Chapter Two

Fully Mixed Sequential Equal Status Multi-Mode Design and Methodology: Qualitative Aspects

2.1 Introduction

Over the past decades transformation has taken place in the mode of teaching and learning—from an instructivist and face-to-face approach to a more constructivist and blended or online approach. In order to adapt to change, three extensive categories should be considered: experience, reasoning, and research. These considerations are independent of each other, but complementary to understanding change in the environment (Cohen et al., 2011:3). "Research is the dialectical interaction of the researcher with the social world through questions and answers" (Bapir Ali, 2009:1). During research, the researcher inquires about the phenomenon and validates the course of action (McMillan & Schumacher, 2001:3). Educational research seeks to improve educational practices, gain information in order to compile new programmes, and plan improvements to challenges in the system (McMillan & Schumacher, 2001:6). This research aims to generate knowledge to compile guidelines for PD in the pedagogical use of ICT through ODL.

This chapter provides a description of the qualitative research design and methodology followed during this research. It explicates the rationale for conducting a systematic literature review and document analysis employed during the qualitative phase of the research. It further elucidates the trustworthiness, validity and reliability of the findings and results, the ethical aspects, and the limitations of the research.

2.2 Worldview of the Research

Research commences when the researchers are conscious of their domain of research, aware of the boundaries which define their perspective, and are able to undertake an intellectual crossing to other research domains (Burrell & Morgan, 1979:ix). Research of sociological nature considers the subjective-objective and the regulation-radical change dimension. When these two dimensions are a subset of each other, four sets of assumptions pertaining to research thinking emerge: ontological, epistemological, human nature and methodological assumptions. The four sets of dimensions contribute towards four paradigms, each with a separate social-scientific reality of how they describe the world. Each paradigm provides guidelines of viewing a problem based on different meta-theoretical assumptions, the mutual belief system, the identity those involve adopt, and the method to use to solve problems and acquire knowledge regarding the phenomenon (Burrell & Morgan, 1979:24; Cohen *et al.*, 2011:5). When additional knowledge is acquired and the initial paradigm cannot address all the questions of the phenomenon, then the parameters of the paradigm should shift (Cohen *et al.*,

2011:5). Research of this calibre is of a complex nature and more than one paradigm is needed to answer the research question. In this study I sequentially made use of the *interpretivist* and the *structuralist* paradigms to explicate the appropriate positioning of my research (Figure 2.1) (Burrell & Morgan, 1979:22-26), and to explain my theoretical position and assumptions for this study. A multi-mode research was established, which relates to a balanced approach, and contributes significantly to addressing the research question.

2.2.1 Ontology

Ontology is a domain of philosophy that relates to the *nature of social reality*, with a fundamental belief in an external reality, which pleads reason rather than experience (Blaikie, 2007:13; Merriam, 2009:8). Ontology's main concern is how people view reality (Mack, 2010:5), and the connection between people, society, and their environment (Eriksson & Kovalainen, 2008:13). In social sciences, ontology adopts two notions: social activities that take place if there are resources and deep-rooted connections, and reality that is built through social activities by those involved in the activity, using their cognitive skills (Blaikie, 2007:14; King, 2004:5-6). One of the attributes of ontology is the clear division between objectivism and subjectivism. *Objectivism* as an ontological point of departure considers people's actions and activities that exist independent of their social worlds, and society has an objective existence and structure (Eriksson & Kovalainen, 2008:13; King, 2004:6). Objective researchers believe that social reality has an independent existence and research must take place outside these boundaries (Eriksson & Kovalainen, 2008:13). *Subjectivism* presumes that people have the knowledge and they are active participants in the social and cognitive processes. Researchers who conduct research from a subjective approach believe that reality does not exist independent of the individual and reality, but relates to the individual (Eriksson & Kovalainen, 2008:14). Ontology considers what reality comprises, while epistemology thinks about the methods to uncover knowledge (Hatch, 2006).

2.2.2 Epistemology

The theory of knowledge, how people acquire knowledge, and to what extent they can obtain knowledge of their environment, is known as epistemology (Blaikie, 2007:19; Merriam, 2009:8). Epistemology delineates the criteria to accumulate knowledge; the methods to access knowledge; the process to evaluate whether the knowledge obtained is genuine and adequate, and the procedure to assess the limitations and foundations of knowledge (Blaikie, 2007:19; Eriksson & Kovalainen, 2008:15; Mack, 2010:5). It aims to represent and describe reality (Hatch, 2006). Questions of epistemology are the foundation for research as epistemology defines and structure the method of inquiry (Eriksson & Kovalainen, 2008:19). Knowledge can be subjective or objective by nature. Ontology and epistemology have an inter-dependent connection as they both provide information and depend on each other in the research process. The ontological and epistemological theories unified construct a paradigm (Mack, 2010:5). Research is aligned when there is a connection between the

ontological position (what can be researched), the epistemological position (what we know about it), and the methodological approach (how we go about it) (Mack, 2010:6).

2.2.3 Research Paradigms

The Burrell and Morgan (1979:22) model of sociological paradigms comprises four paradigms (functionalist, radical humanist, radical structuralist, and interpretivist) according to the sociologies of regulation and radical change (Figure 2.1). The following section provides a brief overview of the functionalist and radical humanist paradigms, but a detailed explanation of the interpretivist and the radical structuralist paradigms of this complex research.

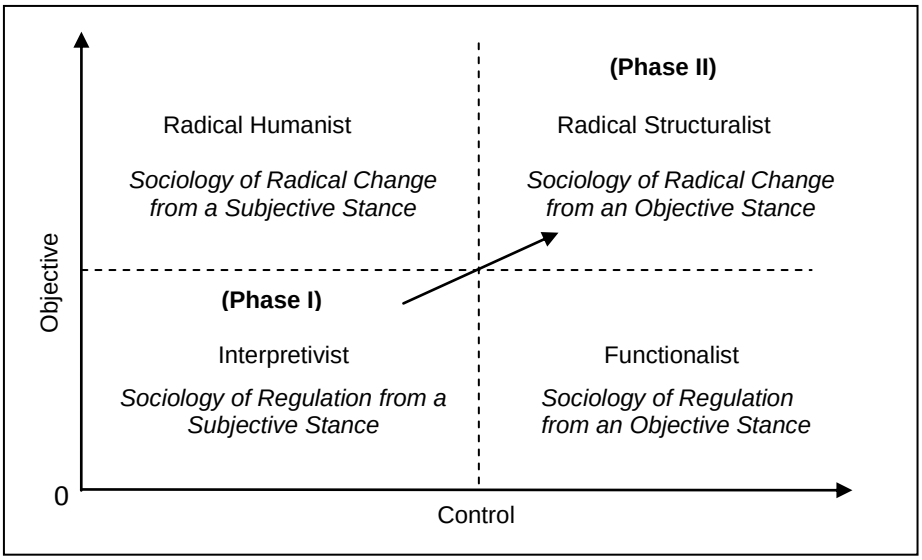

Figure 2.1: Phases of the Complex Research According to the Four Paradigms (Burrell & Morgan, 1979:22)

The *functionalist* paradigm is originated in the *sociology of regulation* and is mainly used to study organisations and the behaviour of academic sociology from an objectivist point of view. This paradigm is mostly used by organisation theorists, industrial sociologists, psychologists, and industrial relations theorists. They are pre-dominantly *realist*, *determinist*, and *nomothetic*. Their stance is dominantly pragmatic and focuses to understand society from a problem-orientated approach. The functionalist aims to accumulate constructive knowledge, gain practical solutions, and to solve practical problems (Burrell & Morgan, 1979:26-28).

