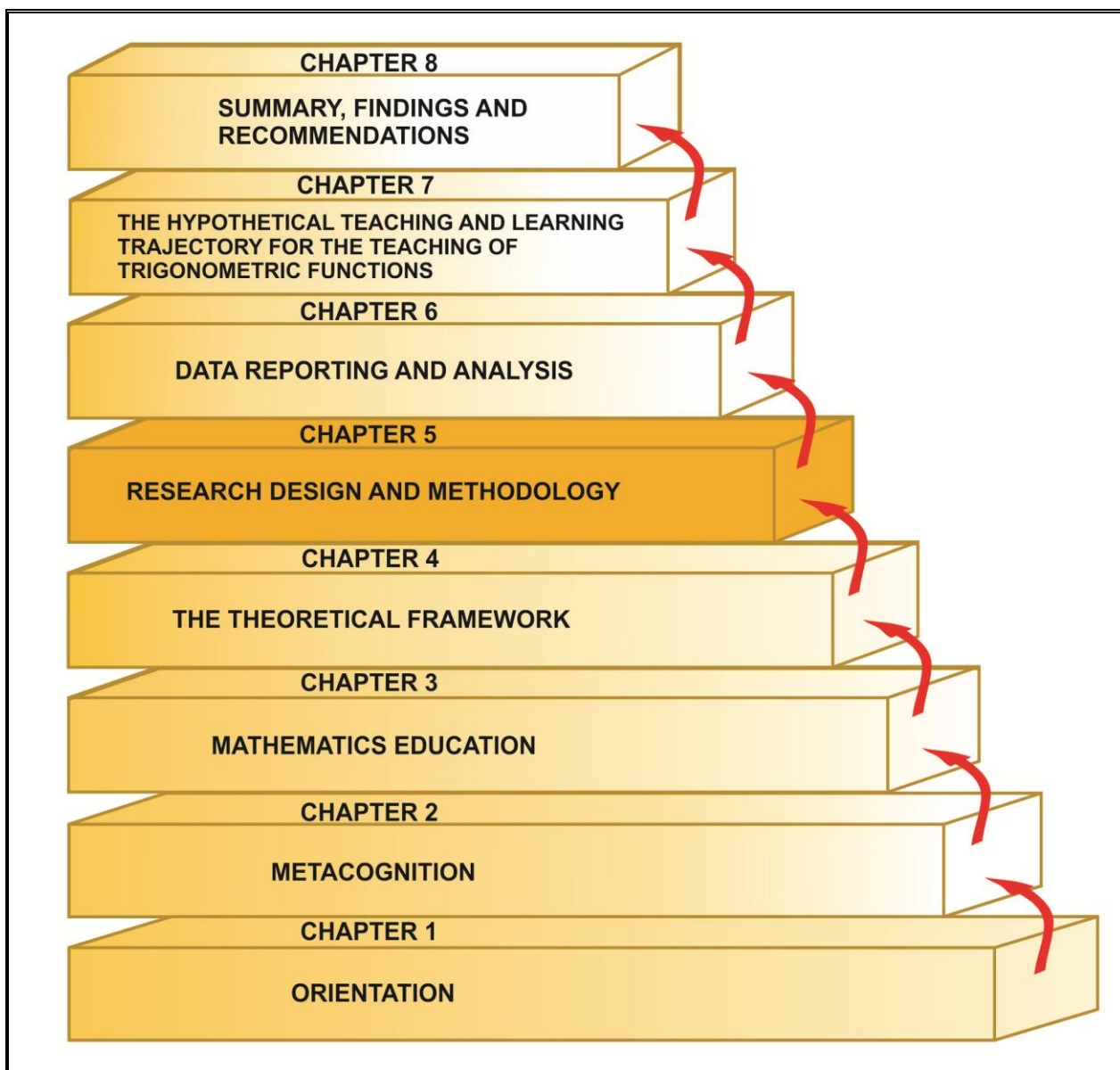
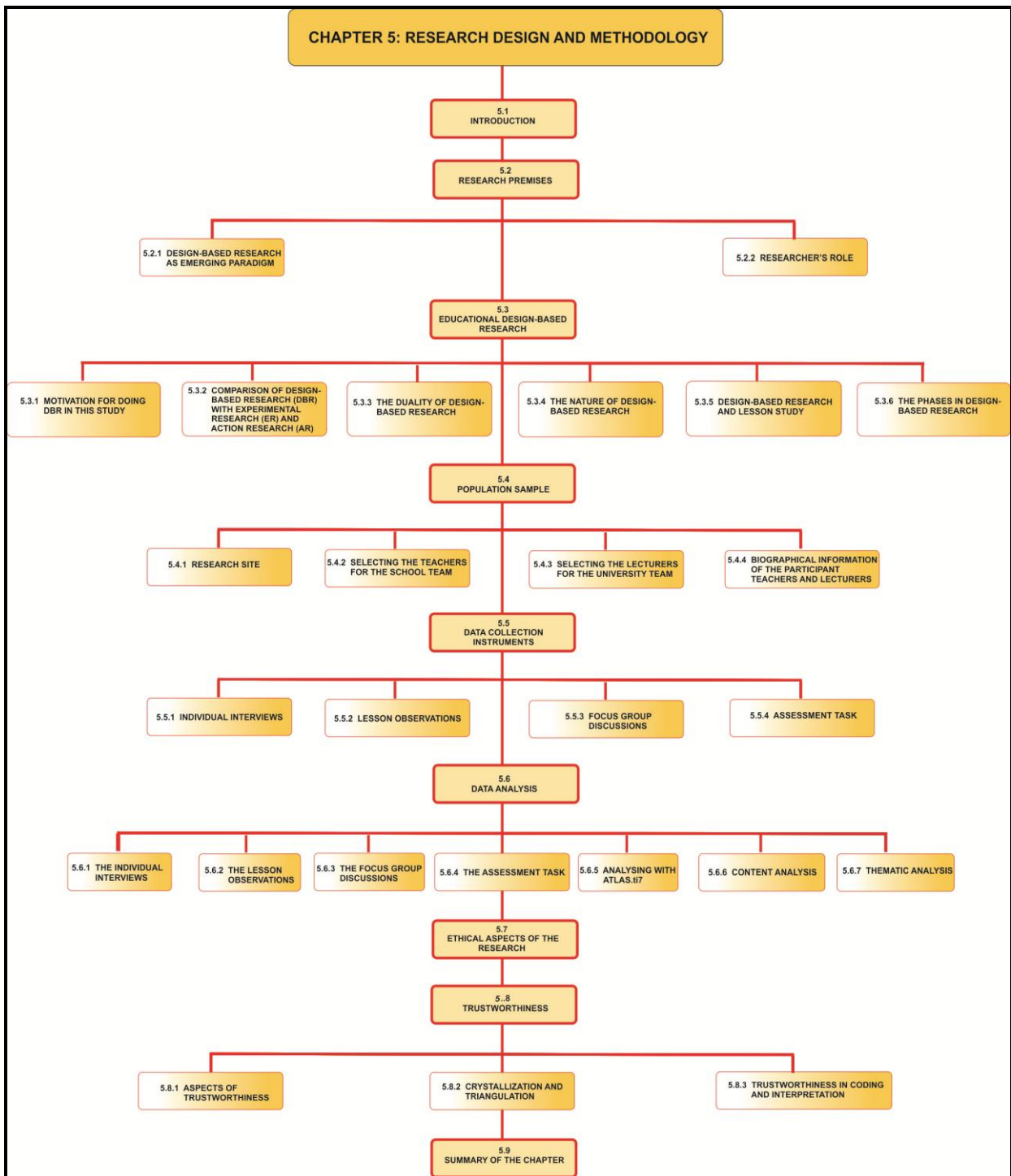


