Chapter Four

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

4.1 Introduction

Chapter Four describes the research design and methodology of Phase II of the research (Figure 2.2). It explicates the rationale for using a questionnaire to conduct the quantitative phase of the research. Furthermore it explains the use of the descriptive statistics, factor analysis, hierarchical linear modelling, and the SEM for the data analysis of the questionnaire. It provides a detailed description of statistical procedures to ensure the validity and reliability of the findings, the ethical aspects relating to the research, as well as the limitations of the research.

4.2 Worldview of the Research

The researcher's theoretical framework is affects the exact nature of the research. As explained in Chapter Two (§ 2.2), research of sociological nature is rooted in four paradigms. Researchers in these four paradigms assume either sociologies of regulation or radical change (Burrell & Morgan, 1979). This research advocates two sets of dimensions which contribute towards two paradigms each with a unique social-scientific reality of viewing the world. Chapter Two (§ 2.2.3) explains the two paradigms of this complex research and how the researcher crossed intellectually from the interpretivist to structuralist paradigm to answer the research question.

4.2.1 Ontology

Ontology describes the concept of reality and how people view reality (Blaikie, 2007:7). Chapter Two (§ 2.2.1) provides an extended description of the concept of ontology. The ontology of structuralist paradigm highlights the rigid and actual nature of reality which exists outside the human mind (Mertens, 2010:7). Research in this paradigm is objective, goal-orientated, and visualised, and the researcher uses quantitative measures to define meaning (Mack, 2010:7).

4.2.2 Epistemology

Epistemology deals with the theory of knowledge and the pathways people choose in their environment to obtain knowledge (Blaikie, 2007:19; Merriam, 2009:8). Chapter Two (§ 2.2.2) provides a holistic explanation of the concept of epistemology. Structuralists believe they can acquire knowledge as an objective observer of the research phenomena. Researchers in the structuralist paradigm remain independent of the research, follow a structured method to obtain information, and do not allow their personal biases to influence the outcomes of the research (Mertens, 2010:15). Structuralists aim to know the world they live in, change the world, identify the structures in society, and analyse the structures in society (Mack, 2010:7; McMillan & Schumacher, 2001:15). Table 4.1 provides an outline of the ontological and epistemological assumptions of the structuralist paradigm.

Table 4.1 Ontological and Epistemological Assumptions of the Structuralist Paradigm *

Ontological Assumptions	Epistemological Assumptions
Social facts with one single reality	Knowledge of their existing world
Reality is external from the human	Knowledge how to change their world
Reality is visualised	Knowledge to identify the structures in society
Reality is goal-orientated	Knowledge to analyse the structures of society

* Adapted from Mack (2010:7); McMillan and Schumacher (2001:15)

4.2.3 Research Paradigms

Chapter Two (Figure 2.1) provides the model of sociological paradigms for this research. Phase I of the research was rooted in the interpretivist paradigm (Figure 2.1) which advocates sociology of regulation from a subjective stance. The complex nature of the research required further knowledge which was essential to address the research question. The interpretivist paradigm could not satisfactorily address the question relating to the phenomenon. The parameters of the paradigm shifted from the interpretivist paradigm to the structuralist paradigm to address the second phase (Phase II) of the research. (Cohen et al., 2011:5) compile the guidelines for the PD of Mathematics teachers for the pedagogical use of ICT in ODL.

4.2.4 Phase II: Radical Structuralist Phase

The *radical structuralist* paradigm presupposes that science provides the clearest possible ideal of knowledge and that it can explain human behaviour. Structuralists are by nature *realist*, *positivist*, *determinist*, and *nomothetic*. Their assumptions contradict those of the interpretivist, but have some similarities with the functionalist paradigm (§ 2.2.3). Radical structuralists advocate sociology of radical change form an objective stance. They assume that through disagreement and transformation humans can liberate from the structures of the society in which they live. Theorists from the structuralist paradigm adopt an approach which emphasizes change, built into the very nature and structure of existing society, and they search for explanations of the basic interrelationships within the context of overall social formulation. Structuralists aim not only to know the world in which they live, but to change it; to analyse the structures of society and how they connect; and to identify the elements in society which contradict each other (Burrell & Morgan, 1979:329). Research according to the criteria of this paradigm is conducted from the external which is goal-orientated and independent of people’s beliefs and feelings (Burrell & Morgan, 1979:18-35; Cohen *et al.*, 2011:6-8; McMillan & Schumacher, 2001:15).

4.3 Fully Mixed Sequential Equal Status Multi-Mode Research Design

This research proposed a fully mixed sequential equal status multi-mode research design as the qualitative and quantitative phases occur sequentially and have equal value in the research process (Leech & Onwuegbuzie, 2007:270). Chapter Two (§ 2.3) explained the fully mixed sequential equal status multi-mode research design of this research. Figure 2.2 provides an overview of the research design of this research of complex nature.

4.4 Quantitative Design

The quantitative phase (Phase II) of the study followed an objective, structured, and scientific approach to obtain the data to answer the research question. Quantitative research uses instruments that collect numerical evidence and the results depend profoundly on the quality of the measurement (McMillan & Schumacher, 2001:239). During quantitative research the data are collected via surveys (questionnaires or interviews) and observations (McMillan & Schumacher, 2001:237). Surveys in educational research is the most frequently used method to collect data at a specific point in time, and about the current circumstances of the phenomenon (Cohen *et al.*, 2011:256). A survey can be distributed to a very large population (e.g. Mathematics teachers across South Africa), to a particular group (Mathematics teachers in the Western Cape), or a local case (Mathematics teachers at a single institution). Phase II (Figure 2.2) of the research builds on the experiences and requirements of systematically selected authors (voices of experts) in order to collect variables from a particular population (senior phase, grades 7-9 Mathematics teachers in the WCED) to compile the guidelines for the professional development of Mathematics teachers for the pedagogical use of ICT in ODL.

4.4.1 Quantitative Research Instruments

There are numerous data collection methods to collect quantitative data, but in most cases organisations use surveys to determine the levels of knowledge of their staff, plan intervention programmes, and evaluate the curriculum and current intervention strategies. During surveys trustworthy information can be collected and the researcher can have access to data on many variables (McMillan & Schumacher, 2001:305). Surveys are the methods most widely used in the social sciences to collect data about a target population on a specific phenomenon at a particular point in time (Fowler, 2009:11; Neuman, 2011:308). Surveys are designed with the aim to produce statistics about the target population (Fowler, 2009:11). Surveys generate precise, dependable and valid data, but only if much thought and accurate planning go into the process to select the appropriate questions to address the research question (Neuman, 2011:308). For survey development ,specific preliminary factors should be taken into account: (i) the motivation for the enquiry; (ii) the target population of the research; (iii) the available financial resources to conduct the data collection; and (iv) the data collection strategy (Cohen *et al.*, 2011:257-258).

Survey research includes survey interviews or questionnaires. For this research, the researcher compiled a custom-made questionnaire to be submitted to senior phase (grades 7-9) Mathematics teachers in the eight EMDCs in the Western Cape in order to determine their attitudes, opinions, behaviours, characteristics, and PD requirements for the pedagogical use of ICT in ODL. The compilation of the survey is discussed in detail in § 4.5. The generic features of questionnaires include: (i) collect numerical data on a single data collection strategy over a large geographical area; (ii) include a large target population; (iii) supply explanatory and inferential information, (iv) calculation of frequencies, (v) be able to standardised information as all the participants complete the same questionnaire, (vi) make generalisations, and (vii) detect patterns in the responses of the target population. Surveys can be either exploratory or confirmatory. While c*onfirmatory* relates to when a model is used, or a causal relationship or a hypothesis is tested; *exploratory* relates to statements or models and patterns in the data which are investigated through correlations, factor analysis, regression analysis, or stepwise regression analysis (Cohen *et al.*, 2011:256-257).

This research made use of an exploratory questionnaire as the analysis included descriptive statistics, factors analysis, comparisons between the demographic profile of participants and extracted factors, and a SEM.

4.5 Planning and Design of a Questionnaire

While choosing a suitable questionnaire is a complex process and even more aspects should be taken into consideration when planning and designing a survey (Creswell, 2012:385). Time, the sophistication of the respondents and the type of instrumentation are aspects which should be taken into consideration when planning a questionnaire. The researcher ascertained if there were existing questionnaires which could be used or modified to measure the variables of this study (Creswell, 2012:385; McMillan & Schumacher, 2001:258). The researcher searched the Internet for questionnaire which could be used or adapted, but the majority of Mathematics surveys focused on the achievement of Mathematics learners. As there was no suitable questionnaire available, the researcher embarked on constructing a questionnaire to address the identified aspects of the study as depicted as a network layout (Figure 3.1).