The *radical humanist* focuses on the *sociology of radical change*, *modes of domination*, *emancipation*, *deprivation*, and *potentiality* from a subjectivist point of view. Radical humanists are inclined to be *nominalist*, *anti-positivist*, *voluntarist*, and *ideographic* of nature (Burrell & Morgan, 1979). They believe that people are confined in organisations of society made and maintained by them. Their aim is to create a pathway so that humans can break free from the existing social patterns which trap them in the social organisation and alter the social world by adapting modes of cognition and consciousness

(Burrell & Morgan, 1979:306). The radical humanist acknowledges the ontological position of the social world and has some attributes in common with the interpretivist (Burrell & Morgan, 1979:32).

This study is of a complex nature (§ 1.3) with two separate social realities, of both objectivist and subjectivist assumptions, and two methodological approaches to a multi-mode research was used, as a balanced approach, to address the complex research question *What are the guidelines for the professional development of Mathematics teachers for the pedagogical use of ICT in ODL*? according to two paradigms: (i) an interpretivist paradigm which supports *sociology of regulation* from an *subjectivist* standpoint (Denzin & Lincoln, 1994:22), and (ii) a structuralist paradigm rooted in a materialist view of the natural and social world that promotes *sociology of radical change* from an *objectivist* standpoint (Burrell & Morgan, 1979:34-35). Figure 2.1 illustrates how the research process developed from the interpretivist to the radical structuralist paradigm. This chapter discusses the interpretivist phase of this complex research.

2.2.3.1 Phase I: Interpretivist Phase

The interpretivist paradigm adopts a method which is implicit rather than explicit. Interpretivists tend to be *nominalist, anti-positivist, voluntarist, and ideographic (Burrell & Morgan, 1979:28)*. Their beliefs are contradictory to those of the positivist and more towards constructivism which accentuates the attributes of the individual to construct meaning (Merriam, 2009:9). They challenge the ontological assumptions of the functionalist paradigm is whether organisations exist side by side in a conceptual sense (Burrell & Morgan, 1979:31-32). Interpretivists support a phenomologist philosophy regarding humans: how their needs will be addressed; how they perceive their environment; and what their subjective interpretations of their environment are (Mack, 2010:7). Fundamentally they aim to understand the social phenomena through the eyes of various participants in the social activity (Patton, 2002:106). Research in this paradigm does not seek knowledge, but knowledge is constructed through interaction with others in their environment (Merriam, 2009:9). Interpretivists do not believe in one single form of reality, but in multiple realities or interpretations for a particular occurrence (Merriam, 2009:9). People derive meaning from symbols and the interpretive processes when they share and interact in their environment (Merriam, 2009:9; Patton, 2002:113). Table 2.1 outlines the ontological and epistemological assumptions of the interpretivist paradigm.

Table 2.1 Ontological and Epistemological Assumptions of the Interpretivist Paradigm *

Ontological Assumptions	Epistemological Assumptions
Individual constructs own reality and reality is subjective	Knowledge is constructed through acknowledging diversity of the participants
Individual forms own opinion of activities and understands activities from own perspective	Researcher grasps subjective meaning of social action
Activities are unique and specific	Knowledge is gained through inductive analysis to construct a theory
Individual constructs own opinion what constitute reality	Knowledge develops when the researcher interact with the individual in their environment
Outcomes are established by means of interpreting the	Knowledge is created through individual experience

Ontological Assumptions	Epistemological Assumptions
experiences and symbols	

* Adapted from Mack (2010:8); Merriam (2009:9)

Interpretivists seek to understand and gain the opinion of those directly involved in social processes through construct and explanations (Burrell & Morgan, 1979; Cohen *et al.*, 2011). Interpretivists believe that *we can only know what we experience* (Patton, 2002:105) and there is no objective experience (Merriam, 2009:9). Within every study numerous sites could be visited, events or activities could be observed, people could be interviewed, and documents could be read. The researcher thus should choose *what, where, when, and whom* to observe or interview (Merriam, 2009:76). Data collection mainly takes place via interviews, observations and or documents (Merriam, 2009). During interviews researchers and participants engage in focussed discussions on the phenomenon, on issues they cannot observe, like opinions, beliefs, meanings, and when it is obviously the best method of data collection (Patton, 2002:340-341). Lincoln and Guba (1985:268) state that interviews is the *here and how* manufacture of individuals, actions, activities, organisations, feelings, motivations, demands, concerns, and elements. Interviews can also represent the remanufacturing of elements as from past experiences and the projections of possible events in the future (Lincoln & Guba, 1985:268). However, as CPTD for the pedagogical use of ICT through ODL in the South African context is a new phenomenon, the work published by researchers in a particular field represents their voices, experiences and expertise on the phenomenon.

Therefore, Phase I (adjustable exploration phase) of this research enquires about the ICT PD requirements directly from Mathematics teachers who should have wide-ranging experience of the phenomenon and experts in the field. Phase I (Figure 2.1) relates to the voices (opinions in documents) of expert authors to provide insight on their expert perceptions and requirements concerning CPTD for the pedagogical use of ICT through ODL (Merriam, 2009:85).

2.3 Fully Mixed Sequential Equal Status Multi-Mode Research Design

The research question of this study relates to an issue complex in nature and I therefore propose a multi-mode approach as a viable method to: (i) integrate different theoretical stances of viewing a problem, (ii) have access to more types of data in conducting both confirmatory and exploratory research; and (iii) to strengthen the processes and outcomes of the analysis (Burrell & Morgan, 1979). Furthermore it supports the aim of the research—to construct guidelines for practice (Cohen *et al.*, 2011).

The *three dimensional typology of multi-method* design conceptualized by Leech and Onwuegbuzie (2007) apply to this research. These three dimensions differentiate between: (i) the level of mixing (partially mixed versus fully mixed); (ii) the time orientation (concurrent versus sequential); and (iii) the emphasis on approaches (equal status versus dominant status). The *level of mixing* relates to the

balance between the quantity of qualitative and quantitative research. *Time orientation* relates to the period during which the qualitative and quantitative stages of the research occur either at the same time (concurrent) or successive (sequential). *Emphasis on the approaches* refers to the level of priority, i.e. whether each phase (qualitative and quantitative) has equal status or whether one phase has a higher level of priority. This research study followed the three dimensional typology of multi-methods design known as a *fully mixed sequential equal status research design.* During this research the qualitative and quantitative phases occurred sequentially and the two phases have equal value in the research process (Leech & Onwuegbuzie, 2007:268). Figure 2.1 provides an overview of the research design of the fully mixed sequential equal status research design for this complex research.

The research commenced with a methodology of systematic literature review analysed inductively according to qualitative constant comparative content analysis (Boeije, 2002:394) with the aim of exploring the literature for relating aspects; followed by quantitative methods comprising a large scale survey whereby I extracted guidelines through a process of structural equation modelling (SEM) (Leech & Onwuegbuzie, 2007:271).