CHAPTER 5: RESEARCH DESIGN AND METHODOLOGY



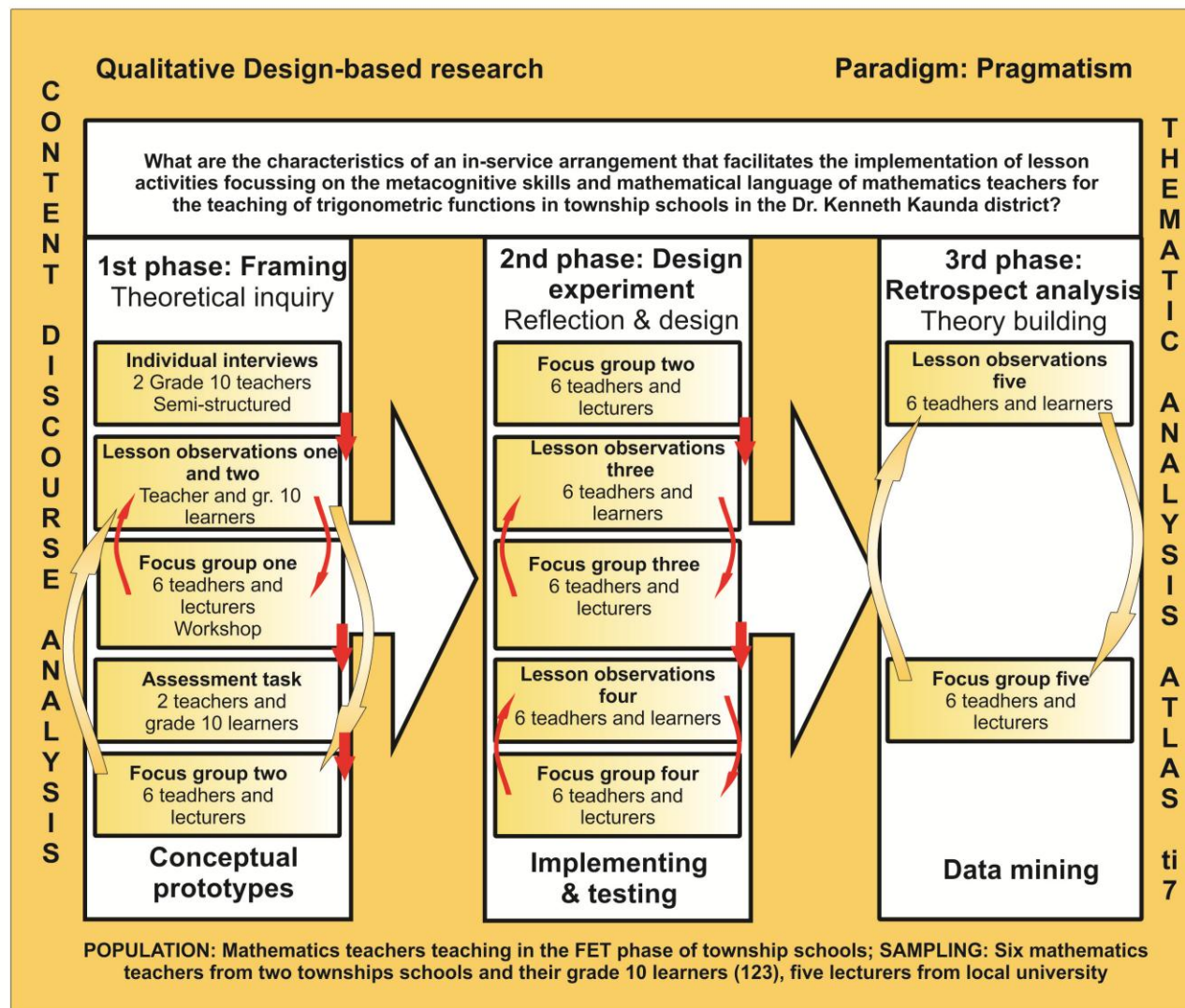


5.1 INTRODUCTION

In order to address the research questions, an empirical study consisting of design-based research was conducted in which the qualitative research approach was employed, additional to the non-empirical review of the literature that was done in Chapters Two, Three and Four. According to Teddlie and Tashakkori (2010), once specific questions have been formulated, a researcher should consider the most diverse array of methodological tools available to answer those questions through a process called *methodological eclecticism*. For Creswell (2009) the research design lies at the intersection of philosophy, strategies of inquiry and research methods, and researchers can follow a qualitative, quantitative or mixed method approach for their research. I have chosen the qualitative approach following Creswell (2009, p. 17) who characterizes qualitative researchers as tending to use the following practices:

- *Bring personal values into the study;*
- *Validate the accuracy of findings;*
- *Make interpretations of the data;*
- *Create an agenda for change or reform;*
- *Collaborate with the participants.*

I also elected methodologies characterizing design experiments in line with what Collins, Joseph, and Bielaczyc (2004, p. 15) promulgate “as a way to carry out formative research to test and refine educational designs based on principles derived from prior research”. In this chapter the premises on which I based this research study are addressed (§5.2), in which I explained my paradigmatic assumptions and my role as researcher within the study, followed by the research design (§5.3). §5.4 clarifies the population and sampling and includes a table with the biographical data of the teachers and lecturers while §5.5 lists and explains the data collection instruments used in the study. Next the data-analysis process in each phase is discussed (§5.6) before some ethical issues (§5.7) and the trustworthiness of the study (§5.8) are discussed. This chapter ends with a summary of the entire chapter. A diagrammatic presentation of the research design and methodology can be seen in Figure 5.1



5.2 RESEARCH PREMISES

5.2.1 Design-based research as emerging paradigm

Compared to other research methods in the education research arena, design-based research is relatively new (Bakker & Van Eerde, in press). According to the Collective (2003) and Anderson and Shattuck (2012), Design-based Research (DBR) is an emerging research paradigm in educational research and is indeed used by Thein *et al.* (2012) as paradigm in their study in which the affordances of design-based research for studying multicultural literature instruction in a teacher-researcher collaboration was interrogated. In their study Thein *et al.* (2012) argue that the following key elements distinguish DBR from other educational research paradigms: Firstly, DBR is always situated in real educational contexts such as classrooms (Collins, 1992), unlike paradigms from experimental research which is carried out in laboratories. Secondly, DBR is different from other ethnographic paradigms in that it takes into account the messiness and complexity of real classroom situations which is not the case in naturalistic settings in ethnographic research.

5.2.2 Researcher's role

Nieuwenhuis (2007a) emphasizes the involvement of the researcher in qualitative studies. In this study I had the dual role of researcher and participant: I performed the role of the researcher, conducting interviews and focus group discussions, but I was simultaneously the facilitator of the workshop and adapted lesson study sessions in which the lesson was designed and studied. As participant I facilitated the workshops, was experimenting and designing with the participant teachers while at the same time, as researcher, reporting on the progress within the study. Where other purely observational approaches try to minimise the observer's impact on the object of the inquiry, the interventionist nature of the methodology used in this study compelled me to be more involved in the study (Brown, 1992).

5.3 EDUCATIONAL DESIGN-BASED RESEARCH

There are many labels to be found in literature for design-based research in education, including (but not limited to) the following: *Design* studies; *Design* experiments; Development/Developmental research; *Formative* research; *Formative* evaluation; *Engineering* research (Van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). However, the following broad definition of Barab and Squire (2004, p. 2) seems to be a generic definition that encompasses most variations of educational design-based research:

a series of approaches, with the intent of producing new theories, artifacts, and practices that account for and potentially impact learning and teaching in naturalistic settings.