The following section focuses on the intricate process followed during the compilation of the questionnaire for this research. In order to compile the questionnaire, the researcher followed the fourteen stages of questionnaire development as delineated by Cohen *et al.* (2011:259).

4.5.1 Stage One: Aim of the Questionnaire

The aim of a questionnaire was to gather data from many respondents on the same phenomena with the intention of describing the nature of the current circumstances or the relationship which exist between specific events (Cohen *et al.*, 2011:256). The questionnaire measured many variables, and derived patterns in the behaviour, experiences and attitudes of the Mathematics teachers (Creswell, 2012:378; Neuman, 2011:312). The researcher obtained a holistic view of the demographical outline of Mathematics teachers in the WCED and the current PD status and needs of the teachers regarding ICT integration. The fundamental aim of this questionnaire was to have all the necessary information to develop guidelines for the professional development of Mathematics teachers for the pedagogical use of ICT in ODL.

4.5.2 Stage Two: Select the Questionnaire

There are two types of questionnaires: *cross-sectional* (obtain data on present trends, attitudes, and beliefs) and *longitudinal* (collect data on a particular group over an extended period) (Creswell, 2012:379). This research used a cross-sectional questionnaire to gain the opinions of Mathematics teachers about the provision of ICT resources; the ICT trends; the ICT teaching and learning conditions at schools; and their PD needs for ICT integration in teaching and learning. A cross-sectional questionnaire examine the attitudes, beliefs, opinions and practices of the participants (Creswell, 2012:377). As the data collections for Phase II of the research included a single data collection, a cross-sectional survey was a viable method to collect exploratory, descriptive and explanatory data from the participants (Neuman, 2011:44). This type of survey is relatively quick to conduct; moderately economical to administer; and it has a strong probability of participation. The research collected data from a specific group of participants, and made use the inferential statistics (Cohen *et al.*, 2011:273). Mostly, in education the cross-sectional questionnaire provides data for either retrospective or a prospective enquiry (Cohen *et al.*, 2011:267). This survey aimed to combine these methods of enquiry. The researcher aimed to obtain data on the governance of ICT; the ICT resource provision status of schools of different quintiles in the WCED; the extent to which the school environment is conducive for ICT integration; the current practices with ICT within Mathematics classrooms; the PD activities previously initiated and conducted within the WCED; and the PD needs and preferable modes for future PD for Mathematics teachers in ICT integration. These were some of the key aspects of ICT integration identified in the literature probe (§ 3.5.1.6).

4.5.3 Stage Three: Linking with of the Research Question

The rationale for the research question for this study: *What are the guidelines for the PD of Mathematics teachers for the pedagogical use of ICT in ODL?* was explained in § 1.2. Each item within the questionnaire related to specific aspects on governance (§ 3.3), school environment (§ 3.4), ODL (§ 3.5), and PD (§ 3.6) to meet the objectives of the research (McMillan & Schumacher, 2001:258).

4.5.4 Stage Four: Linking with Key Aspects

Four key variables or themes (Governance, School Environment, PD, and ODL) emerged from the inductive and factor analysis (Table 2.5). Each variable (governance and school environment) either represents one section of the questionnaire with multiple sub-questions or two variables (PD and ODL) are grouped into one section with numerous sub-questions (Neuman, 2011:312). Additionally, the analysis required personal information of the teachers and demographical information of the participating schools to be used in comparison (Cohen *et al.*, 2011:25-27).

4.5.5 Stage Five: Clarification of Information to Address Key Aspects

In order to address the key aspects in the research certain categories of questions should be posed. Neuman (2011:309) proposes a list of category questions which is essential in questionnaire: behaviour; attitudes, beliefs, or opinions; characteristic; expectations; self-classification; and knowledge. The researcher formulated all these questions grouped in Parts C, D, E, F and G of the questionnaire according to the identified themes of Governance, School Environment, ODL, and PD (Table 2.5) (Addendum 2.9).

4.5.6 Stage Six: Determine the Target Population

Sampling is an integral part in the survey approach (Cohen *et al.*, 2011:264). Disposable funds available for collecting data, time available for the data collection process, and access to the areas are the aspects which the researcher has to take into consideration at the outset of the research and before samples for participants are selected (Cohen *et al.*, 2011:143). The five key factors which influence sampling are: (i) the sample size; (ii) the representation and restrictions of the sample; (iii) means of contact with the sample; (iv) sample selection strategy; and (v) the research methodology. As soon as these aspects have been addressed, the sample selection can be completed.

The systematic literature review (§3.2.1.3) elucidates various ICT projects in South Africa since the launch of the e-Education Policy (Department of Education, 2004b). The chapter indicated that the Western Cape teachers received substantial ICT training through the Khanya Project (Western Cape Education Department, 2011) therefore the Western Cape defined as a target population. A similar project in the Gauteng Province (Gauteng Online) was less than successful, resulting in more than 500 schools without basic ICT resources and many other schools with inoperative facilities (§3.2.1.5). Recently the Gauteng Department of Education cancelled the project without achieving their aim—the positioning of Gauteng at the cutting edge of change through technological innovation (Blignaut &

Howie, 2009:663; Timse, 2013:1). The Mathematics teachers of the WCED were therefore identified as the target population for this study.

The target population is a specified large group of many subjects from which the researcher draws a sample (Neuman, 2011:246). A sample is a set of units a researcher chooses from the large group and generalises to a particular population (Investopedia, 2013b; Neuman, 2011:240). Sample selection is a critical component of research which is guided by the type of analysis being performed. Sampling in quantitative research is when the researcher selects units and regards them as representatives of the total population. The features of the sample the researcher selected emphasized key elements in a complex social world in order to give clarity, insight, and understanding about the concerns in the social world (Neuman, 2011:241). It was therefore important that the researcher made sampling decisions during the initial planning of the research project (Cohen *et al.*, 2011:143; Neuman, 2011:242).

Five key factors were taken into consideration when the researcher selected the sample: (i) the sample size; (ii) the symbolization and limitation of the sample; (iii) the access to the sample; (iv) the sample strategy to be used; and (v) the type of research that is being conducted. There is no clear cut method to select the appropriate sample (Neuman, 2011:242). Therefore it is an intricate process which depends on: (i) the aim of the study; (ii) the characteristics of the population under study; (iii) the level of accuracy needed form the data; (iv) the response rate estimated from the data collection; (v) the number of variables included in the study; and (vi) the research methodology used for the study (Cohen *et al.*, 2011:144). For quantitative research a larger sample is more appropriate as larger samples contribute towards increased reliability and the use of sophisticated statistical procedures. The researcher applied the eight stages of planning a sample strategy as Cohen et al. (2011:163) describes them. Table 4.2 provides a summary of the planning stages of the sample selection of this research.

Table 4.2 Stages in Sample Selection *

Stages	Activities
1	Identifying of WCED schools as target population
2	Identification of senior phase (grades 7-9) Mathematics teachers as subjects from the population
3	Selection of the sample with the assistance of my co-promoter, a senior statistician
4	Accessing of the EMIS database of the WCED in order to locate the sample schools
5	Identifying the participating schools through systematic random cluster sampling
6	Building in redundancy through oversampling
7	Listing of contact information of participating WCED schools
8	Adjusting the sample according to circumstantial conditions at grassroots

* Adapted from Cohen *et al.* (2011:163)

The WCED is divided into eight education districts: four are rural districts which correspond to one or more district municipalities, while the other four are urban or metro districts located within the City of Cape Town (Table 4.2). Each district has one education management district centre (EMDC) with a district director, a circuit team with a circuit team manager which coordinate the tasks of the curriculum advisors, Special Needs Education (SNE) professionals, Institutional Management and Governance planning (IMG) and a School Governance and Management (SGM) team (Addendum 4.1). Table 4.3 and Figure 4.1 provide information on the districts, and site locations of the eight education districts in the WCED.