2.4 Qualitative Design

The qualitative phase (Phase I) of the study followed a non-interactive basic (generic) qualitative design (Figure 2.1) (Merriam, 2009:3). Three types of interviews underpin qualitative research: highly structured, semi-structured and unstructured which the researcher can use when conducting an interview. In most cases interviewing is open-ended and less structured (Merriam, 2009:89-90). *Observation* is when research of the phenomenon takes place in the natural setting and the data obtained are the result of a direct encounter with the phenomenon of interest (Merriam, 2009:117). When a researcher conducts an observation it has to be methodical, address the research question, and must be subject to assessment in order to produce truthful results. Observations allow us to have knowledge of the context and create a platform to study a phenomenon where a new perspective is needed and the participants are not willing to discuss the topic explicitly (Merriam, 2009:119). *Documents* are an existing source of data accessible and an alternative for the researcher when interviews and observations are not applicable to study the phenomenon of interest. These documents or artefacts can be written, visual, digital or physical materials. A number of generic documents like official records, letters, newspapers, poems, songs, government documents, research articles, etc., can be included as research materials (Merriam, 2009:139-140). The documents included for this analysis included: policy, journal articles, conference proceedings, book chapters, and literature reviews.

I conducted a document analysis whereby I made use a systematic literature review as data collection strategy which is a methodological strategy to identify, collect, evaluate, and synthesise relevant issues on a specific topic (Goodwin & Geddes, 2004:249). Qualitative research requires that one uses

stakeholders that really know about the topic (Merriam, 2009:89). ODL as a mode of training and course delivery is unfamiliar to Mathematics teachers within schools as teachers do not have first-hand experience of PD activities and programmes for ICT integration. Therefore the insights provided by Mathematics teachers would not be a suitable or sufficient method to obtain information to construct a survey to generate guidelines for PD of Mathematics teacher for the pedagogical use of ICT in ODL (Burrell & Morgan, 1979:34; Cohen *et al.*, 2011:256). Document analysis through a systematic literature review is thus a viable method to obtain the information on PD of Mathematics teachers for the use of ICT during teaching and learning practices. However, the selection of documents has to adhere to the same rigorous criteria as selecting participants for qualitative research (Merriam, 2009:154). Selecting documents in a random way does not contribute towards validity of the study and does not ensure that documents of the highest quality are selected. If documents are of high quality and representative of the opinions in the field, it could lead towards bias in the research and diminish the scientific value of the research. Therefore, selection of pertinent documents is a major part of the research process (Merriam, 2009:151). An alternative method to select the documents was needed to gain insight into the experiences of people in the field (Hemingway, 2009).

A mixed-method systematic literature review ensured the authenticity and accuracy of the document selection process (Figure 2.1) (Briner & Denyer, 2010b:9). It is a structured technique to holistically identify, evaluate and interpret all valid (qualitative, quantitative or mixed-method) research which relates to the research phenomenon. When there is an extended range of research on a particular subject, a researcher will use this mode of literature selection to direct the process (Petticrew & Roberts, 2006:19-21). I chose the mixed-method systematic literature review as method as I aimed for findings rich in detail on different contexts to provide a holistic picture of the experiences of the participants and PD opportunities (Maxwell, 2005:177). Systematic literature differs from traditional narrative methods of randomly selecting appropriate literature as the approach can be repeated, is of scientific value, and is transparent (Cronin *et al.*, 2008:38). When the researcher reports on the results, there is a clear structure to appraise, summarize, and communicate the findings and suggestions without vast quantities of data and a variation of results (Briner & Denyer, 2010b:11; Petticrew & Roberts, 2006:9-10; Tranfield *et al.*, 2003:208).

2.4.1 Mixed-method Systematic Literature Review

Conducting a mixed-method systematic literature review for this research guaranteed the same level of rigorousness to reviewing research evidence in the first place (Hemingway, 2009). Furthermore systematic literature reviewing can identify the gaps in the existing research and provide a framework to direct the research (Kitchenham, 2004:2). Systematic reviews present the maximum range of evidence, and the expert authors search for high quality studies to address the research question (Barratt, 2009). During this qualitative approach to mixed-method systematic literature review “people converse, announce positions, argue with a wide range of eloquence, and describe events or scenes

in ways entirely comparable to what is seen and heard during fieldwork" (Merriam, 2009:150). I selected documents through a stringent process of selecting expert authors in the field of PD of Mathematics teachers for the pedagogical use of ICT in ODL as well as all the policy documents which relate to the integration of ICT in South African schools.

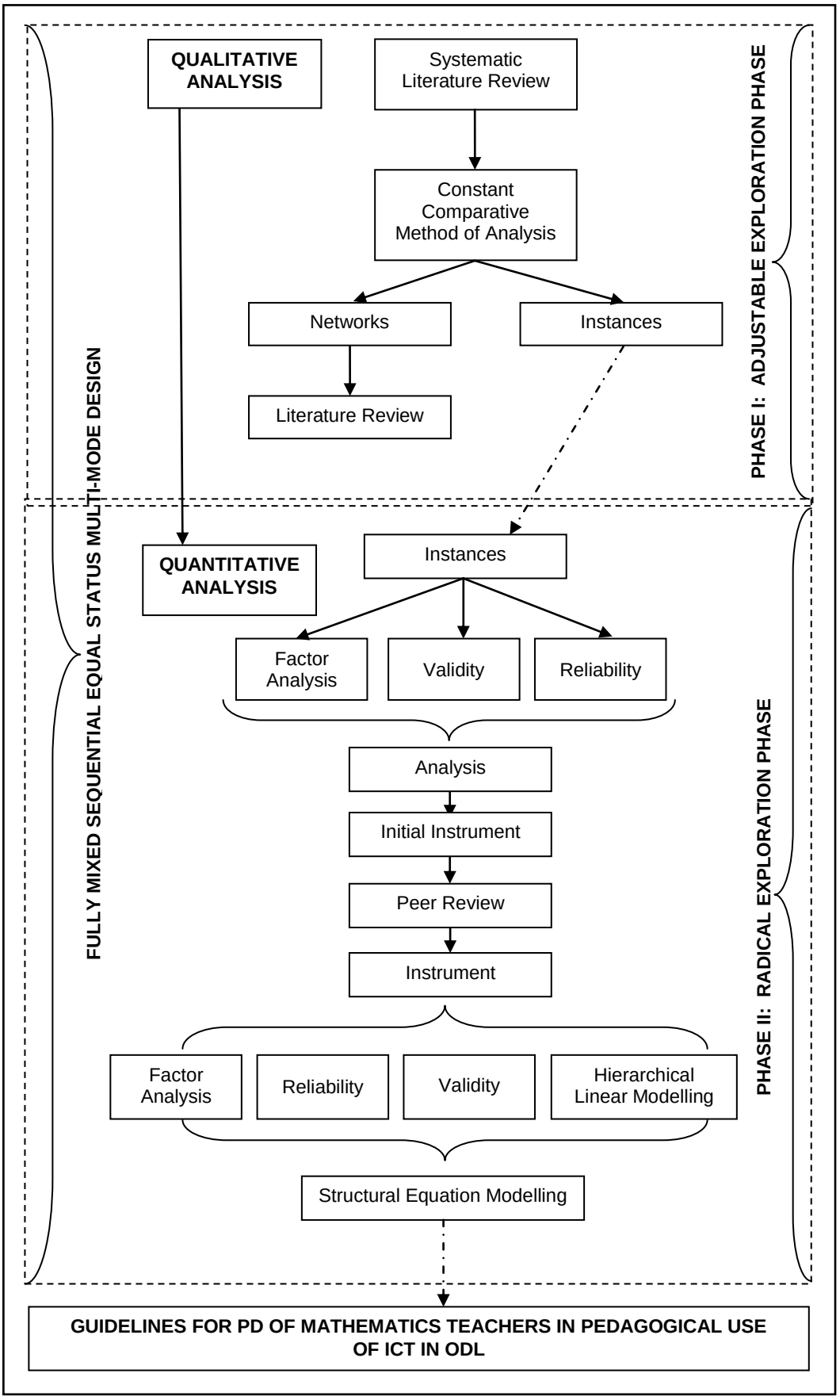

Figure 2.2: Fully Mixed Sequential Equal Status Multi-mode Design (Adapted from Leech and Onwuegbuzie (2007:271))