However, for the sake of consistency and because the name “design-based research” is used by the Design-Based Researcher Collective (2003) I decided to use the name “design-based research” in this study. Design-based research (DBR) has its origin in experimental research and blends empirical educational research with the theory-driven design of learning environments (Van den Akker et al., 2006). According to Collins *et al.* (2004, p. 15) the term “design experiments” was first used in 1992 by Ann Brown (1992) and Allan Collins (1992). The research component of this research study seeks to understand how a combination of the mathematics teacher’s metacognitive skills and mathematical language can be employed to bring about enhanced teaching of trigonometric functions. In the design component lessons were collaboratively developed and a hypothetical teaching and learning trajectory for the teaching of trigonometric functions was designed and implemented with an explicit focus on the mathematical language and metacognitive skills of the participant teachers during adapted lesson study.

5.3.1 Motivation for doing DBR in this study

Initially action research was selected for the proposed study because of the following compelling reasons:

Firstly, I wanted to bring about a positive change in practice and in the professional development of the participant teachers.

Secondly, I wanted immediate action and implementation, even while the phenomenon is not fully understood yet.

However, it was imperative that this study should also incorporate elements of experiment and design in the adapted lesson study, and as proponents of design-based research (Edelson, 2002; Kelly & Lesh, 2000), design experiments (Brown, 1992; Collins, 1992) and developmental research (Gravemeijer, 1994), all view design as a strategy for developing and refining theories, I decided to change to DBR. Gravemeijer and Cobb (2006) explain that DBR is meant to provide theories of how an innovation works: “It is tailored to develop subject and topic specific instruction theories in mathematics education” (Gravemeyer & Cobb, 2006, p. 34). Another reason for shifting from action research is that I realized that the primary obligation of teachers is teaching and not researching. Teachers have less time and resources to do research than lecturers for whom research is part of their task agreement. This made me realize that to expect each of the participant teachers to do their own complete action research study with the workload that they have and the limited resources for research, posed a challenge for the South African teacher.

As design-based research is normally used for understanding how, when, and why educational innovations work in practice (Sandoval & Bell, 2004), this was the perfect research design for finding the ways in which metacognitive skills and mathematical language can be used for the teaching of trigonometric functions. As the Design-Based Research Collective (2003, p. 6) explains:

Importantly, design-based research goes beyond merely designing and testing particular interventions. Interventions embody specific theoretical claims about teaching and learning, and reflect a commitment to understanding the relationships among theory, designed artefacts and practice. At the same time, research on specific interventions can contribute to theories of learning and teaching.

Design-based research is best described by the Netherlands term “ontwikkelingsonderzoek”. In this study design-based research entailed the investigation of a phenomenon (the metacognitive skills and mathematical language of the participant teachers) while at the same time developing these skills and language use through iterative cycles of experimentation (adapted lesson study) for the enhanced teaching and learning of trigonometric functions. As qualitative methods usually reflect more fully the voices of the teachers and are expected to be gauging the metacognitive skills and mathematical language usage of the teachers more effectively, focus

groups, individual interviews, lesson observations and a trigonometric task assessment were used as data gathering instruments.

5.3.2 Comparison of Design-based Research (DBR) with Experimental Research (ER) and Action Research (AR).

As design-based research emerged originally from experimental research and tends to sometimes be confused with action research, the following table highlights some differences and also similarities of DBR with ER and AR within this particular study, adjusting tables developed by (Bakker & Van Eerde, in press) that list the similarities and differences between DBR, ER and AR.

Table 5.1: A comparison of Design-Based Research (DBR) with Educational Research (ER) and Action Research (AR)

	ER	DBR	AR
Commonalities	New intervention is proposed to replace existing traditional instructional theory		
	Experimental in nature		
		Open, researcher can be participant, reflective cyclic process Aims to bridge theory and research	
Differences		Researcher can be observer and not participant	Researcher can only be participant
	Comparison of existing teaching methods by means of experimental and control groups	Design of an innovative learning environment is necessary	Design is possible
	Testing theory	Developing and testing theory simultaneously	Focus on action and improvement of a situation
	Proof of what works	Insight into how and why something works	
	Statistical generalization	Analytical or theoretical generalization	.
	Research interest is isolated by manipulating variables separately	Holistic approach	
	Causal claims based on a regularity view on causality are possible	Causality should be handled with great care and can only be based on a realist, process-orientated view on causality.	

Source: Bakker & Van Eerde, in press, p. 7

Lastly traditional research designs seemed ill-suited to achieve both understanding and improved practice simultaneously in the field. It was therefore more appropriate to use a design which not only brings about simultaneous understanding and improvement but which could also cope with the fuzziness and complexity of mathematics teaching and learning and in this case trigonometric teaching in a real time classroom. The diagram in Figure 5.2 shows how research improves practice in design-based research.

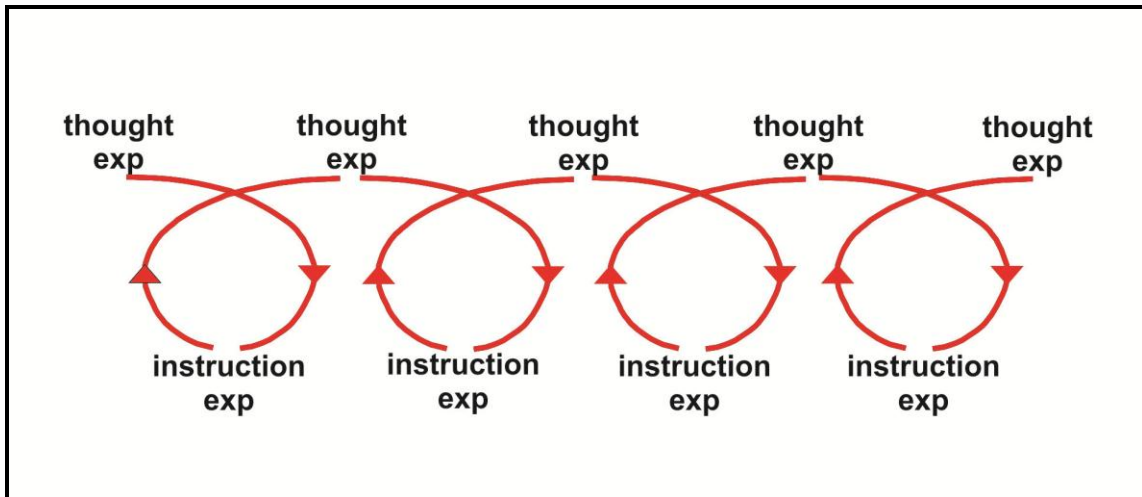


Source: Van den Akker, 2006:13

Figure 5.2: How research improves practice

5.3.3 The duality of design-based research

Although the general goal of design-based research is to investigate the possibility of educational improvement, two definite roles can be distinguished: (i) Designing and (ii) experimenting (Gravemeijer & Van Eerde, 2009). Designing happens through thought experiments while the experimenting role happens through instruction experiments in an iterative process of micro design cycles as the following figure (Figure.5.3) illustrates.



Source: Gravemeijer and Van Eerde 2009, p. 514

Figure 5.3: An iterative process of micro design cycles

In the same vein they explained further that for the research part design-based researchers draw from various disciplines such as the cognitive sciences and developmental psychology while for the design part might draw from fields such as computer science and teacher education. This duality within design-based research found exposition in the activities of two teams of the research collective in this study: Firstly there was the school team that consisted of all the participating teachers, while the research team consisted of the researcher, her colleagues in the mathematics department of the university and also other members within the project across different faculties (Education Sciences and the Natural Sciences), universities (North-West University and the Walter Sisulu University), provinces (North-West and Limpopo) and even countries (South Africa and the Netherlands). Workshops and lesson observations at the two schools and project-meetings at the university were the two main occasions from which data collection and analysis originated. The two teams and their activities within the study are illustrated (Figure. 5.4) below.