Table 4.3 Site Location of the Nine Education Districts in the WCED *

Location	District	EMDC
Urban	Metro Central Education District	Athlone
Urban	Metro East Education District	Kuilsriver
Urban	Metro North Education District	Parow
Urban	Metro South Education District	Mitchell's Plain
Rural	Cape Winelands Education District	Worcester
Rural	Eden & Central Karoo Education District	George
Rural	Overberg Education District	Swellendam
Rural	West Coast Education District	Paarl

* Adapted from the Western Cape Education Department (2013a)

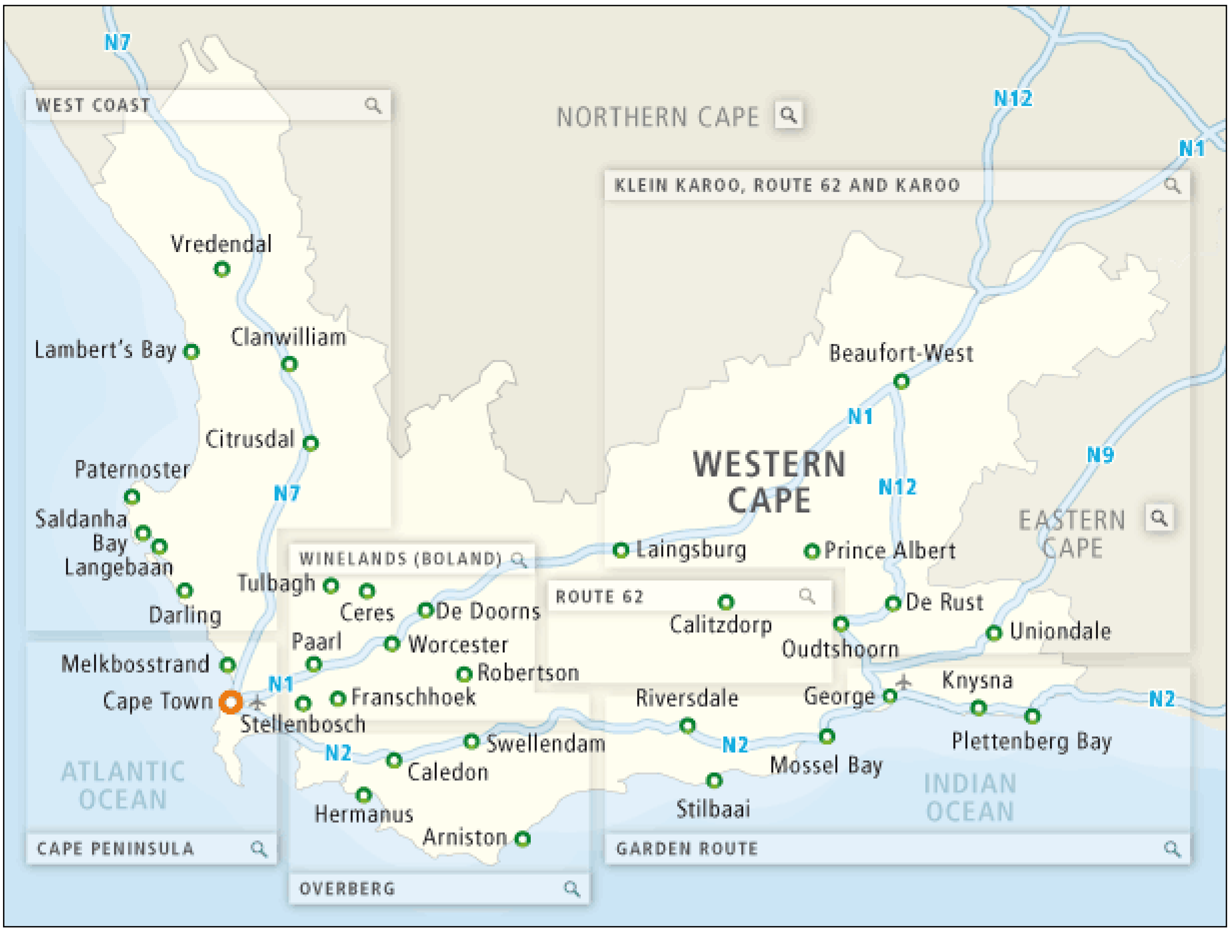

Figure 4.1: Geographical Locations of the Districts in Western Cape Province (Google, 2013)

For this research a probability sample was used and specifically a systematic random cluster sample where schools represent the cluster and the teachers are the elements within the cluster (Creswell, 2012:142). The study covered a large geographical area (Western Cape Province) (Figure 4.1) and represents Mathematics teachers within the district and the province. Metro Central, East, North and South EMDCs are located in the Cape Peninsula; Cape Winelands EMDC is located in the Cape Winelands (Boland); Overberg EMDC in the Overberg area; West Coast EMDC in the West Coast area; and Eden Central Karoo EMDC covers the Garden Route, Klein Karoo and part of the Karoo (Figure 4.1).

The office of the Superintendent-General of Education of the WCED (Addendum 4.2) gave permission to access the Education Management Information System (EMIS) database list of schools (Addendum 4.3) from which the sample was drawn. The database provided the following information required during sampling:

- Name of school
- Medium of instruction
- Number of learners
- Type of school (secondary, intermediate or combined)
- Highest and lowest grades
- Name of the district
- EMDC
- Quintile
- Longitude
- Location details
- Contact details.

With the assistance of the Department of Statistical Consultation Services, the researchers selected a systematic random sample from a list of all schools ordered according to the number of learners in each school where the first participating school was selected randomly, (Cohen *et al.*, 2011:160; Neuman, 2011:252). Every 6th school thereafter was selected which included all prerequisites which the sample had to adhere to (Cohen *et al.*, 2011:160). The final sample of this study constituted of Mathematics teachers in schools in the Western Cape Province and comprised: (i) a total of 167 schools presenting Mathematics in the Senior Phase (Grade 7-9); with an average of (ii) two Mathematics teachers per school from all the districts. The population constituted senior phase (grades 7-9) Mathematics teachers (N=300) in the Western Cape (Table 4.8) (Addendum 4.4). From the initial list of 1455 schools within the WCED, 228 schools formed the systematic sample for the data collection (Addendum 4.5). Critical aspects that formed the basis for consideration during sample selection related to the following criteria:

- schools had to present senior phase (grades 7-9) classes
- sample had to comprise a combination of combined, secondary (high) and primary schools
- schools from diverse quintiles (one to five) (Table 4.6)
- schools with a variation in learner numbers (large and small schools)
- schools located in urban and in rural areas
- schools with versatile medium of instruction

- school location and contact details had to be available.

Table 4.4 provides an outline of the number of schools selected in the eight educational districts in the Western Cape during the systematic stratified sample selection (Addendum 4.6).

Table 4.4 Participating Schools in the Eight Educational Districts

District	Number of Schools
Metro Central Education District	33
Metro East Education District	24
Metro North Education District	34
Metro South Education District	31
Cape Winelands Education District	36
Eden & Central Karoo Education District	33
Overberg Education District	14
West Coast Education District	23
Total:	228

It was critical to have all the educational districts represented in the sample in order to obtain a holistic view of the WCED as a unit. The educational districts which were densely populated (Metro Central, Metro North, Metro South, Cape Winelands, and Eden Central Karoo) had the largest representation. The West Coast education district covers vast distances, but the population were less congested. Overberg district is the smallest of the districts; therefore it had the smallest sample representation. Table 4.5 provides an outline of the type of schools in the sample for the data collection in the eight educational districts in the Western Cape (Addendum 4.6).

Table 4.5 Types of Participating Schools

Type of School	Number of Schools
Intermediate Schools	38
High/Secondary Schools	170
Combined Schools	20
Total:	228

The high or secondary schools represented the majority of the sample selected for this study. As the distribution of the survey focused on Mathematics teachers in senior phase (grades 7-9, and grade 8 and 9) are accommodated at either high or secondary schools. The intermediate schools accommodate grade 7 and the combined schools hosts from grades 1-12.

Schools in South Africa are divided into quintiles (a fifth of the whole) as a cut-off point for the provision of funding to schools (Investopedia, 2013a). Table 4.6 provides an outline of the quintiles of the schools selected during the systematic stratified sample for the data collection in the eight educational districts in the Western Cape (Addendum 4.6).

Table 4.6 Quintiles of Participating Schools *

Quintile	Number of Schools	Funding per Annun
NQ 1	22	R 960 per learner
NQ 2	32	R 880 per learner
NQ 3	48	R 880 per learner
NQ 4	45	R 480 per learner
NQ 5	81	R 165 per learner

* Adapted from Investopedia (2013a); Western Cape Education Department (2013a)

Schools in quintile one receive more funding than schools in quintile five (Table 4.6). The division of schools in quintiles are done by the provincial department using the socio-economic statistics from Statistics South Africa (Statistics South Africa, 2012).

Table 4.7 provides an overview of language as medium of instruction of the selected schools in the eight education districts (Addendum 4.6).