The rationale for selecting documents of expert authors and evidence-based policies according to a mixed-method systematic literature review process for this research served multiple purposes: (i) it allowed me to incorporate diverse theoretical stances of viewing a problem to strengthen the processes and outcomes of the analysis (Merriam, 2009:154), (ii) it provided access to analysed and synthesized qualitative data which enabled me to write a comprehensive literature review on the phenomena and (iii) it enabled me to export the values of quantitized qualitative data (Saldańa, 2011:49; Tashakkori & Teddlie, 2003:9) as author's instances and quantized to conduct an exploratory factor analysis to construct the activity systems for the research; and (iv) it allowed me to use the constructs to develop a questionnaire to distribute to Mathematics teachers in the senior phase (grades 7-9) in an educational province in South Africa to develop the guidelines for PD of Mathematics teachers for the pedagogical use of ICT in ODL (Burrell & Morgan, 1979:34; Cohen *et al.*, 2011:256).

There are six key steps in conducting a mixed-method systematic literature. Table 2.3 outlines the keys steps and activities which I used during the mixed-method systematic literature.

Table 2.2 Six Key Steps in Conducting a Systematic Literature Review *

Key steps	Activities during key steps
1. Mapping the field through a scoping review	• Prepare a review plan with methods and the protocol for the systematic review • Compile a list of appropriate key words (Jesson *et al.*, 2011:108)
2. Comprehensive research	• Access the electronic databases and search using exact keywords relating to the research and document the process • Refine the research. If the same author names keep appearing, author saturation occurs
3. Quality assessment	• Read all the documents, and apply the quality assessment using the hierarchy of research (Jesson *et al.*, 2011:108) • Assess documents by additional independent reviewers (peers in the field) • Calculate results according to a Cohen's Kappa procedure to determine the agreement of documents for inclusion (Wood, 2007:2)
4. Qualitative content analysis	• Conduct a constant comparative content analysis (Boeije, 2002:391)
5. Synthesis	• Phase I: the data from the Atlas.ti™ will be compiled as a single network, as well as sub-networks for use during the formal literature study (Jesson et al., 2011:108) • Phase II: individual authors' values exported into a Microsoft Excel™ spread sheet as instances, indicating the frequency of codes associated with each author
6. Reporting	• Use the quotations, codes, categories and themes (Atlas.ti™ networks) as a basis for writing a balanced, objective and complete literature from the systematic review format (Cronin *et al.*, 2008:40; Jesson *et al.*, 2011:108)

2.4.1.1 Process and Documentation for a Systematic Literature Review

The mixed-method systematic review conducted was based on a set of three principles: (i) the process should be able to recur at any given time; (ii) there should be a documented assessment trail of the standardized selection process and reviewers' decisions; and (iii) the researcher must have a record of assessment for exclusion and inclusion of documents according to a hierarchy of research (Briner, 2010).

As this process was evidence-based, the qualitative data adhered to the criteria of validity, reliability, trustworthiness (Cohen *et al.*, 2011:181) and thus minimized bias (Briner, 2010; Kitchenham, 2004:2). To adhere to this criterion, I documented the process with the following: (i) search process documentation, (ii) selection process criteria documentation, and (iii) quality assessment of primary documents.

I conducted a mixed-method systematic literature search using the following keywords: *Continuous Professional Teacher Development*, *Mathematics in education*, *ICT in education*, and *Open Distance Learning*. I performed numerous trial searches using a combination of search terms relating to the research question in consultation with three librarians (Kitchenham, 2004) of the Faculties of Natural Sciences, Health Sciences, and Education Sciences at the Potchefstroom Campus of the North-West University in South Africa, who respectively assisted me during the complex searches of criterion-based literature selection. This method of conducting literature is a standard practice in Natural Sciences and Health Sciences and these two librarians assist many students in their respective fields to conduct this process. Little evidence of the use of systematic literature review as research strategy is found in Education.

I searched the following databases: Scopus, ISI Web of Knowledge™, Proquest™, EbscoHost™, LexusNexus™, Sabinet Online™, SAePublications™, RefWorks™, ScienceDirect™ and the North-West University online library catalogue. Additionally, I searched in print sources and conducted hand searching for additional relevant sources.

2.4.1.2 Search Process Documentation

It was imperative that the whole process of the mixed-method systematic review be documented in detail to ensure that the rigorous procedure can be repeated at any given time by an independent researcher (Briner & Denyer, 2010a:11). All searches during the course of conducting the mixed-method systematic review were noted and justified (Kitchenham, 2004:9).

My research diary reflects on the research documentation process of the search process (Addendum 2.1). Each search was numbered, dated, and the databases with their respective keywords and the number of hits were documented. Documents relevant to the research were then selected from the hits according to the selection process criteria. In total, I conducted 20 searches independently and in collaboration with the librarians.

2.4.1.3 Selection Process Criteria Documentation

All the above mentioned electronic databases were accessed and searched using exact keywords relating to the research. The searches were conducted structuring the keywords with bullions i.e.,

[(teacher* or educator*) and (educat* or learn* or develop*) and math* and (ict or "educational technol*" or odl)]. Depending on the hits, the search was refined. Documents relevant to the keywords were screened, selected and exported in a Microsoft Excel™ spread sheet (Addendum 2.2). In ISI Web of knowledge™ the citations maps from the retrieved documents were used to identify more authors in the field and the references list of the exported documents in the Microsoft Excel™ spread sheet were consulted for additional authors in the specialized fields. As this research included four main concepts: (i) professional development, (ii) Mathematics education, (iii) the pedagogical use of ICT, and (iv) open distance learning, expert authors which conducted research in all these fields were complicated to find. João Pedro da Ponte emerged as an expert author working extensively in research relating to PD of Mathematics teachers in the pedagogical use of ICT in ODL. Two of his documents were included for analysis.

2.4.1.4 Quality Assessment of Primary Documents

I systematically studied all the documents and applied the quality assessment using the hierarchy of research. Documents were assessed by additional independent reviewers (peers in the field). Criteria for final selection of documents determine that the:

- documents included could be of quantitative, qualitative and mixed-method research
- documents had to be published in books, accredited journals and conference proceedings
- documents included had to have been published between 2000 and 2012 as reform in the curriculum in South Africa were implemented during this period, i.e. Revised National Curriculum Statement grade (R-9) (Department of Education, 2002b) and the White Paper on e-Education (Department of Education, 2004b) were introduced
- documents had to address four, three or at least two of the key concepts of the research
- documents which addressed two key aspects had to include valuable information on the research topic
- government policy documents relevant to ICT integration and the curriculum had to be included (Jesson *et al.*, 2011:9).