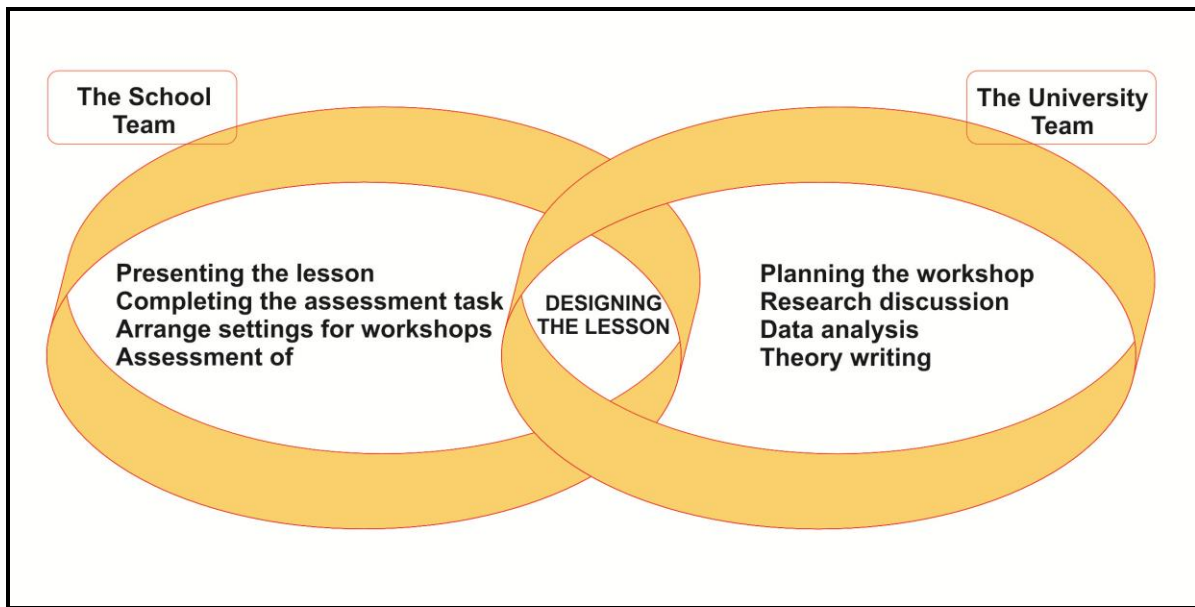


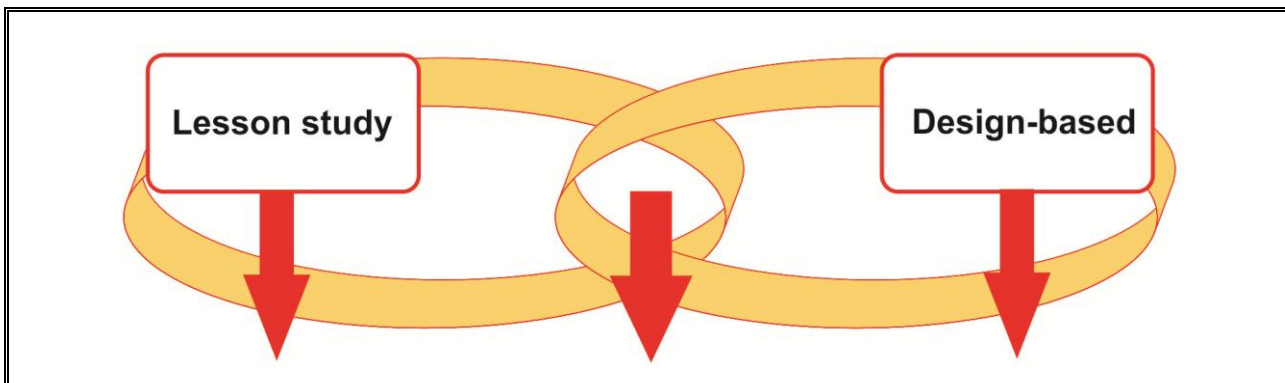
Figure 5.4: Activities of teams within this study

5.3.4 The nature of design-based research

Sandoval and Bell (2004, p. 200) explain that design-based research is of such a nature that it “simultaneously pursues the goals of developing effective learning environments and using such environments as natural laboratories for the study of teaching and learning”. This characteristic of design-based research mentioned by Sandoval and Bell (2004) concurs with the first of five features identified by Cobb, Confrey, DiSessa, Lehrer, and Schauble (2003) which apply to design-based research: Firstly the purpose of design-based research is not only to develop theories about learning but also to create the means to support that learning. The second cross-cutting feature of design-based research lies in its desire to become involved in a problem or a crisis which does not concern it directly. Design-based researchers are not constrained to improve the design after an experiment cycle has been carried out. Thirdly, design-based research has a reflective and a prospective component that need not be separated by an experiment. The fourth feature is the cyclic character of design-based research which forms an iterative process. The fifth crosscutting feature of design-based research is that the theory under development has to do real work and should be general enough to be applicable in different contexts such as classrooms in schools, locally and abroad. In this regard, (Joseph, 2004) concurs that the day-to-day needs of real-world practice place constraints and demands on both design and research activities.

5.3.5 Design-based research and adapted lesson study

As was explained earlier, the original research design for this study was action research. The idea to use adapted lesson study as vehicle through which the metacognitive skills and the mathematical language of the participating teachers could be investigated, and through which a Hypothetical teaching and learning trajectory for the teaching of trigonometric functions was designed, was the main reason why the original research design was changed to design-based research. Lesson study actually involves four stages (Lewis et al., 2006), but in this inquiry these stages were adapted to only three stages: The first stage (the planning) happened in the focus group prior to the lesson, while the second stage (implementation) happened with the presentation of the lesson by one of the teachers. The last stage (reflection) happened in the focus group held soon after the lesson that was presented. However, design-based research is not lesson study. Sack and Vazquez (2011) developed a Venn diagram (Fig. 5.5) that illustrates how these two differ but also what they have in common in terms of the activities involved, teacher and or researcher learning and lastly the outcomes:



Activities	• Observe the research lesson and collect data on student learning and development. • Use the data to reflect on instruction more broadly	• Plan a research lesson based on goals for student learning and development • If desired, review and reteach the lesson research lesson to a new group of students	• Teach the research lesson and collect data on student learning and development. • Use the data to reflect on the lesson and student learning.
Teacher/Researcher learning	• Motivation	• Increased knowledge and connections among knowledge • Sense of efficacy • Professionalism • Lesson plans • Representations/models • Manipulatives/worksheets • Assessment protocol	• Dissemination of knowledge
Outcomes		• Improved classroom practice	• Curricular resources for the development of spatial skills

Source: Sack & Vazquez, 2011: 218

Figure 5.5: The intersection between lesson study and design-based research Venn diagram

One main commonality between lesson study and design-based research, except the fact that they are both conducted within the naturalistic setting of the school environment, is their iterative character. Both consist of cycles in which practice has to improve. The nature of lesson study and design-based research in terms of its purpose, the different roles played by the teachers, the researcher and the lecturers, as well as the outcomes thereof in this study can be tabulated as follows:

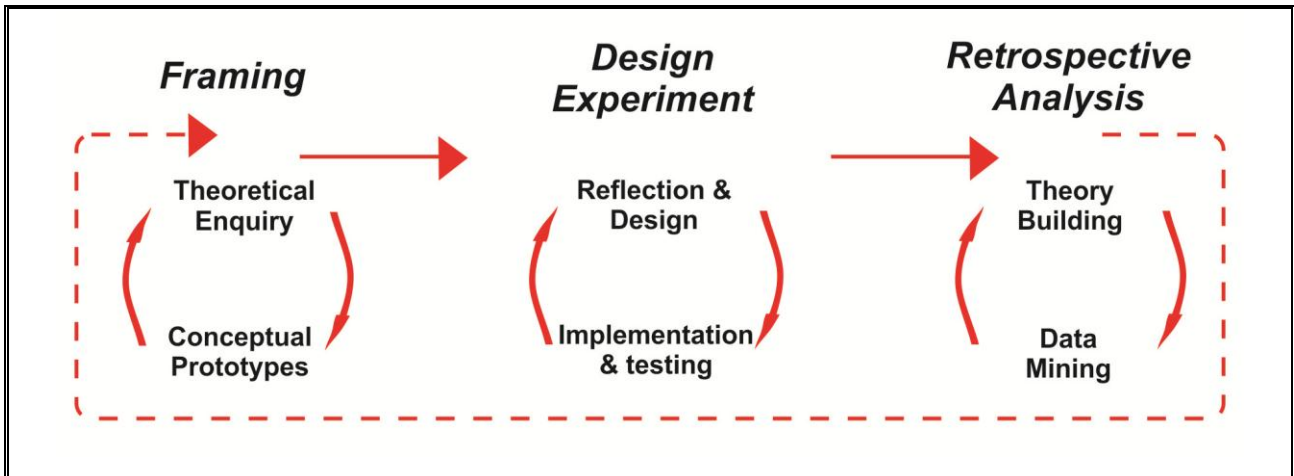
Table 5.2: Adapted lesson study and design-based research as manifested in this study

Criteria	Adapted lesson study	Design-based research
Purpose	Improve the practise of teachers to ensure optimum learning for the learners	Develop theories about learning Create means to support learning
Role of teachers	Plan and re-plan of study lesson Teach and re-teach of study lesson Observe video recording of study lesson Critique and discuss lesson	Design learning experiences informed by theory Teach and re-teach of lessons Observe video recording of study lesson Critique and discuss lesson in focus group discussion Attend workshops
Role of researcher	Plan lessons collaboratively with teachers Observe lessons Critique lessons Conduct discussion forum	Design lessons informed by theory Observe lessons using criteria from theory Collect data Twig/adjust theory Analyse data Conduct discussion forums Conduct workshops
Role of lecturers		Design learning experiences informed by theory Observe video recording of study lesson Critique and discuss lesson in focus group discussion
Outcomes	An effective lesson Lesson plan More effective instruction More and better learning Improved content knowledge Improved reflection practices More critical stance Improved self-knowledge	New or adjusted theory More effective instruction More and better learning Improved content knowledge Effective interventions Improved reflection practices More critical stance Improved self-knowledge

The next session addresses the three phases of design-based research which I decided upon in order to carry out the study.

5.3.6 The phases in design-based research

With the literature indicating either three phases (Bakker & Van Eerde, in press; Mor, 2010) or four phases (Herrington et al., 2007) for a design-based study, I decided to use only three phases as this was sufficient for my study. According to Mor (2010) the process of a design study starts with a framing phase, followed by a design experimenting phase which may consist of multiple iterations of the design experiment and ends in a retrospective analysis phase in which empirical data from all the iterations are considered as can be seen in Figure 5.6.



Source: Mor 2010, p. 47

Figure 5.6: The research design meta circle

Phillips (2006) agrees with these phases when he views the scientific cycle in design-based research as starting with the identification and clarification of a significant problem and moving, via a series of studies and analyses, to a refined hypothesis or treatment that is worthy to be tested.

5.3.6.1 The Framing phase

Phillips (2006) prescribes, for this preliminary investigation, deep factual and theoretical background knowledge if the researcher wants to come up with an intervention or treatment that is worth testing. Van den Akker et al. (2010) advises for this phase an analysis of the needs and the context, a review of the extant literature on metacognition (Chapter 2), as well as the development of a prototype (Chapter 3) and theoretical framework (Chapter 4) for the study. The analysis of the needs and the context also included a thorough study of what is required from the

curriculum regarding trigonometric functions as section of trigonometry (§3.9.4), and studies already done in trigonometry (§3.9.2 & 3.9.5). The researcher also discussed trigonometric functions and the trigonometric tasks (Addendum D3) which were used in the lessons with her colleagues in line with suggestions made by Bakker and Van Eerde (in press) for the first phase which they refer to as the Preparation and Design Phase. The assessment task was given to knowledgeable lecturers within the mathematics subject group to refine the task. During this first phase the two grade 10 teachers were interviewed to pinpoint their perceptions of mathematics and beliefs about mathematics, as well as how they experienced their training as mathematics teacher (Addendum D1). In this phase the first two lessons were presented in which trigonometric functions were introduced. In order to be on the same page with each other, this phase also included a workshop in which metacognition and adapted lesson study was discussed in more detail. This workshop was held at the same time as the first focus group discussion; the focus group discussion was held directly after the workshop. At the end of the workshop, teachers were completing the trigonometric assessment task themselves and during the task had to reflect on their thinking. Hereafter the discussion of the first lesson followed. This phase is also characterized by the initial development of the hypothetical teaching and learning trajectory (§3.9.6).

5.3.6.2 The Design Experiment phase

Bakker and Van Eerde (2012) refer to this phase as the teaching experiment and propose for this phase that researchers and teachers use any appropriate activity or type of instruction in the lesson and “take their best bets” (p. 12). In this study this second phase consisted of two cycles in which two lessons were observed and three focus group discussions were held. The framework for the examination of metacognition in metacognitive instruction, the MTFM, discussed in Chapter 2 (§2.7.4) was implemented to a great extent in this phase to gauge the metacognitive skills and mathematical language used by the teachers. Van den Akker *et al.* (2010) proposed for this phase “an iterative process of ‘successive approximation’ or ‘evolutionary prototyping’ of the ‘ideal’ intervention” and warns that “direct application of theory is not sufficient to solve those complicated problems” (p.46). It is advisable to rather follow a more constructivist approach with “researchers and practitioners cooperatively construct workable interventions and articulate principles that underpin the effects of those interventions” (p. 47). Formative evaluation of the intervention further characterizes this phase.

5.3.6.3 The Retrospective analysis phase

Other than in the previous phase where formative evaluation was applied to assess the “success” to find out whether the intended outcomes were reached with the intervention, this phase employed summative evaluation. Van den Akker (2010, p. 48) is alluding to the fact that this evaluation should not only highlight the weak points of the intervention, but also that suggestions for improvement be made:

Formative evaluation within development research should not only concentrate on locating shortcomings of the intervention in its current (draft) version, but especially generate suggestions on how to improve those weak points. Richness of information, notably salience and meaningfulness of suggestions in how to make an intervention stronger, is therefore more productive than standardization of methods to collect and analyze data.

In conclusion of this discussion about the different phases, it is also important to keep in mind that the adapted lesson study cycles were also incorporated in these three phases. As adapted lesson study was employed within a design-based research the operationalization produced a big challenge to me as researcher. I had to plan carefully how adapted lesson study would function within my study. The following figure (Figure 5.7) attempts to visualize how the different cycles played out within the three phases of this design-based research study, as well as indicating the timeframe in which the cycles factored into the three phases.