Table 4.7 Medium of Instruction of Participating Schools

Medium of Instruction	Number of Schools
Afrikaans	76
English	72
Dual medium	13
Afrikaans/English	56
Afrikaans/English/Xhosa	2
Afrikaans/Xhosa	1
Xhosa	8

In terms of the section 9, 29(2), 30 and 31 of the South African Schools Act (South Africa, 1996:5) the schools determine the medium of instruction subject to the constitution. As the majority of schools in the Western Cape use either Afrikaans or English as medium of instruction. The sample selected represented: (i) Afrikaans, (ii) English, (iii) dual medium, (iv) Afrikaans/English (parallel medium), (v) Afrikaans/English/Xhosa, (vi) Afrikaans/Xhosa, and (vii) Xhosa medium of instruction. The parallel medium (Afrikaans/English) is the third largest sample of the selected schools. Very few schools in the WCED deliver teaching and learning in more than two languages as the focus is more home language and parallel medium instruction (Western Cape Education Department, 2001; Western Cape Education Department, 2002).

Table 4.8 provides an account of the schools and respondents which participated in the data collection strategy followed during this study (Addendum 4.4).

Table 4.8 Number of Schools and Participants

District	Number of Schools	Number of Respondents
Metro Central Education District	29	43
Metro East Education District	37	50
Metro North Education District	11	21

District	Number of Schools	Number of Respondents
Metro South Education District	19	27
Cape Winelands Education District	26	69
Eden and Central Karoo Education District	23	53
Overberg Education District	4	5
West Coast Education District	28	42
Total:	179	300

4.5.7 Stage Seven: Compile the Questions and the Metrics

Babbie (2010:256-262) and McMillan and Schumacher (2001:258-260) propose that the researcher formulate questions and constructs questionnaires to: (i) operationalize the variables of the research; (ii) collect data for analysis and interpretations; (iii) ensure maximum response; and (iv) extract data for the analysis:

- **General question format.** The arrangement of the questions in the questionnaire is of equal importance to the nature and wording of the questions asked. Jumbled and short phrased questions confuse the respondents, and can lead to respondents not replying to questionnaire items (Babbie, 2010:252-262). The researcher planned the layout of the questions in the questionnaire in order to optimally use space and simultaneously contribute towards readability. The researcher consulted an expert to assist with the wording of the questions.
- **Usable format for respondents.** The researcher made use of tick boxes to capture responses easily. For Parts C-F of the questionnaire, she used a five-point Likert scale (1 = strongly agree; 2 = agree; 3 = strongly disagree; 4 = disagree; and 5 = do not know).
- **Ordering of items in the questionnaire.** The researcher arranged the demographic data at the beginning of the questionnaire (Parts A and B) to have an easy start and make the respondents feel at ease. The more complex questions on attitudes, attributes, opportunities; self-classification; and knowledge variables followed in Parts C, D, E, F and G.
- **Questionnaire instructions.** A cover letter introduced the background and the rationale for the research (Addendum 4.7), followed by basic instructions (Addendum 4.8) on how to complete the questionnaire.
- **Pre-testing the questionnaire.** To ensure that the questions were clear and unambiguous, the researcher approached (i) five Mathematics lecturers from the Faculty of Education Sciences at the North-West University in Potchefstroom (Addendum 4.9), and (ii) Mathematics teachers from three schools in the Potchefstroom area (Addendum 4.10) in the North-West Province to assess the readability and layout of the questionnaire.
- **Data-processing**. The questionnaire created a data-processing pane on the questionnaire (i) to assist the researcher during the capturing and checking of the data, and (ii) for respondents to see which data will be used for the analysis (Babbie, 2010:252-262; McMillan & Schumacher, 2001:258-260).

Table 4.9 provides a synopsis of the seven guidelines used during the compilation of the questionnaire.

Table 4.9 Seven Guidelines to Formulate Questions *

Guidelines	Explanation
Make items clear	Respondents interpret it the same, with no unclear words
Avoid double-barrelled questions	Question were limited to one single idea or question
Respondents must be competent to answer	Respondents could supply trustworthy answers
Questions should be relevant	Respondents should be able to answer the questions based on their experiences
Short, simple items are best	Avoided long questions, the shorter questions ensured respondents read and answered quickly
Avoid negative items	Respondents could not misinterpret and answer the opposite of what was intended
Avoid biased items or terms	The researcher avoided formulating questions in the direction she wants the response to go

* Adapted from (Babbie, 2010:252-262) and McMillan and Schumacher (2001:258-260)

4.5.8 Stage Eight: Create the Questionnaire

The researcher compiled the questionnaire according to its seven parts (Addendum 4.11).

4.5.8.1 Parts A and B: Personal and Demographical Information

Part A included the personal information: (i) gender, (ii) age, (iii) home language, (iv) language of instruction, (v) years of teaching experiences in the various grades, (vi) standard of qualification, and (vii) subject specialisation.

Part B comprised demographical information relating to the: (i) school district; (ii) nearest town or city; (iii) geographical location (rural or urban area); (iv) quintile of the school; (v) number of Mathematics classes per grade; (vi) number of Mathematics classes teachers teach; (vii) availability of computers for teaching, learning and administration; and (viii) access to the Internet for administration, teaching and learning. For some questions, the respondents had to select the appropriate option and in other fill in the applicable response.

In the following sections, the researcher provides a detailed description of the questions organised as Parts C, D, E, and F as the four variables as conceptualised as four activity systems in Chapter Three (§ 3.6). They relate to complex questions on attitudes, attributes, opportunities; self-classification; and knowledge relating to the research. Part G relates to PD models. In § 4.5.8.2-4.5.8.5 the researcher illustrates the relationship between the literature constructs as deducted from the systematic literature review and the individual questions. Parts C, D, E, and F posed questionnaire items relating to the four activity systems (Governance; School Environment; ODL; and PD). The selected quotations from the qualitative analysis illustrate the underpinning constructs. A closed form method of a five-point Likert scale (1= strongly agree, 2= disagree, 3= agree, 4= strongly agree, 5=do not know) pinpoints respondents' inputs.

4.5.8.2 Part C: Governance

Table 4.10 provides a comprehensive description of the compilation of the questions for Part C on governance created from the inductive analysis (Addendum 2.9).

Table 4.10 Comprehensive Description of Compilation of Questions for Governance

Question		Text from Inductive Analysis
C1	The WCED motivates the use of ICT in Mathematics teaching	Promote effective practices in the use of ICTs in teaching, learning (Department of Education, 2004b:26)
C2	The WCED allocates funds for ICT Mathematics training	The DBE provides access to technology, including teacher development (Department of Education, 2004b:35)
C3	The WCED gives funds for ICT resources	To build an integrated e-Education system requires better investment in the education sector (Department of Education, 2004b:35)
C4	The WCED provides my school with computers for administration	Learners, teachers, managers and administrative staff should have access to hardware, software and connectivity (Department of Education, 2004b:22)
C5	The WCED supplies my school with computers for teaching and learning	ICT should be an integral part of teaching and learning by both learners and teachers (Department of Education, 2004b:22)
C6	The WCED gives training to Mathematics teachers in ICT integration	All teachers and school managers have access to basic training in the use of ICTs (Department of Education, 2004b:35)
C7	The WCED provides Mathematics teachers with Webquest training	All role players in the GET and FET band must have the knowledge, skills and support they need to integrate ICTs in teaching and learning (Department of Education, 2004b:35)
C8	The WCED offers IntelTeach training to Mathematics teachers	INTEL Teach to the Future Teacher Development Program provides teacher training in ICT integration into teaching and learning (Department of Education, 2004b:25)
C9	The circuit stimulates the development of ICT in Mathematics teaching and learning	Technology integration is influenced by how technology is professed and integrated as part of the culture in schools, districts, and communities (Swan *et al.*, 2002:176)
C10	The circuit provides professional development in ICT integration in Mathematics	PD should occur in teachers' contexts (Daly *et al.*, 2009:55)
C11	The circuit motivates Mathematics teachers to share their practices with ICT	Subject-specific needs have been met by access to external experts, subject advisors and peers in other schools (Daly *et al.*, 2009:55)
C12	The circuit creates an online network where Mathematics teachers share practices	A supportive online 'community of practice' with teachers collaborating and sharing ideas (Daly *et al.*, 2009:34)
C13	My school supplies computers for administrative purposes	Most schools do not budget adequately for technology and technology training (Swan *et al.*, 2002:174)
C14	My school installs computers for teaching and learning of Mathematics	For e-Learning to be successful, learners must have frequent access to reliable infrastructure (Department of Education, 2004b:25)
C15	My school provides IWB for the teaching and learning of Mathematics	IWB use can sustain interactive teaching and learning (Miller & Glover, 2010:119)
C16	My school supports ICT professional development activities from external providers	Over half of participants had adequate support in their workplace that would allow them to feel confident in accessing professional learning in an online mode (Broadley, 2011:188)
C17	My school provides access to the educational PORTAL (Thutong)	All institutions are connected to an educational network (Department of Education, 2004b:22)
C18	My school supports ICT professional	The support of school managers strongly affect