Figure 2.2 presents the mixed-method systematic flow diagram of the document selection process. The first selection for the review process included 97 documents (Addendum 2.2): 97 journal articles published in local and international accredited journal, conference proceedings, reports, as well as four policy documents addressing the concepts of the research problem. After the assessment of the documents according to the above mentioned criteria, 61 documents were excluded. Forty documents were selected for detailed screening (Addendum 2.3) and after the process 32 formed the basis of the next screening process. Due to quality imperfections, eight documents were excluded and 23 documents comprised the data for qualitative analysis (Addendum 2.4) (Hemingway, 2009).

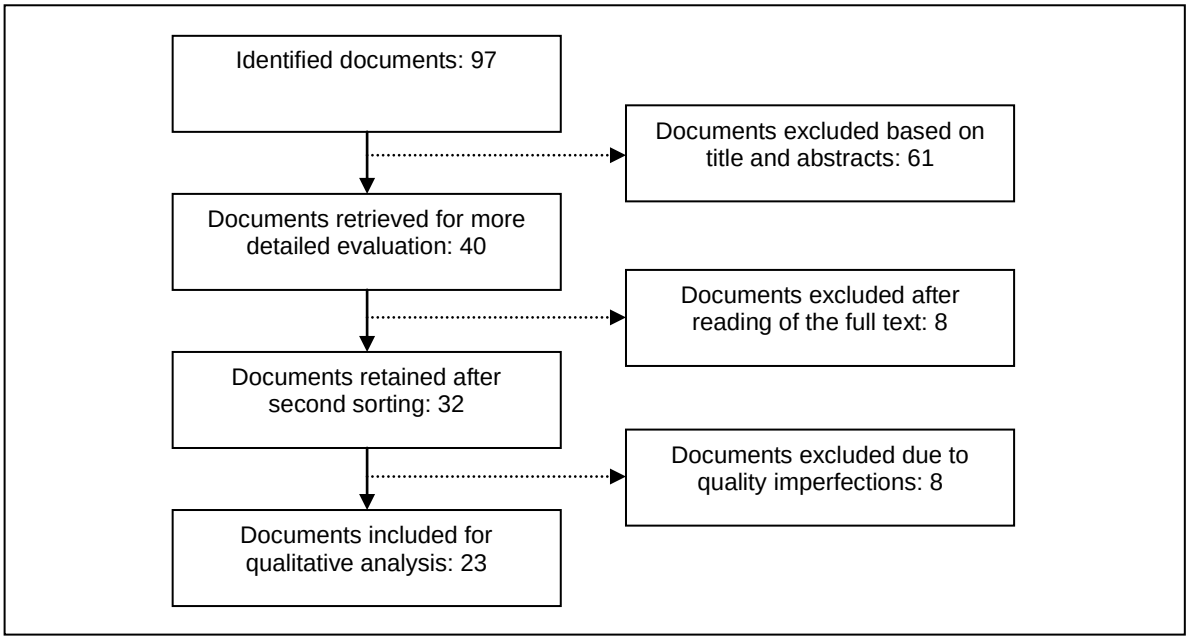

Figure 2.3: Mixed-method Systematic Review Flow Diagram of Document Selection Process

After the reviewing process, the results were calculated according to a Cohen's Kappa procedure to determine the agreement of documents for inclusion (Wood, 2007). A Kappa can range from -1.0 to +1.0, where a Kappa of 1.0 means that two reviewers show perfect agreement, a Kappa of -1.0 indicates that they show perfect and consistent disagreement, and a Kappa of 0 means that the two reviewers show a random level of agreement or disagreement (Wood, 2007). In collaboration with my promoters and an independent peer, I reassessed the documents according to the criteria for exclusion and inclusion (Kitchenham, 2004:10). A Kappa, with the value of 1.0 indicated consistent agreement (Addendum 2.5).

2.5 Data Analysis

After the reviewing process of the documents according to a constant comparative content analysis (Boeije, 2002:391; Saldaña, 2011:23) with a qualitative analysis computer data analysis system (QACDAS)—Atlas.ti™—on the integrated dataset comprising 23 selected documents from the mixed-method systematic literature (Figure 2.1). Atlas.ti™ assisted me to identify data clusters (codes, categories and themes) pertaining to professional development of Mathematics teachers in the pedagogical use of ICT in ODL (Jesson *et al.*, 2011:108). Table 2.4 provides a description of the terminology and functions of Atlas.ti™.

Table 2.3 Terminology and Functions of Atlas.ti™ *

Terminology	Description
Hermeneutic Unit (HU)	• Core of Atlas.ti™ • HU is the workbench for inductive analysis • HU store primary documents • Assign text, graphics, pictures etc. to the HU for inductive analysis
Primary document	• Interface between the HU and the data • Gives access to the data source
Theme	• Outcome after coding, categorizing, and reflecting of analytical process
Code	• A word or short phrase which describes a selection of words or visual data • Standard code is directly linked to the quotations
Memo	• Gives a holistic description or definition of the code • Assists to capture thoughts regarding the text
Category	• Emerging patterns of codes with same attributes
Network view	• Ocular illustration of how codes, categories and themes connect
Quotation	• A section of text from a primary document
Sub-category	• A cluster of codes with a mutual strand • Has the same function as the code family
Super code	• Numerous codes combined

* Adapted from McMillan and Schumacher (2001:476); Saldaña (2011:3-13)

Qualitative data analysis is an eclectic process solely dependent on the creative and intellectual involvement of the researchers to build a theory (McMillan & Schumacher, 2001:462). I analysed the qualitative data inductively with the aim of exploring and organizing the data into categories and identifying patterns (Leech & Onwuegbuzie, 2007). Inductive analysis is a conceptual synthesis of the data whereby the category and patterns materialize from the data without a pre-determined structure (McMillan & Schumacher, 2001:462). During the inductive data analysis I systematically made sense of the data through selecting, categorizing, comparing, synthesizing and interpreting the data based on Engeström's third generation activity theory (§ 1.3.1.5) (Engeström, 2000:960; McMillan & Schumacher, 2001:462; Neuman, 2011:201). Figure 2.3 provides an illustration of the steps during the inductive analysis with of Atlas.ti™.

There are six essential interactive steps conducting the inductive analysis with Atlas.ti™. I applied these procedures interactively and not sequentially (Figure 2.3 next page):

- **Opening a Hermeneutic Unit**. I named my HU *Guidelines for the Professional Development of Mathematics teachers for the pedagogical use of ICT in ODL* which is the title of this study.
- **Assigning of primary documents.** I systematically selected 23 documents to assign to my HU which included: *twelve* journal articles, *four* policy documents, *two* reports, *three* book sections, *one* conference paper, and *one* guideline (Addendum 2.4).
- **Discovering relevant passages.** I selected those parts of the text which are relevant to the four main components of the research: professional development, pedagogical use of ICT, Mathematics teaching and learning, and open distance learning.