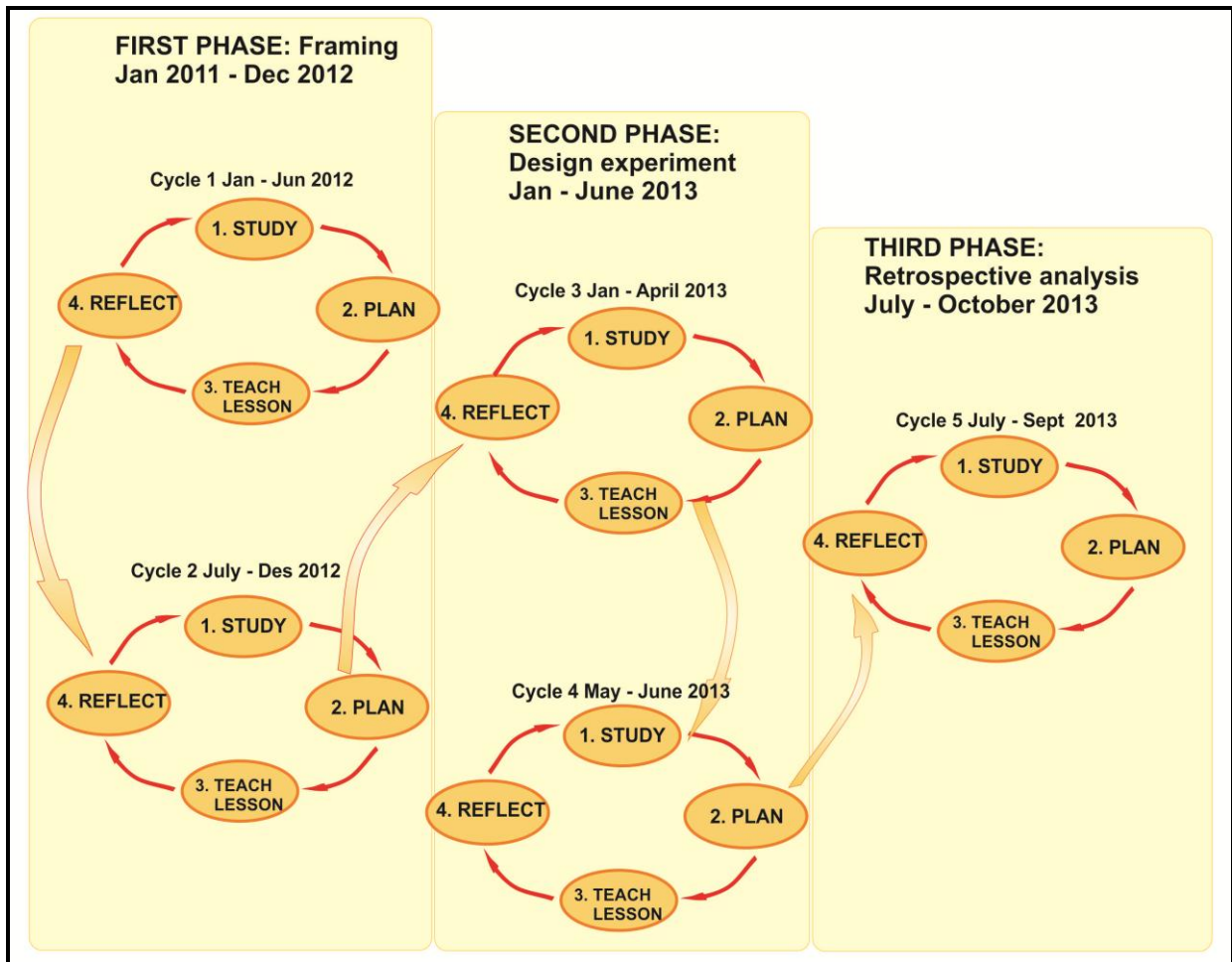


Figure 5.7: Operationalization of adapted lesson study within the design-based approach

The next section addresses the population and sampling within this study.

5.4 POPULATION AND SAMPLE

The population for this study involved all mathematics teachers teaching in the FET phase of township secondary schools in the Dr Kenneth Kaunda District of the North West Province. The sample comprised six mathematics teachers teaching in two township secondary schools, five lecturers were selected to participate in the study as well as the grade 10 learners (about 120 in total) in year 2012 and 2013 from the two schools.

5.4.1 Research site

The research sites where the research was carried out were two rural secondary schools in the Dr Kenneth Kaunda district of the North West province. These schools are referred to in this study as the Red School and the Blue School characterized by the color of the school uniform worn by the learners. Purposive sampling was employed to identify the two schools with the help of the Mathematics Subject Specialist in the Dr Kenneth Kaunda district in the North West province. The criteria for selection of the schools were mainly based on: (i) accessibility (schools are near to university) and (ii) positive attitude (for change) of the teachers.

5.4.1.1 The Red School

The school was established in 1992. At the time the school consisted only of grade 9s. During this time they shared the current building with another school in the neighbourhood. The building did not have any windows, doors and furniture. Educators had to share offices for administrative work. The staff consisted of 15 educators.

The school has expanded since then to a fully-fledged high school that currently goes up to grade 12. The staff establishment for 2013 is 30 members which consist of a principal, a deputy principal and four heads of department. There are 748 learners on the roll.

Extra mural activities include soccer, netball, athletics and choral music. The school starts at 7:30 till 14:10 in the afternoon. There is a feeding scheme which is subsidised by the Department of Education.

5.4.1.2 The Blue School

The Blue School is a fairly new school. The school was established in 2007 with 277 learners and 11 educators from grade 8 to 12. In 2013 the learner number has risen to 1122, with 38 educators. The school management team consists of one principal, two deputy principals and four heads of departments. The school day starts at 7:30 and ends at 14:30.

The school is also involved in extra mural activities. They compete in chess on a national level and other activities include athletics, soccer, netball and choral music. The school is part of the National School Nutrition Program which provides food for learners during the day.

Since the inception of the school they have maintained a remarkable feat of an annual pass rate of more than 96%.

The next section explains how I arrived at my sample.

5.4.2 Selecting the teachers for the school team

As was previously mentioned, at the start of my study in 2011 the two schools were selected by the subject advisor who deemed support of any kind necessary for these two schools. The one school was fairly new and the other school was not doing very well (Matric pass mark constantly under 50%) and was what has now become acceptable to be referred to as a “trapped school”. For the purpose of this study I refer to the new school as the Blue school (the learners’ uniform is blue) and the other school as the Red school (because of the learners’ uniform being red). I then made an appointment with the two principals and asked to be given an opportunity to speak to the mathematics teachers in the FET phase regarding my proposed study. At the information session at each of the two schools, I informed the teachers about my study and invited them to take part. Three of the four teachers at the Blue school accepted the invitation to be part of the study. I then handed them consent forms and explained about the adapted lesson study issue which might cause some discomfort but assured them that they might withdraw at any time if they felt uncomfortable because of this issue. Two of the teachers, one female and the other a male teacher, took part in the study until the end while the third teacher (male) from the Blue school withdrew in the second year of my study explaining that the study is interfering with his own Honnors study at the same university I am working. For the purpose of the study and to ensure confidentiality I refer to the female teacher as Teacher B and the male teacher as Teacher C. At the Red School all four teachers teaching mathematics in the FET phase agreed to take part in the study. These teachers seemed very excited about the study and were eager to learn whatever the study could offer. All the teachers at the Red school were male teachers and took part in the study until the end. To ensure confidentiality I renamed the four teachers as teacher A, D, E and F. In order to ensure a meaningful and more in-depth study of the learning happening for the teachers, only two of the teachers, teacher A, the grade 10 male teacher from the Red School and teacher B, the grade 10 female teacher from the Blue school were focused

on. Although six teachers were used in the study the teaching and particularly the learning of only two teachers were focused on for a more in-depth interrogation of exactly how these two teachers are using their metacognitive skills and mathematical language in the teaching of trigonometric functions. I am of the opinion that taking this route resulted in a more intensive and rigorous study.