Question		Text from Inductive Analysis
	development activities initiated by the WCED	PD successes in their schools (Swan *et al.*, 2002:182)
C19	My school provides time for Mathematics teachers to use the ICT facilities at school to prepare lessons	The time constraints in practical workshops and school-based planning hinders the extend of ICT integration activities (Loveless *et al.*, 2006:9)
C20	My school supports the use of ICT in the teaching and learning of Mathematics	Continuous support at school and curricular level is vital for ICT integration (Swan *et al.*, 2002:176)
C21	My school creates a timetable for Mathematics teachers to use the ICT facilities for teaching and learning	School managers must reorganise the educational institutions to adapt to the integration of ICT (Department of Education, 2004b:26)
C22	My school encourages Mathematics teachers to use the ICT facilities for teaching and learning	School managers must view ICTs as an indispensable tool for teaching and learning and in his/her role encourage and support the use of ICTs (Department of Education, 2004b:26)
C23	My school supports online Mathematics networks	ODL motivates collaboration and writing which offers teachers the opportunity reflect on practices and to design activities and resources (Da Ponte, 2010:10)

Part C of the questionnaire addressed the *Governance* of ICT implementation at provincial (WCED), district and school level. The majority of the items in this section relate to the objectives of the three-phase ICT integration plan as stipulated in the White Paper on e-Education (Department of Education, 2004b). Even though the WCED has a responsibility towards the implementation of policy, the school is the driving force to ensure the integration of ICT for Mathematics teaching and learning (The World Bank Group, 2002).

4.5.8.3 Part D: School Environment

Table 4.11 provides an overview of the assemblage of the questions for Part D on School Environment formulated from the inductive analysis. Aspects relating to the school environment were grouped as one part of the questionnaire with various sub-questions.

Table 4.11 Comprehensive Description of Compilation of Questions for School Environment

Question		Text from Inductive Analysis
D1	I use social software for personal use, e.g. email, Facebook, Twitter, Mxit, WhatsApp, BBM	Many researchers recognise the value of social software in ICT PD (Ala-Mutka *et al.*, 2010:2)
D2	I use the Internet to find Mathematics resources	The Internet can be a tool to search for new developments in Mathematics teaching and learning (Da Ponte *et al.*, 2002:1)
D3	I use ICT in Mathematics teaching to achieve the Learning Outcomes	During training teachers used ICT in problem solving, produce Mathematics lessons, and create new problems (Swan *et al.*, 2002)
D4	I develop lessons to use ICT in Mathematics teaching	Teachers make too much use of pre-prepared resources and their teaching and learning of Mathematics (Miller & Glover, 2010:121)
D5	I use a variety of teaching methods with ICT in my Mathematics class	ICT is an important tool in Mathematics teaching and learning, i.e. to prepare lessons, search for materials and for collaborating (Da Ponte *et al.*, 2002:2)
D6	I decide which ICT applications to use in Mathematics teaching and learning	Teachers creatively utilize and explore the utilisation of ICT appropriately (Da Ponte *et al.*, 2002:2)
D7	I assist my learners to use ICT in Mathematics lessons	Teachers encourage a learner-centred and activity-based approach to teaching and learning (Department of Education, 2004b:22)
D8	I take responsibility for my own learning regarding the integration of ICT in Mathematics	Teachers have a sense of responsibility for their own PD (Daly *et al.*, 2009:27)

Question		Text from Inductive Analysis
	teaching	
D9	I have a positive attitude towards ICT for teaching and learning Mathematics	Teachers' deep-seated beliefs about learning attitudes changed regarding the role of technologies for teaching and learning (Attwell & Hughes, 2010)
D10	I carry out Mathematics investigations with my learners through ICT	Any ICT integration requires that teachers engage in rethinking and reshaping their engagement with the curriculum (Department of Education, 2004b:22)
D11	I stimulate my learners to be creative with ICT	Teachers are able to initiate change which has an impact on learners' learning (Daly *et al.*, 2009:27)
D12	I use ICT to accommodate the diverse group of learners in my class	When integrating ICT effectively teachers have a more learner-oriented pedagogical approach to teaching and learning (Drent & Meelissen, 2007:198)

The questions in Table 4.11 relate to aspects regarding the extent to which Mathematics teachers: (i) create a classroom environment where they utilise the Internet and ICT applications; (ii) download resources; (iii) develop lessons with the help of ICT; (iv) stimulate their learners to be creative; (v) use the vast array of resources to improve their academic performance; (vi) achieve the assessment standards; and (vii) have a positive attitude towards the use of ICT for teaching and learning of Mathematics.

4.5.8.4 Part E: Information and Communication Technologies

Table 4.12 provides a comprehensive description of the compilation of the questions on ICT for Part E of the questionnaire. This section concentrates on some general questions on ICT with no particular emphasis on Governance, School Environment, PD or ODL, but it was one of the key elements of the research.

Table 4.12 Comprehensive Description of Compilation of Questions for Information and Communication Technologies

Question		Text from Inductive Analysis
E1	My school negotiates with service providers for reliable Internet access	Stakeholders negotiate easier access to reduce costs for Internet enabled devices (Department of Education, 2012a:35)
E2	My school has an ICT policy	Every South African learner will have the capability to function within an ICT environment by 2013 (Department of Education, 2004b:38)
E3	My school has teachers who use ICT innovatively	Schools should have skilled and capable teachers who use ICTs to enhance teaching and learning (Department of Education, 2004b:18)
E4	My school's ICT vision aligns with the latest trends in the curriculum	The school manager shape the ICT vision through collaborative work (Daly *et al.*, 2009:30)
E5	I plan my ICT integration Mathematics activities in advance	Teachers do not use computers in spite of their availability; this points to inadequate planning (Mofokeng & Mji, 2009:1612)
E6	I communicate with remote colleagues through ICT	The Internet presents teachers with the possibility to interact in a virtual environment with teachers (Da Ponte, 2010:3)
E7	I am confident to use the ICT applications in my Mathematics lessons	ICT provides new opportunities to the teachers' work – using such technology in classes, preparing lessons and classroom materials, writing reports, carrying out administrative work (Da Ponte, 2010:2)

Question		Text from Inductive Analysis
E8	I do not use ICT in the teaching and learning of Mathematics despite the affordances for teaching and learning	Technologies are *oversold and underused* in education institutions (Daly *et al.*, 2009:16)
E9	I use ICT for assessment of Learning Outcomes	Using technology to record learner progress, to inform the learning and teaching process and to promote independent learning (Daly *et al.*, 2009:81)
E10	My learners gain ICT competency when I use ICT in my Mathematics lessons	The effectiveness of outcomes-focused and technology-rich learning environments in promoting student retention, achievement, attitudes and equity (Pearson & Trinidad, 2004)

Many schools in the WCED have ICT resources as discussed in Chapter Three (§ 3.2.1.1), but it was questionable whether they have an ICT policy which drives the implementation process. An ICT policy structures the ICT implementation strategies and activities at school level (Waters, 2012). The rationale for including these questions as a separate section of the questionnaire was to learn about the existing ICT integration practices in schools in the WCED.

4.5.8.5 Part F: Professional Development and Open Distance Learning

Table 4.13 provides a comprehensive description of the compilation of the questions for Part F on PD conceptualised from the inductive analysis. Two of the four activity systems (PD and ODL) were grouped as one part with various sub-questions. ODL is a relatively new form of service delivery especially in the school context; the researcher did not want to overwhelm the Mathematics teachers with this new-found mode of training as a separate section in the questionnaire.