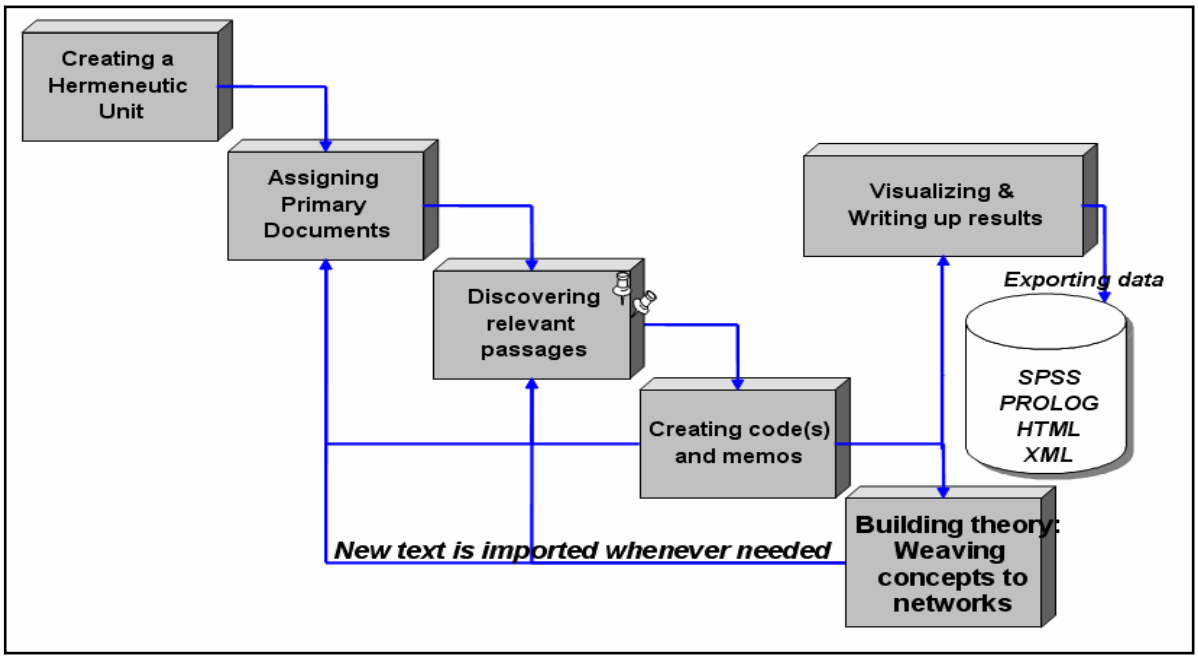

Figure 2.4: The Atlas.ti™ Workflow (ATLAS.ti, 2004)

- **Creating codes and memos.** The key concepts in the research and the text of the primary documents guided me to create codes. I did not have pre-determined codes even though I used the components of Engeström's activity theory as a background of the aspects which can influence the implementation of ICT in the teaching and learning of Mathematics. As the codes materialised I created the memos to define the meanings of the codes within the context of the study. I applied my own subjectivity, ideas, and predispositions to the analytical process (Saldaña, 2011:7). With the assistance of a peer in the field and my promoters, I determined the selection criteria for documents for the peer coding: (i) one document of research done in the South African context; (ii) one document had to address two of the main concepts; (iii) one document had to concentrate on three of the main concepts; and (iv) one documents had to deal with all the main concepts of the research. All the documents included for peer coding, except the policy document (Addendum 2.5), were published between 2009 and 2011 which gives an indication of the recent research done relating to the research topic. The rationale for including the White Paper on e-Education (Department of Education, 2004b) as this policy document is fundamental in the research process, and a major part of the research was conceptualized around the policy aims and shortcomings of ICT integration. The title, aim and focus, and rationale for the selection of documents for peer coding are summarized (Addendum 2.6). During peer coding no new codes emerged and the disagreements were re-coded or a consensus was reached. Four themes, six categories, 59 codes, and 1551 quotations were conceptualized during the qualitative constant comparative analysis (Figure 2.4).
- **Building theory.** Engeström's` activity theory was used as conceptual tool to analyse the data and to comprehend Mathematics teachers' learning conditions in their natural settings (Yamagata-Lynch, 2010b). I applied the basic activity theory lens of the activity system, with the integrating components: object, subject, tools, rules, community, and division of labour as the analytical tool

for the coding process. The qualitative data were subjected to (i) qualitative and (ii) quantitative data analysis techniques (Figure 2.1) (Tashakkori & Teddlie, 2003:24). The findings from the qualitative analysis (Jesson *et al.*, 2011:24) formed the basis of a comprehensive and balanced literature review on the PD of Mathematics teachers in the pedagogical use of ICT in ODL (Phase I) (Figure 2.1). The code counts of the analysis were exported from Atlas.ti™ to a Microsoft Excel™ file (Addendum 2.7) for further analysis (Cohen et al., 2011:306). Table 2.5 provides the pattern matrix of the exploratory factor analysis of the code counts of the qualitative data (Addendum 2.8).

- **Visualising and reporting of results.** I created visual maps of the four activity systems (Addendum 2.9). The components: object, subject, tools, rules, community, and division of labour represent categories and each cluster of factors (sub-codes) was arranged through an inductive process under the applicable categories (object, subject, tools, rules, community, and division of labour). These visual maps (Atlas.ti™ networks) with the themes, categories and codes formed the structure for compiling a literature review (Chapter Three) (Jesso*n et al.*, 2011:108).

All factor loadings less than 0.3 were not considered important in practice and removed from the table. The variables which had more than one factor loading were grouped according to the highest factor loading. The majority of the factors show a factor loading of higher than 0.5 (Table 2.4). The Barlett's test of sphericity test shows a significance of $p<0.00$ for this factor analysis (Cohen et al., 2011:676). During the exploratory factor analysis (Phase II) (Figure 2.1) (Addendum 2.8) the variables were clustered into homogeneous groups. The factor analysis clustered four factors that I used to construct four activity systems: *governance*, *school environment*, *open distance learning* and *professional development* (Garrett-Mayer, 2006a). I inductively analysed the text in each code and placed it within the six interrelated components of the activity system. The codes of each cluster of factors Figure 2.4 provides the structure and code density of the Guidelines for the Professional Development of Mathematics for the pedagogical use of ICT in ODL (page 40).

Table 2.4 Pattern Matrix of Factors

Variables	Component			
	Factor 1	Factor 2	Factor3	Factor4
PD model/framework	0.959			
PD concerns	0.917			
Barriers to ICT	0.902			
School leadership role in PD	0.896			
Teacher barriers in ODL	0.887			
Recommendations for PD	0.853			
Influences PD	0.832			
PD strategies	0.785			0.368
PD through ODL	0.761			
Policy challenges	0.750		0.540	
Influence of policy on teachers	0.742			
Enablers	0.735			
Role of teacher	0.730	-0.336		
Teaching and learning environment	0.701			
Environmental barriers	0.697			
ICT integration priorities	0.696			
Role of teacher in PD	0.596			

Variables	Component			
	Factor 1	Factor 2	Factor3	Factor4
Environmental barriers in ODL	0.578	-0.526		
Responsibility towards PD	0.561			
PCK	0.554			
Teacher expectations for PD	0.495			
PD characteristics	0.469			
PD process	0.364			
TK		-0.973		
CK		-0.935		
PK		-0.910		
Positive experiences ICT		-0.858		
Contributors to SPD	0.386	-0.858		
Feedback on PD courses		-0.798		
Objectives of PD		-0.777		
PD course outline		-0.755		
ICT and SPD		-0.742		
ICT contributors to teaching and learning		-0.562	0.408	
PD course activities and data collection		-0.532		0.494
PD instruments		-0.458		
Policy initiatives			0.978	
Resources and funding			0.969	
Value of ICT at managerial level			0.965	
Responsibility: teaching and learning			0.965	
Responsibility of DoE			0.942	
Objectives			0.917	
Responsibility: management			0.862	
Value of ICT		-0.358	0.826	
ICT initiative concerns			0.615	
School leaders' role in ICT			0.401	
Teacher and teacher-students' experiences				0.936
Individual and social identity				0.888
PD and social identity				0.871
Value of ODL				0.832
ODL and SPD		-0.409		0.799
ODL barriers	0.483			0.725
Building a SPI		-0.453		0.710
Effect on ODL on Mathematics teachers		-0.509		0.698
Role of teacher in ODL				0.645
Teacher barriers in ODL	0.506			0.543
Aspects influences ODL	0.353			0.449
ODL technologies				0.448