5.4.3 Selecting the lecturers for the university team

I used to speak a lot about my study to my colleague who I am working with very closely in the Advanced Certificate in Education Programme. As a result she became very interested and was the first lecturer I invited to take part in my study. The next lecturer I selected because of his knowledge in Trigonometry. He had just received his master's degree in Mathematics and I invited him to take part in my study. I then approached two of my other colleagues in the mathematics department, working in professional development programmes of distance education and invited them to take part in the study. Lastly I approached my study leader whom at this stage was also the leader of the project in which my study was based, to join and especially to act as moderator in the focus group discussions. According to McMillian and Schumacher (2001), an experienced moderator is essential to give direction to the discussion, keep track of who did not have an opportunity to speak and to keep the focus in the group discussions. These lecturers were essential in my study to provide theoretical knowledge but also to bring their experiences as they all used to be mathematics teachers themselves. Due to confidentiality I refer to these lecturers as lecturer A, B, C and D and then I kept the name Study Leader (SL) the same way I referred to myself as Researcher (R) in the transcriptions of the focus group discussions. Except for lecturer D who is based in the Natural Sciences faculty, all the other lecturers were based in the Education Sciences faculty where they were involved in teacher training daily and were all researchers. These lecturers were very valuable for this study, particularly in the focus group discussions.

5.4.4 Biographical information of the participant teachers and lecturers

Table 5.3: Biographical data of teachers and lecturers

Teacher/Lecturer	Age	Qualifications	Tertiary Institution/s where qualifications were awarded	Main subjects	Mathematics teaching experience (in years)
Teacher A	41-50	ACE (Advanced Certificate in Education) BEd Hons degree	North-West University	Mathematics Educaion	Less than 10 years
Teacher B	41-50	Teachers diploma BEd Hons degree	College of Education North-West University	Mathematics	11- 20 years
Teacher C	41 -50	3 year Teachers diploma BEd Hons degree Med degree	College of Education North-West University	Mathematics	11-20 years
Teacher D	41-50	3 year Teachers diploma	College of Education	Mathematics	11 – 20 years
Teacher E	41-50	BEd Hons degree MSc Chemical Engineering	North-West University	Science	11-20 years
Teacher F	41-50	ACE (Advanced Certificate in Education) Higher Diploma in Education Science Education	North-West University	Mathematics Science	11-20 years

Teacher/Lecturer	Age	Qualifications	Tertiary Institution/s where qualifications were awarded	Main subjects	Mathematics teaching experience (in years)
Lecturer A	51 -60	National Diploma in Technical Education (1994) B-TECH (1998) Post Graduate Diploma: Mathematics Education (1999) MSc Mathematics Education (2000)	Technikon Northern Transvaal which became the Tshwane University of Technology (Pretoria) Port Elizabeth Technikon which became the Nelson Mandela Metropolitan University Curtin University of Technology (Western Australia) Curtin University of Technology (Western Australia)	Mathematics and Electrical Mathematics education Mathematics education	14 years as mathematics teacher 3 years as lecturer (mathematics education)
Lecturer B	51 - 60 years	BSc 1978 HOD 1979 BEd Hons 2011	University of Pretoria University of Pretoria North-West University	Mathematics Mathematical Statistics Computer Science	23 years teaching 18 years as Mathematics teacher 6 years as lecturer (Mathematics education)

Teacher/Lecturer	Age	Qualifications	Tertiary Institution/s where qualifications were awarded	Main subjects	Mathematics teaching experience (in years)
Lecturer C	51-60	BSc 1980 NHOD 1981 BEd 1992 MEd 2005	Rand Afrikaans University Rand Afrikaans University University of South Africa University of South Africa	Mathematics and Chemistry Mathematics Education	As Mathematics teacher: 7 As lecturer (Mathematics education): 17
Lecturer D	41 – 50 years	B. Econ 1994 HDE 1995 B.Ed Hons 2008 B.Sc Hons 2011 M.Sc 2012	University of the Free State University of the Free State North-West University North-West University North-West University	Financial Mathematics and Economics Mathematics and Economics Didactics Mathematics Education Mathematics Mathematics	As Mathematics teacher: 6 years As Mathematics lecturer: 8 years

Teacher/Lecturer	Age	Qualifications	Tertiary Institution/s where qualifications were awarded	Main subjects	Mathematics teaching experience (in years)
Study leader	Between 50 and 60 years	PhD (2008)	North-West University Potchefstroom campus	Mathematics German	Mathematics Teacher: 18 yrs Mathematics Subject Advisor: 6 yrs Lecturer (Mathematics Education): 15 yrs 39 years

Data from the individual interviews that was held with teacher A and B rendered the following useful information.

Teacher A

Teacher A is a male teacher between 41 and 50 years old. He holds a degree with specialization in Mathematics Education and has been teaching Mathematics for less than 10 years. His home language is Setswana, but he is teaching in English and finds trigonometry easy to teach, but mentions that learners find it difficult. On the question regarding mathematics schooling and training, teacher A explained that he did not get the best mathematics instruction when he was at school, but he did experience his tertiary training in mathematics from the university quite positively.

Teacher B

Teacher B is a female teacher who is between 41 and 50 years old. She holds a degree with specialization in Mathematics as well as a postgraduate teaching qualification and has been teaching Mathematics for more than 11 years, but less than 20 years. She is teaching in English, although it is not her home language and finds trigonometry easy to teach.

The next section addresses the strategies how data were gathered in this study.

5.5 DATA COLLECTION INSTRUMENTS

The research study consisted of both non-empirical and empirical components: The non-empirical component encompasses literature regarding metacognitive skills (Chapter 2) and mathematical language as well as adapted lesson study (Chapter 3) in support of the non-empirical component. The empirical component of the study was both exploratory and explanatory and comprised the following qualitative data collection instruments: lesson observations, individual and focus group interviews (audio and video-recording, verbatim transcriptions),

The data collection instruments were all qualitative, and how these instruments were employed in this study in an attempt to address the question and specifically the sub-questions can be tabulated as follows:

Table 5.4: Data collection instruments in relation to the research questions and unit of analysis

Question	Data-collection instrument	Population	Unit of analysis
How do mathematics teachers apply metacognitive skills and mathematical language in the teaching of trigonometric functions in township schools in the Dr. Kenneth Kaunda district?	Individual interviews	Teachers	2 grade 10 teachers (One from each school)
	Assessment task	Teachers	Teachers
		Learners	Grade 10 learners of 2012 and 2013 from the two schools
	Lesson observations	Teachers	Teachers and grade 10 learners
Which are the challenges mathematics teachers are facing in the teaching of Trigonometric functions in township schools?	Individual interviews	Teachers	2 grade 10 teachers (One from each school)
	Lesson observations	Teachers	Teachers and grade 10 learners of 2012 and 2013 from the two schools
	Focus group discussions	Teachers	Teachers and lecturers
How can the teaching of Trigonometric functions be improved focussing on the metacognitive skills and mathematical language used by mathematics teachers in township schools?	Focus groups discussions	Teachers	Teachers and lecturers
	Lesson observations	Teachers	Teachers and grade 10 learners of 2012 and 2013 from the two schools

Data collection in a design-based research requires a systematic approach even more than what is required in other research methodologies because of the *empirical testing* of both the usability and the effectiveness of the intervention (Van den Akker et al., 2010).