Table 4.13 Comprehensive Description of Compilation of Questions for Professional Development

Question		Text from Inductive Analysis
F1	I should develop my Mathematics competencies myself	Teacher's own attitude regarding his/her development (Da Ponte, 2010:2)
F2	I should know about the current trends in Mathematics education	The structure of the teachers' activity has undergone important changes involving new curriculum goals and professional responsibilities (Da Ponte, 2010:2)
F3	I should be innovative with ICT in my Mathematics teaching	Teachers to explore new ways of using this technology (Da Ponte, 2010:9)
F4	I should use ICT to communicate with other Mathematics teachers	Teachers engage in regular, on-going, and concrete subject-specific talk about teaching practice with peers (Daly *et al.*, 2009:28)
F5	I should share ICT practices with other Mathematics teachers	ICT provides the opportunities for teachers to share information and experiences with other teachers (Da Ponte, 2010:2)
F6	I should share my views in an online environment	ODL enabled teachers to develop a more thoughtful stance and they had many positive encounters of professional collaboration (Da Ponte, 2010:9)
F7	I should network with other Mathematics teachers	Teachers must have plenty of opportunities to interact with peers (Daly *et al.*, 2009:56)
F8	I should attend ICT Mathematics professional development training according to my individual needs	Teachers wanted ICT PD that enabled them to develop their own personal interests (Daly *et al.*, 2009:56)
F9	I should attend ICT Mathematics professional development based at my own pace	Mentors structure the PD schedule to adapt to the school and participating teachers' individual needs

Question		Text from Inductive Analysis
		(Swan *et al.*, 2002:171)
F10	I should receive ICT subject specialized professional development training	ICT PD training but none of it has been based on classroom application (Attwell & Hughes, 2010)
F11	I should attend ICT professional development training at my school	The school-based mentors provide training to teachers on technology utilization at school (Swan *et al.*, 2002:170)
F12	I should attend online ICT Mathematics professional development training	Teachers participate in online collaborative PD (Daly *et al.*, 2009)
F13	I should combine face to face and online ICT Mathematics professional development training	Teachers miss the face-to-face interaction during online PD (Da Ponte, 2010:7)
F14	I should receive classroom support based training and mediation where trainers visit my classroom	Effective PD should be constructive and situated in authentic classroom practice (Borko *et al.*, 2002:970)
F15	I should advance my ICT Mathematics professional development through distance learning	ODL can accommodate the interests of each group, according to curriculum and professional orientations and concerns (Da Ponte, 2010:10)
F16	I should have access to a lead teacher at my school during ICT professional development training	To enable an increase in teachers' confidence with computers, they need lead teachers to assist them to effectively use of ICT in their lessons (Younie, 2006:394)
F17	I should attend ICT professional development Mathematics training to suit the context and needs of my school	PD should focus on the development of local cultures to be sustainable (Swan *et al.*, 2002:169)
F18	I should have access to joint WCED and district ICT professional development training	DBE should provide the requisite training if computers are to be part of the teaching and learning context in South Africa (Mofokeng & Mji, 2009:1613)
F19	I should have access to ICT professional development guidelines on the integration of ICT in the teaching and learning of Mathematics	The DBE must develop a national framework for PD of teachers the use of ICTs for teaching and learning which must be integrated into pre-service and in-service training (Department of Education, 2004b:25)

In this section the researcher aimed to: (i) confront issues on PD of Mathematics teachers; (ii) gain insight on the opinions of Mathematics teachers on the future PD opportunities; (iii) know about the context in which the PD activities should occur; and (iv) assess the modes in which PD should take place.

4.5.8.6 Part G: Professional Development Models

The final part of the questionnaire (Part G), includes four PD models conceptualised using the multiple PD models and frameworks from the mixed-method systematic literature (§ 3.5.1.6). The researcher adapted a variety of PD models, tested in other education systems across the world by the expert researchers in this particular field, to suit the background and context of South African schools.

- PD Model 1 was a school based training model, face-to-face or online, organised by the WCED and local EMDC. Mathematics teachers participate in a collaborative group to share ideas and best practices. Mathematics teachers determine, within their subject group, their own PD needs.
- PD Model 2 represents the scenario where Mathematics teachers start a subject network group (face-to-face or online), take lessons from the Internet, and adapt those lessons to suit the context of their classroom. In their subject network group teachers access their initiatives and share their best practices and shortcomings. This is an on-going process driven by the Mathematics subject group (Table 3.3.).

- PD Model 3 was a school-based PD model which started with shaping an ICT vision for the school. Mathematics teachers in collaboration with HODs plan their PD activities. Mathematics teachers address their own PD needs. Mathematics teachers access an online platform to participate in PD where they collaborate with peers online and face-to-face (§ 3.4.1.3).
- PD Model 4 describes an online network group which drives the PD process. Mathematics teachers receive training in Web 2.0 technologies. Mathematics teachers implement these technologies in their classrooms, and participate in PD to master the technologies. PD is a continuous process to adapt to the changes in the curriculum and the advancement of technological resources (§ 3.5.1.1). The respondents selected two models (Addendum 4.11).

4.5.9 Stage Nine: Determine Data Collection Strategy

The data collection of a survey can be conducted via postal interviews, interview surveys, telephone survey, and Internet-based surveys. Each of these strategies has its own strengths and weaknesses (Cohen *et al.*, 2011:274). The researcher administered the questionnaire by personally delivering it to and collecting it from individual sampled schools. The researcher clarified queries, ensured that the respondents completed the questionnaire, and motivated them to participate in the research. The researcher also attended group sessions that CAs organised at schools in order to optimize her data collection (Addendum 4.12). Figure 4.2 illustrates one group session in the West Coast EMDC and Figure 4.3 illustrates a group session in the Metro South EMDC organised by the CAs of the respective districts. The questionnaire was completed and none of the participants could be identified. The researcher got permission from the groups to take a few pictures as evidence of the data collection.

Figure 4.2: Group Session in the West Coast EMDC

Figure 4.3: Group Session in the Metro South EMDC

4.5.10 Stage Ten: Piloting the Questionnaire

The validation of the questionnaire before it can be distributed to the participants is critical. Two components have to be piloted: (i) the instructions, and (ii) the questionnaire itself (McMillan & Schumacher, 2001:307). After compilation of the initial questionnaire, it was formally peer reviewed by five lecturers at the Unit for Open Distance Learning (UODL) at the North West University Potchefstroom South Africa (Addendum 4.9). Subsequently the researcher piloted the questionnaire with: (i) two Mathematics teachers from a quintile 1 school; (ii) two Mathematics teachers from a quintile 3 school; and (ii) one Mathematics teacher from a quintile 5 school (Addendum 4.10). This contributed towards the validity and reliability of the questions and ensured the comprehensiveness of the questionnaire (Cohen *et al.*, 2011:402-403; Strydom, 2005:206-210) (Addendum 4.11). The five Mathematics teachers had similar characteristics as the teachers from the target group of the main study (McMillan & Schumacher, 2001:307). Their results did not form part of the large scale implementation. After revising the questionnaire, the researcher submitted the final questionnaire to the target schools in the Western Cape during February and March 2013.

4.5.11 Stage Eleven: Prepare for the Data Collection

After obtaining ethical clearance from the North-West University Ethics Committee (Addendum 4.13) and permission from the WCED (Addendum 4.14) to distribute the questionnaire in the eight education districts, the researcher planned her data collection strategy. The researcher contacted the Mathematics CAs in the eight districts and scheduled appointments with the selected schools via telephone and email. The researcher obtained permission from the EMDCs to be accommodated during standard setting meetings which were held during the first school term (January to March 2013) (Addendum 4.12). The researcher planned the data collection period in accordance with the schedule of the district offices (Addendum 4.12). The data collection strategy comprised four standard setting meetings where the Mathematics teachers completed the questionnaire, and numerous scheduled school visits in order to meet with individual teachers (Addendum 4.12). Due to time constraints and voluntary participation of the respondents, it was not possible to visit and include the data from all the schools selected in the systematic stratified sample. However, the collected data were sufficient to provide a satisfactory sample representative of all the EMDCs in the Western Cape (Addendum 4.4).

4.5.12 Stage Twelve: Collect the Data

The researcher confirmed all the appointments for the data collection group sessions and school visits telephonically. The data collection journey started in Beaufort-West (Eden Karoo EMDC) on Thursday the 31st of January 2013 and ended on Friday the 8th of March in Cape Town 2013 (Metro North EMDC) (Addendum 4.12). In total, the researcher travelled 37 days and 9287 km kilometres in her motor vehicle to collect the data.

The data collection journey was an experience which held many challenges, frustrations, eye openers, and satisfaction. Some of the challenges the researcher encountered were: (i) whether there would be sufficient fully-completed questionnaires from the Mathematics teachers in the WCED to validate the data, (ii) whether there would be enough time to visit the schools selected according to the random stratified sample. Aspects that frustrated the researcher most on the data collection journey were the: (i) dependence on the cooperation of the Mathematics teachers; (ii) number of times the researcher had to return to distant schools to collect the completed questionnaires (Addendum 4.15, line 211). The researcher found it difficult to visit all the schools on the list within the short space of time. The visible social inequities amongst the schools were disturbing to see, even after so many years of democracy which had not bridged the expanded gaps (Addendum 4.15, line 270-271). There were schools in the districts with cutting-edge technology, fewer than thirty learners per class competing with schools with less than basic resources and in dire need of upgrading. Some schools situated in poor communities really went the extra mile to be innovative, aspire for quality teaching and learning, and to assist the researcher in her quest to collect adequate data for her study (Addendum 4.15, line 276-278). Many of the CAs accommodated the researcher into their busy schedules. With their help and the cooperation of the many schools and Mathematics teachers, the researcher managed to collect sufficient data to meet a Cronbach's Apha reliability coefficient of ≥0.7 for most of the factors (McMillan & Schumacher, 2001:247).