Factor 1=Professional Development
Factor 2=School Environment
Factor 3=Governance
Factor 4=Open Distance Learning

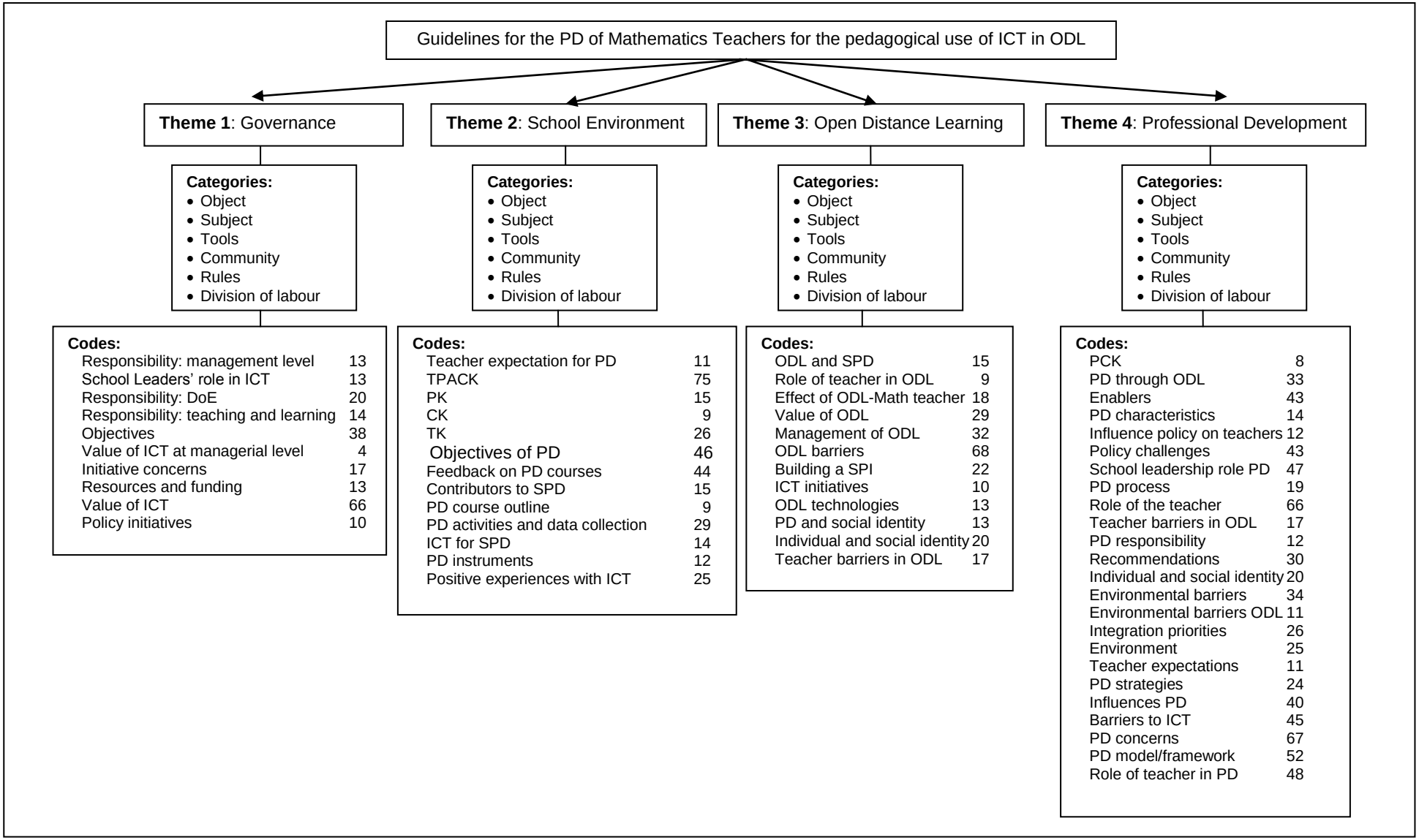

Figure 2.5: Structure and Code Density of the Guidelines for the Professional Development of Mathematics Teachers in the Pedagogical use of ICT in ODL

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2.6 Role of the Researcher

Merriam (2009:124-125) describes four roles that a qualitative research could assume: complete participant, participant as observer, observer as participant, and complete observer. During this phase of the research, I assumed the role of complete observer as the researcher is hidden from the participants (authors from systematically selected articles) (McMillan & Schumacher, 2001:435; Merriam, 2009:124-125). During constant comparative data analysis, my role comprised two duties: (i) I conducted the systematic literature review process with the assistance of the librarians, and (ii) I analysed the documents of the systematically selected authors in collaboration with an independent assessor (peer) for verification. After the exploratory factor analysis I inductively analysed the content of the codes to fit within the applicable super codes.

2.7 Trustworthiness in Qualitative Research

Trustworthiness in qualitative research highly depends on the credibility of the researcher as the person to uphold a high standard of ethics in the process (Merriam, 2009:235). Silverman (2006:281) discusses *credibility* of qualitative data which include two central concepts to evaluate qualitative data namely validity and reliability. Credibility is the confirmation of whether the findings of the qualitative research are authentic, transferable, and pertain to the context of the research (Bapir Ali, 2009; Guba & Lincoln, 1994:213; Merriam, 2009).

2.7.1 Validity in Qualitative Research

Validity in social sciences is a disputed term as each researcher understand the concept from their point of orientation and they derive their own meaning within the context of the research (Bapir Ali, 2009). Sarantakos (2005:76) states that validity in qualitative research has a *methodological element*: the method to determine validity of qualitative data would not apply to validity of quantitative data. Qualitative validity is when the researcher conducts research in a proficient, precise and, systematic manner and it is transparent to gain social acceptable knowledge (Bapir Ali, 2009:9,16). Validity is a goal rather than a product and should not be taken for granted. Maxwell (1992:149) and Misher (1990) testify that the term validity within qualitative research tends too much towards the positivist paradigm (objectivism) and *understanding* is a more applicable term to use in qualitative research. Validity in qualitative research assigns meaning to the events and not to the data (Cohen *et al.*, 2011:181). The fundamental principles of validity in qualitative research are: *credibility*, *transferability*, *dependability*, and *confirmability* (Cohen *et al.*, 2011:181). There are five types of validity in qualitative data: descriptive, interpretive, theoretical, generalizable, and evaluative (Maxwell, 1992:149). *Descriptive validity* refers to the truth of the events which is not twisted. *Interpretive validity* is when the research is able to grasp the significance, interpretations, conditions, and purpose of the activities. *Theoretical validity* relate to the theory building within the research process, and how the research explain the phenomenon. *Generalizable validity (generalizability)* refers to the commonalities within a

specific group, community, or situation (internal validity), and within the broader community, or other situations (external validity). *Evaluative* validity is to take a stance towards the phenomenon being researched. There are numerous steps the researcher can take to ensure validity in qualitative research: collect plentiful data; identify the key aspects in the research; feedback from the participants; focus on the finer details during data collection; verify that there is a good representation of participants; check for researcher bias; make comparisons between the participating groups and findings; and seek patterns between the findings and the literature (McMillan & Schumacher, 2001:407; Onwuegbuzie & Leech, 2006:236; Teddlie & Tashakkori, 2009:24). However, most researchers agree that *internal validity* and *triangulation* are two important validity strategies in qualitative research (Cohen *et al.*, 2011:195; McMillan & Schumacher, 2001:407; Merriam, 2009:229; Sarantakos, 2005:76-77; Silverman, 2006:439). Fundamentally, to determine whether the data collection process in qualitative research is valid, depends on the data collection, data interpretation techniques and analysis methods of the specific research (McMillan & Schumacher, 2001:407; Onwuegbuzie & Leech, 2006:234). Table 2.6 provides the strategies applied to guarantee the validity of the document analysis of this research.

