Byron Abrahams

I Mr/Miss/Mrs..... give permission for the above mentioned to involve me in the research.

Signed:

Date:

APPENDIX C: Cape Peninsula University of Technology Ethical Clearance Form



Cape Peninsula
University of Technology

APPENDIX II: FACULTY OF EDUCATION ETHICS FOR ORIGINAL RESEARCH

This form is to be completed by the student, member of staff and other researchers intending to undertake research in the Faculty. It is to be completed for any piece of research the aim of which is to make an original contribution to the public body of knowledge.

For students this type of work will also have educational goals and will be linked to gaining credit - it is the type of work that will be the basis for a Masters/Doctoral thesis or any research project for which ethical clearance is deemed necessary:

Name(s) of applicant	Byron Abrahams
Project Title	Teachers' use of Habits of Mind to promote learners' relational understanding of mathematics.
Is this a staff research project?	No
Degree	M Ed in Mathematical Education
Supervisor(s)	Prof C. Vermeulen
Funding sources	N/a

Attached: Information sheet ☐ Consent form X ☒ Questionnaire ☐ Other (Specify)

Summary of proposal/project (300 words maximum)

This research is being done to answer the question: How do teachers' use Habits of Mind to promote learners' relational understanding of mathematics? The aim of this research is to look at how teachers use Habits of Mind as a tool to promote relational understanding of mathematics in their learners. The study is focused on the teachers and their use of the habits of Mind and not on the learners. This study has the objective of providing professional development for the teachers and myself, being a researcher and a practitioner in this study, as we attempted to address the problem of low mathematics achievement in our school.

The teachers being used in the research are all part of a community of practice, consisting of four mathematics teachers, whose aim is addressing the poor mathematics achievement of the learners in the school. These teachers will get together for five interviews in the form of group discussions for data collection. The group discussions will be semi structured and therefore will not have any set questions, however will be structured around a focal concept. Each teacher will also plan a Habits of Mind based lesson which will be video recorded and discussed in the fifth and final interview. The data collection plan can be seen below. It includes the provisional dates of the interviews and video observations, as well as shows the concept that will be focused on in each interview.

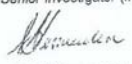
Completed by:	Collection Instrument	Details
01 Aug 2014	Group discussion 1	Using habits of mind in relation to Addition & Subtraction.
15 Aug 2014	Group discussion 2	Using habits of mind in relation to 2D Shapes
29 Aug 2014	Group discussion 3	Using habits of mind in relation to Transformations
12 Sep 2014	Group discussion 4	Using habits of mind in relation to Number patterns and preparing for video observation
26 Sep 2014	Observation	Each of the four teachers is video observed.
23 Oct 2014	Group discussion 5	Using habits of mind in the video lessons

To conduct the research ethically firstly no names of school, staff members, or children will be disclosed. Letters of permission will also be given to all participating teachers, guardians where needed and the principal of the school, as well as the permission forms will be sent to Cape Peninsula University of Technology (CPUT) and Western Cape Education Department (WCED), thus providing informed consent. To avoid any deception in the research, participants will be fully aware of the nature and aim of the research before and during the process. All group discussions (interviews) and observations will be conducted on the school premises, with permission of the principal and the WCED, and will not intentionally hinder the teaching and learning process in any way.

Research Checklist:		Yes	No
1:	Does the study involve participants who are unable to give informed consent? Examples include children, people with learning disabilities, or your own students. Animals?		X
2:	Will the study require the co-operation of a gatekeeper for initial access to the groups or individuals to be recruited? Examples include students at school, members of self-help groups, residents of nursing homes — anyone who is under the legal care of another.	X	
3:	Will it be necessary for participants to participate in the study without their knowledge and consent at the time — for example, covert observation of people in non-public places?		X
4:	Will the study with the research subject involve discussion of sensitive topics? Examples would include questions on sexual activity or drug use.		X
5:	Will the study involve invasive, intrusive, or potentially harmful procedures of any kind (e.g. drugs,		X

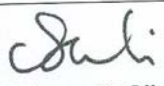
	placebos or other substances to be administered to the study participants)?		
6:	Will the study involve prolonged or repetitive testing on sentient subjects?		X
7:	Will financial inducements (other than reasonable expenses and compensation for time) be offered to participants?		X
8:	Does your research involve environmental studies which could be contentious or use materials or processes that could damage the environment? Particularly the outcome of your research?		X

Signatures:

		Supervisor/Senior investigator (if applicable): 
Researcher/Applicant:	Byron Abrahams	Prof C. Vermeulen
Date:	25 June 2014	Date:

Please note that in signing this form, supervisors are indicating that they are satisfied that the ethical issues raised by this work have been adequately identified and that the proposal includes appropriate plans for their effective management.

Education Faculty Ethics Committee comments:

EFEC unconditionally grants ethical clearance for the study titled, "Teachers' use of Habits of Mind to promote learners' relational understanding of mathematics." The certificate is valid for 3 years from the date of issue.			
Approved		 Chairperson: Cina P Mosito, PhD	Date: 5/8/2014
Approval Certificate/Reference: EFEC 10-8/2014			

APPENDIX D: Western Cape Education Department Ethical Clearance Form



Education

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Private Bag x9114, Cape Town, 8000

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REFERENCE: 20140917-36656

ENQUIRIES: Dr A T Wyngaard

Mr Byron Abrahams
7 Greenway Close
Ascot
Ottery
7780

Dear Mr Byron Abrahams

RESEARCH PROPOSAL: TEACHERS' EXPERIENCES IN THE IMPLEMENTATION OF HABITS OF MIND THAT PROMOTES MATHEMATICS LEARNERS' RELATIONAL UNDERSTANDING

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from **01 February 2015 till 30 September 2015**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Dr A.T Wyngaard at the contact numbers above quoting the reference number?
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:

**The Director: Research Services
Western Cape Education Department
Private Bag X9114
CAPE TOWN
8000**

We wish you success in your research.

Kind regards.

Signed: Dr Audrey T Wyngaard

Directorate: Research

DATE: 27 January 2015