The researcher captured the data with *EpiData*—a data capturing software programme. Dr Suria Ellis of the Statistical Consultation Services provided the researcher with an electronic data sheet before the data collection journey (EpiData, 2013). The researcher entered the quantitative data at the end of each day after collecting the completed questionnaires. This strategy saved time and contributed towards the validation of the captured data and efficient data analysis.

4.5.13 Stage Thirteen: Data Analysis Phase II

During Phase II various statistical procedures (descriptive statistics, factor analysis, linear modelling, and SEM) were conducted to analyse the data collected from the survey.

4.5.13.1 Descriptive Statistics

Descriptive statistics analysed and interpreted the data in Parts A and B. Descriptive statistics included: frequencies; measures of central tendency (means, modes, medians); standard deviations (measures of dispersal); cross tabulations; and effect sizes (Cohen *et al.*, 2011:622). The descriptive statistics described the numerical data. Frequency distribution is the most convenient method to describe the numerical data of one variable (Neuman, 2011:386). The researcher used the percentage frequency distribution to summarise the findings from Part A (personal information) and Part B (demographical information) of the instrument. The measures of central tendency are a statistical measure which condenses information about the distribution of the data for one variable into a single number. The *mode* is the most popular or frequent number in the data. The *median* is the central point for one variable that points to half of the instances which are higher and half which are lower. An arithmetic average where all the scores are added and an average is calculated is known as the *mean*. Standard deviation is a complex method to measure the scattering of data around the mean, but it is used to compare data (Cohen *et al.*, 2011:627; Neuman, 2011:387-391).

4.5.13.2 Factor Analysis and Reliability

A principal axis factor analysis determined the correlation of items of instruments to indicate underlying constructs. The factor analysis enabled the researcher to explore the data for patterns, verify and decrease the number of variables within the instrument (Cohen *et al.*, 2011:402). Subsequent factors are, in turn, intended to account for the maximum amount of the remaining common variance until, hopefully, no significant common variance remains (Suhr, 2006). With factor analysis the variables clustered the data into homogeneous groups, created new factors, and the researcher gained insight into the construct s underlying the data (Garrett-Mayer, 2006b). Barlett's test of sphericity tested whether the correlation matrix was an identity matrix, which would indicate that the variables are unrelated and unsuitable for structure detention. Significance values ≤0.05 indicated that the factor analysis could be useful. The Kaiser-Meyer-Olkim (KMO) tested whether the observed data and their correlations were large enough to form a concise factor structure (Cohen *et al.*, 2011:641). A measure of or above 0.9 indicated a good fit. Cronbach's Alpha was used to measure the reliability of the sub-scales in the questionnaire as it is known as the most appropriate type of reliability for survey research (McMillan & Schumacher, 2001:247). Values above 0.7 and in many cases a value of 0.5 would have sufficed (Nunnally, 1978) with an average inter-tem correlation in the range of 0.15-0.50 (Clark & Watson, 1995:315).

4.5.13.3 Comparisons between Biographical Information and Extracted Factors

Comparisons between biographical variables and extracted factors were drawn with hierarchical linear modelling in SPSS (2012) and SAS (1976). This correlation was to account for the dependency of teacher from the same school. The researcher made comparisons between the extracted factors and: (i) the age of Mathematics teachers; (ii) the gender of the Mathematics teachers; (iii) the number of years teaching; (iv) the qualifications of Mathematics teachers; (v) the school quintiles; (vi) the language of instruction; (vii) the subject specialisation of the Mathematics teachers; (viii) the different EMDCs; (ix) the type of school; (x) the availability of computers in each EMDC; and (xii) the computer literacy level of the Mathematics teachers. The hierarchical linear models made comparisons between categorical items in Part A and Part B of the questionnaire with the extracted factors. The effect sizes of the linear modelling were measured by Cohen's d-values: $d \leq 0.4$ as small with little or no significant difference, $0.5 \leq 0.8$ medium that tended towards practically significant difference and $d \geq 0.8$ large with practically significant difference. Only medium and large effects sizes and the $p \leq 0.05$ of the linear models and the factors which showed a significant effect were used for this interpretation (Cohen, 1988:25-27).

The SAS models made comparisons between continuous variables (e.g. number of computers) in Part A and Part B of the questionnaire and the extracted factors. The effect sizes were measured by R^2, the proportion of variance explained, ≤ 0.01 indicates a poor fit; ≥ 0.1 indicates a moderate fit; and ≥ 0.25 indicates a strong fit (Cohen et al., 2011:701).

4.5.13.4 Structural Equation Modelling

A structural equation modelling was performed with Analysis of Moment Structures (Amos) (SPSS, 2006), structural equation modelling (SEM) software (Figure). SEM builds on concepts of regression analysis. Using SEM software the regression models and factor analysis can be integrated to make up a general model. In a model one-headed arrows and two-headed arrows, indicating the relationship between factors. The one-headed arrows indicate causal effect, from one variable to another, whereby the two-headed arrows indicate associations (correlations), and do not measure causal effects. The technique for extracting factors attempts to take out as much common variance as possible in the first factor. A SEM can be used to confirm the results of the factors analysis and the relationship between components of the questionnaire. The goodness-of-fit (CFI) statistics calculated the proportions of variance accounted for by the model. Mueller (1996) suggests that the Chi-square test statistic should be divided by degrees of freedom. Interpretation of the size of this value depends to a large extent on the viewpoint of the researcher, but in practice ratios of 3, 4 or even 5 were considered a good model fit (Mueller, 1996). Chi-square test statistic divided by its degrees of freedom (CMIN/DF) value of 2.22, which should be smaller than 5 to indicate a good fit (Mueller, 1996). Comparative Fit Index (CFI) value of 0.74, where values larger than 0.9 are indicative of a good overall fit (Mueller, 1996). Root Mean Square Error of Approximation (RMSEA) value of 0.11 with a 90% confidence interval of 0.10; 0.12, which should be smaller than 0.1 for acceptable fit (Blunch, 2008:77)

4.5.14 Stage Fourteen: Reporting of Findings

While Chapter Five provides a detailed analysis of the descriptive statistics, factor analysis, hierarchical linear modelling, and the SEM, Table 4.14 provides a synopsis of the fourteen stages of questionnaire development for this research.

Table 4.14 Fourteen Stages in Questionnaire Development *

Stage	Activity
Stage 1: Define the aim	• Gain information from Mathematics teachers to develop PD guidelines for the pedagogical use of ICT
Stage 2: Determine which type of survey to use	• Used a cross-sectional survey
Stage 3: Formulate research question	• What are the guidelines for the professional development of Mathematics teachers in the pedagogical use of information and communication technologies through open distance learning?
Stage 4: Identify the aspects on which to focus	• Used the four activity systems as guideline to structure the main components which had to be addressed in the research
Stage 5: Clarify which information are needed to address the research question	• Used the quotations from the inductive analysis to formulate the items in the questionnaire
Stage 6: Determine the target population	• Senior phase (grades 7-9) Mathematics teachers in the WCED
Stage 7: Compile questions and the metrics	• A printed instrument with a five-point Likert scale
Stage 8: Make the instrument	• Compiled a questionnaire with seven parts
Stage 9: Determine data collection strategies	• Self-administered survey
Stage 10: Pilot the instrument	• Reviewed and piloted the questionnaire with five lecturers and in three schools in the Potchefstroom area
Stage 11: Prepare for the data collection	• Planned the data collection by scheduling appointments with subject advisors and principals in the WCED
Stage 12: Collect the data	• Collected the data in the WCED during February and March 2013
Stage 13: Analyse the data	• Analysed the data with descriptive statistics and factor analysis, reliability and comparisons between biographical variables, and extracted factors, and SEM
Stage 14: Report the findings	• A full report on the findings in Chapter Six

* Adapted from Cohen *et al.* (2011:259)

4.6 Role of the Researcher

In quantitative research the researcher is detached from the data collection process to avoid bias. Quantitative research focuses on the instrument and is renowned to be *disciplined subjectivity* and *reflexivity* where the researchers critically self-examine their role throughout the research process