Table 2.5 Strategies for Validity of the Document Analysis

Strategy	Description
Systematise the data	I conducted an analytical induction through a constant comparative method with Atlas.ti™ (Maxwell, 1992:153; Merriam, 2009:205-206; Silverman, 2006:439)
Audit trail	I documented each step of the mixed-method systematic process and have written evidence of the data analysis process (Merriam, 2009:223)
Assessment criteria for documents	Criteria for exclusion and inclusion of documents was pre-determined independent peers (Briner, 2010:11)
Authenticity of documents	All the documents were published in accredited journals, conference proceedings, in book chapters, as well as policy documents
Peer coding	Five of the documents were peer coded by a lecturer in the research field
Time frame	All the documents selected for inclusion were from between 2000 and 2012 to assess the changes in policies and practice within this time frame
Triangulation	Both qualitative, quantitative, and mixed-method documents were selected for the document analysis (McMillan & Schumacher, 2001:409; Merriam, 2009:229; Sarantakos, 2005:76-77)
Maximum variation	A diverse selection of documents (23 of which four relate to policy) was used (Merriam, 2009:229)

2.7.2 Reliability in Qualitative Research

In the social sciences *reliability* is regularly used to determine whether the procedures used within the context of the research are consistent and if there is a strong link between the method, the concept and the context (Bryman, 2008:33). *Reliability* as validity also has a *methodological element* as reliability in qualitative research differs from reliability in quantitative research (Bapir Ali, 2009:12). Reliability should be distinct to the context of the qualitative research as it is a complicated aspect of the research, particularly in social sciences (Merriam, 2009:221). In qualitative research it is common that people disagree on the aspect of reliability as there are a variety of qualitative research methods (observations, interviews or an document analysis) and each one is unique (Bapir Ali, 2009:13;

Neuman, 2003:170-171). Reliability is the "consistency and dependability" to capture qualitative data (Neuman, 2003). Silverman (2006:288) and Neuman (2003:171) states that reliability is guaranteed when the research is conducted in a *systematic and transparent* method and the reader has access to the data. Researchers feel that the concept of reliability is misguided in qualitative research and *coherence, openness, and discourse* apply more to the context of qualitative research. Coherence is the level of goal acquisition, openness is the versatility of methods for data collection, and discourse is the flexibility of data interpretation and discussion (Bogumil & Immerfall, 1985:71). Reliability is also known as *dependability* (will the data be relevant at all times) and *confirmability* (idea of values to influence the standard) of the research (Sarantakos, 2005:87-88). Many researchers, however, use the terms *internal reliability* and *external reliability* in qualitative research. Internal reliability is when research is being conducted and more than one observer (*parallel reliability*) at different times (*stability of observation*) agree on the findings; external reliability is when the research process can be repeated and the same results will be achieved (Lecompte & Goets, 1982:31). To ensure reliability the researcher has to file all the notes of the data collection process; collect tapes and transcripts of the procedure; allow external evaluators and peers (*inter-rater reliability*) access to the data (Bapir Ali, 2009:17; Silverman, 2006:280,288).

For this research I documented the systematic literature procedure to show that the process was systematic, it was transparent for others to duplicate, and it was consistent with the data collected (Bapir Ali, 2009:17; Merriam, 2009:221). Qualitative research does not require the verification of the data analysis procedure with coding consistency (Merriam, 2009:222), but for my satisfaction, after the peer coding I calculated a Cohen's Kappa for intra-rater reliability which was 1.0 (Randolph, 2008). Table 2.7 provides the strategies I used to ensure the reliability of the research procedure.

Table 2.6 Strategies for Reliability of Document Analysis

Strategy	Description
Role of the researcher	• I took the role as an observer as I was hidden from the process • I documented the whole systematic process for any researcher and any reader to duplicate
Document selection	• I used a scientific procedure to select the document of expert authors in the combined field of: professional development, ICT, Mathematics teaching, and ODL
Inter-rater reliability	• A peer in the field of ODL and Mathematics education and I peer-coded, after my inductive analysis, five of the primary documents to see if the codes were consistent with my analysis • I calculated a Cohen's Kappa
Code-recode strategy	• I coded the documents and repeated the coding process before the peer coding sessions which were done over a period of three consecutive days
Audit trail	• A peer authenticated the findings from the document analysis following the same inductive process

2.8 Ethical Considerations in Qualitative Research

The validity and the reliability of the qualitative research depend on the ethics of the researcher. Researchers should be aware that the ethical issues of any research are pervasive and intricate. Information obtained during research should not be used at the expense of others. Credibility of the

researcher include *intellectual rigour, professional integrity, and methodological competence* (Patton, 2002:570). There are two basic categories of ethical responsibility researchers have to adhere to: responsibility to those who participate in a project; and the responsibility to the discipline of science to be accurate and honest in the reporting of their research (Strydom, 2005:56-69). During the qualitative research (Phase I) of this study the following measures were taken to ensure the credibility of the research:

- The documents of the mixed-method systematic literature are in public domain and I acknowledged the authors in the customary fashion
- None of the documents selected in the process contained information that could harm any person
- The stringent scientific method of document selection ensured that researcher bias is not an issue
- I conducted the mixed-method systematic literature review with integrity
- I acknowledged the expert authors in all the documentation of the process
- A literature review in Chapter three reports on the findings with accuracy, objectivity, clarity, unambiguously, and includes all the critical information of the inductive analytical process (Merriam, 2009:229-233).

2.9 Limitations of the Mixed-method Systematic Literature Review

There are some limitations to using a systematic literature review: it is a complex process to conduct especially if the researcher is an undergraduate researcher; it is an expensive and intensive process which can take many hours to perform; it is a rigorous process which involves more than one person to screen and access the quality of the documents; it is reliant on access to electronic databases; it limits the researcher to published, peer-reviewed and documents published in the public domain; and it can also lead to researcher bias if certain strategies are not in place to prevent this from occurring (Briner & Denyer, 2010b:8; Hemingway, 2009; Petticrew & Roberts, 2006:103). Even though this process has limitations it was the appropriate method to apply within the context of this research as I did not have access to experts in the field to interview on the phenomenon.

2.10 Summary of the Chapter

This chapter explicated the qualitative phase of this research. It also explained the appropriate theoretical positioning and assumptions of this complex research, and the rationale for the fully-mixed sequential equal status multi-mode research design. This chapter also gave an in depth description of the systematic literature review process and the qualitative data analysis strategies with ATLAS.ti™ to build a theory. Furthermore it explained the role of the researcher and the trustworthiness of the qualitative data. The ethical considerations were also taken into account. In addition, it clarified the limitations of the qualitative phase of the study. Chapter Three presents the culminant retrospect of the systematic literature probe.