(McMillan & Schumacher, 2001:16). The researchers' role comprised of multiple tasks during the research process to ensure that the research remained objected and goal-oriented (Cohen *et al.*, 2011:6-8). The researcher used guidelines (Table 4.9) to structure the questionnaire to ensure that the final product was objective, clear, and reliable. The researcher made sure that the questionnaire was validated by Mathematics teachers and peers in the field (§ 4.7.1). The researcher obtained permission from the various role players (WCED, school districts, schools and participants) for the research. The researcher communicated with the Head of Education (Addendum 4.2), and the schools (Addendum 4.16) to: (i) describe of the rationale for the research; (ii) outline the timeframe of the research; (iii) describe the data collection strategies; and (iv) summarise the measures in place to protect the anonymity of the participants. Informing the participants beforehand showed respect to the respondents, as well as a concern for the prospective interference of the study into their workplace and it created the platform for realistic expectations on their part (Creswell, 2012:147). The researcher obtained permission from: the office of the Superintendent-General of Education in the WCED (Addendum 4.2); the school districts (Addendum 4.17); the specific schools (Addendum 4.16); and the participants (Addendum 4.18). The researcher scheduled appointments with the respondents. During the data collection process the researcher explained the questionnaire, made sure that respondents understood the instructions, and that the questionnaire was completed within the given time-frame as stipulated on the questionnaire. The researcher captured the data, controlled the capturing process and checked the data before these were analysed. In collaboration with the statistician the researcher selected the applicable statistical procedure to present the findings. The data were interpreted and the results were presented to the respondents and to the reader.

4.7 Credibility in Quantitative Research

Validity and reliability in quantitative research differ from qualitative research as the methodological element tends to be more objectivist and adheres to the positivist principles (Cohen *et al.*, 2011:180; Neuman, 2011:208). Credibility (validity and reliability) in quantitative research is measured through statistical procedures. Validity and reliability in quantitative research are linked in multifaceted ways as they tend to overlap or can be measured exclusively as well (Creswell, 2012:307). These two ideas conjointly establish the credibility of the findings (Neuman, 2011:206).

4.7.1 Validity in Quantitative Research

Validity proposes truthfulness and it deals with the methods used to measure the social reality using a general idea inferred or derived from specific instances (Neuman, 2011:208). There are numerous principles in quantitative research to determine validity: *controllability, replicability; predictability; generalizability; context-freedom; fragmentation and atomisation of research; randomisation of samples; objectivity; and observability* (Cohen *et al.*, 2011:180). Validity in quantitative research is when one measures the appropriate use of information and explanations (McMillan & Schumacher, 2001:243). In quantitative research one has to address internal and external validity. Internal validity measures the accuracy of the phenomena, focuses on the question, and conducts the experiments while external validity asks the question, supplies the effects of the experiment on the population and makes generalizations (Cohen *et al.*, 2011:183).

Researchers use an instrument to measure the validity of the items within the survey. There are four types of measurement validity: face validity; content validity; criterion validity; and construct validity. Face validity measures the while content validity determines the clarity of the content. Criterion validity uses criteria to establish a construct accurately where the researcher compares the results using a variety of measuring tools (Cohen *et al.*, 2011:189). The researcher applied *construct validity* through factor analysis to group the items of the questionnaire meaningfully. Convergent and discriminant validity are the two facets of construct validity. *Convergent validity* is when multiple indicators of the same construct function in comparable ways. Measures of correlation, factor analysis and the standard regression weights were used in this research as convergent validity. Using construct validity validates the extent to which the survey used in this research for data collection corresponds with the theoretical context (Cohen *et al.*, 2011:189; Neuman, 2011:213). After factor analyses were conducted on Parts C, D, E, and F , the researcher performed a reliability test with Cronbach's Alpha to test whether the extracted frequencies were significant and if the items within the questionnaire were valid (Cohen *et al.*, 2011:641).

4.7.2 Reliability in Quantitative Research

Reliability refers to the dependability and consistency when the data are measured several times and the same results recur under similar conditions (Cohen *et al.*, 2011:199; Neuman, 2011:208). Reliability in quantitative research relates strongly to positivism. Positivists seek for trends, patterns, predictability and control when they measure the reliability of the data (Cohen *et al.*, 2011:200). There are three types of reliability in quantitative research: stability reliability; equivalence reliability; and representative reliability. *Stability reliability* measures reliability by testing and re-testing with similar samples over a short period of time. *Equivalence reliability* is when the construct is measured with either equivalent form of the data instrument or through inter-rater reliability in coded observational data. *Representative reliability* demonstrates internal consistency where the instrument is tested once by means of the split-half method. The split-half method separates the data is into two halves, with items equal in difficulty and content (Cohen *et al.*, 2011:201; Neuman, 2011:208-209). This is a typical method to determine reliability within the structuralist paradigm. Reliability as internal consistency can be found in Cronbach's Alpha frequency referred to as the alpha coefficient of reliability, with a reliability level of 0.7 as acceptable, but in some cases a level of 0.5 is also acceptable (Cohen *et al.*, 2011:639-640).

This research used representative reliability to make assumptions (e.g. the questionnaire, whether the data and findings were suitable, predictable, reliable and replicable) and to minimise the external sources of variation in the data (excluding acute answers from the data analysis) (Cohen *et al.*, 2011:201; Neuman, 2011:208).

4.8 Ethical Considerations in Quantitative Research

The completion of a questionnaire is an intrusion on the time of the respondents, the data collection invades the respondents' privacy, and the questionnaire can include sensitive questions. Respondents are active in the research process and the subjects of the research. Their cooperation may be encouraged, but is entirely voluntary, and the invasion of their privacy should be minimal (McMillan & Schumacher, 2001:198). Ethical clearance ensures that the research protects the respondents and informs them respondents of confidentiality, anonymity and the non-traceability of the research (Cohen *et al.*, 2011:377-378). The survey used for Phase II of the research was cleared by the North West University Ethics Committee (Addendum 4.13). The researcher obtained written permission from the: (i) office of the Superintendent-General of Education of the WCED (Addendum 4.14); (ii) Mathematics subject advisors (Addendum 4.17); (iii) principals of the selected schools (Addendum 4.16), and (iv) individual teachers (Addendum 4.18) to submit the survey during the first quarter of 2013. All the respondents were informed about the need of the study, their anonymous participation, and their right to withdraw from the study at any point in time. The results of the study will be made available in the public domain for all respondents to obtain information on the results of the study. The research strategies were executed rigorously to ensure that all the processes were complete, carried out with utmost care, and performed with demarcated accuracy to ensure reliability and validity of the results (Cohen *et al.*, 2011:228-229; Strydom, 2005:65).

The authenticity of the research report were confirmed with a Turnitin process where the researcher submitted each chapter of the research report individually. Turnitin is a software programme used to identify comparisons between the researchers' work and existing documents in various databases (Addenda 4.19-24).

4.9 Limitations of Quantitative Methodology

Irrespective of the constraints of developing and using a questionnaire the researcher addressed Phase II of the research, and developed the guidelines for PD of Mathematics teachers for the pedagogical use of ICT in ODL. Numerous aspects influence the quality and success of questionnaires. Some of these issues were dealt with beforehand and some aspects the researcher had little control over. The researcher ensured the questionnaire: (i) comprised accurate and appropriate questions that addressed the research problem; (ii) included suitable instrumentation, appropriate sampling; and (iii) yielded adequate data to address the research question optimally. The researcher ensured the success of this quantitative study by: (i) using a well formulated questionnaire;

(ii) piloting before the data collection; (iii) acquiring the services a professional statistician to assist in the analyses of the data with relevant statistical procedures (Cohen *et al.*, 2011:261). Some issues impacted negatively on the research process: (i) researcher's extensive travelling; (ii) high cost of accommodation; (iii) insufficient cooperation from some of the respondents; (iv) respondents' deliberate over-reporting or under-reporting of information; and (v) time constraints to collect the data within time limitations of a PhD study (Cohen *et al.*, 2011:261; Neuman, 2011:339) (Addendum 4.15).

4.10 Summary of the Chapter

This chapter explicated the research design and methodology of the quantitative phase, Phase II, of the fully mixed sequential equal status multi-mode design. It also described the sample selection process and the fourteen stages of questionnaire development. Chapter Four also explained the statistical procedures for the quantitative phase of the research. Furthermore it explained the credibility of the quantitative data and the ethical considerations which were taken into account. In addition, it clarified the limitations of the quantitative phase of the study. Chapter Five presents the findings of the quantitative analysis of the data generated by the questionnaire.