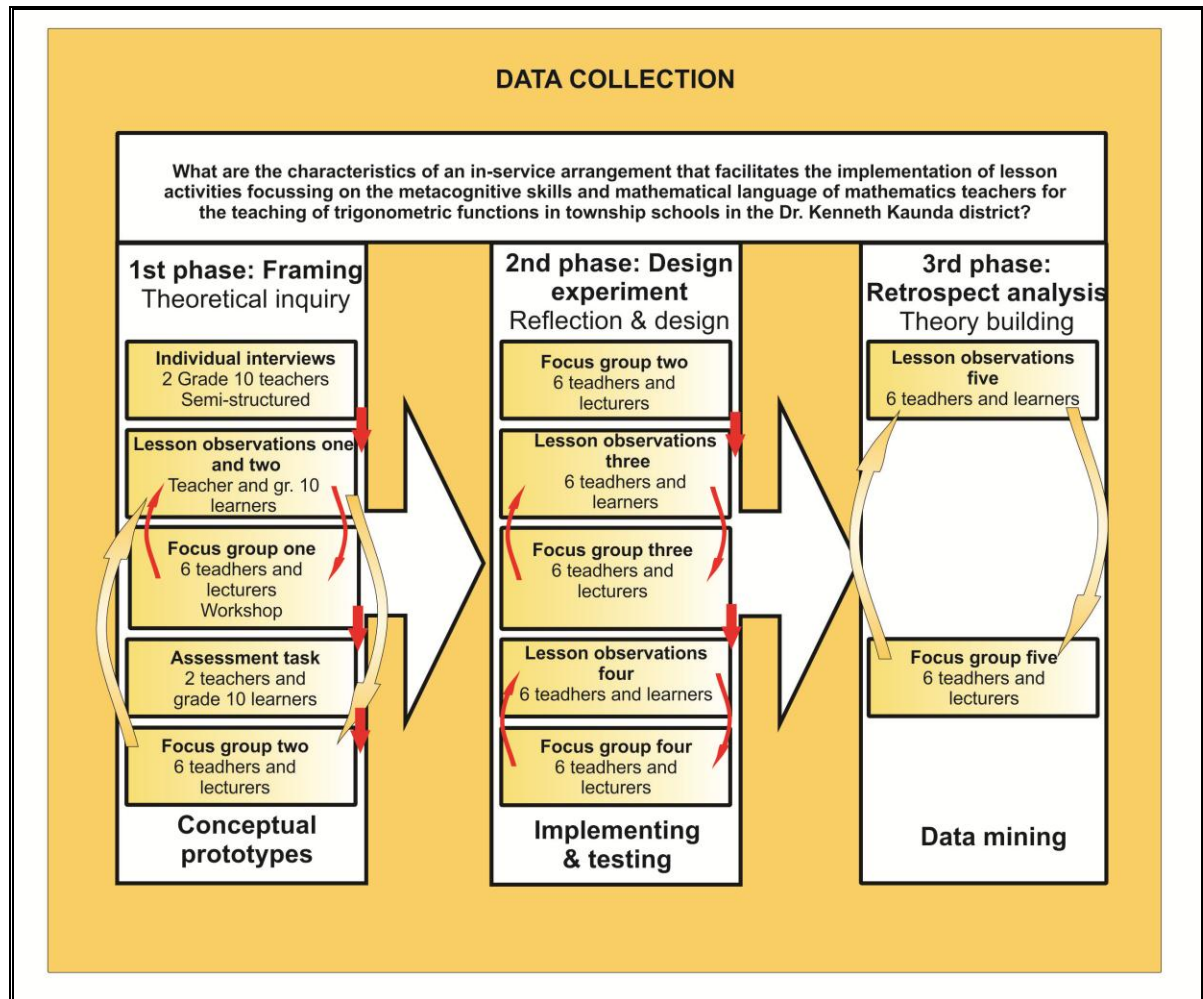


Figure 5.8: The data collection process within the three phases of the study

5.5.1 Individual interviews

The knowledge required by the research question and the qualitative nature of the study instigated the use of individual semi-structured interviews which provided a situational and contextual account of how knowledge was constructed in the study in line with the view of Mason (2002) that qualitative interviewing tends to be seen as knowledge that is constructed and reconstructed and not merely excavated. The interview becomes a team effort between the interviewer (researcher) and the interviewee in a co-production to create meaning and

understanding in the interaction of the researcher and the interviews. Individual semi-structured interviews were held with the participant teachers mainly in order to develop the metacognitive performance profiles of each of the two grade 10 teachers. These interviews reflected on the experiences of the participant teachers with the emphasis on the metacognitive skills as well as the mathematical language used in the given lesson. All the interviews were audio-taped and transcribed verbatim by the researcher and were sent for member-checking to the participants in an attempt to enhance the trustworthiness of the study.

5.5.2 Lesson observations

The aim of lesson observation as data-collection instrument in this study was twofold: Firstly, observations by the researcher during the first two lessons informed the establishment of an metacognitive performance profile for each of the two grade 10 teachers in the study. Secondly the lessons were video-taped and the video recording of these lessons were played as stimulant for discussions during the focus group sessions by the rest of the teachers and the lecturers, following the work of Sherin (2004) and Sherin and van Es (2009) that video recording of lessons shows great potential for teacher development. The following nine indicators from the work of Artzt and Armour-Thomas (2002) were selected to form the main criteria for the lesson observation (Addendum D2): The nature of the mathematical content, questioning, motivation and teaching strategies, homework, use of class time, verbal behaviour of learners, task orientation of learners, assessment and teacher expectations and stereotyping.

5.5.3 Focus group discussions

Researchers (Creswell, 2009; De Vos, Strydom, Fouchè, & Delpont, 2011; Kitzinger, 1994; Nieuwenhuis, 2007b) agree that the focus group is a technique that involves the use of in-depth group interviews for which the participants are identified because they form a purposive sample, and not necessarily because they represent a specific population. The opportunity to build on each other's ideas and comments is one characteristic that cannot be obtained with individual interviews and as such it is a big advantage of the focus group interview (Nieuwenhuis, 2010). In this study the focus group interview is embarked upon in order for participants to reflect collectively on the use of their metacognitive skills and their mathematical language in the given lesson. I made sure that the number of members participating in the focus group discussions never exceeded twelve people. All the discussions were video-taped and transcribed verbatim. Copies of all the transcriptions were sent to each focus group discussion participant to member-check.

A schedule (Table 5.5) with planned focus group discussions and lesson observations was drafted in collaboration with the study group. It is important to note that the Japanese lesson study was adapted to suit the South African context as well as the needs of the six participant teachers. Lessons were for example video-taped to be viewed later by the other teachers where Japan lesson study teachers were watching the actual lesson.

Table 5.5: Schedule of the planned focus group discussions and lesson observations to be held

Focus group	Date	Focus
Lesson observation one at Red School	May 2012	Metacognitive skills and mathematical language usage by teachers and learners
Focus group discussion one	May 2012	Common understanding of the teaching of trigonometric functions within the CAPS document Discussion of first video- taped lesson
Lesson observation two at Blue School	June 2012	Metacognitive skills and mathematical language usage by teachers and learners
Workshop one: Metacognition and Mathematical language	August 2012	Metacognition Mathematical language
Focus group discussion two	February 2013	Common understanding of trigonometric functions within the CAPS document Discussion of second video- taped lesson
Lesson observation three at Red School	March 2013	Adapted lesson study: Observing implementation of hypothetical teaching and learning trajectory
Focus group discussion three	March 2013	Adapted lesson study Designing of hypothetical teaching and learning trajectory
Lesson observation four at Blue School	April 2013	Adapted lesson study: Observing implementation of hypothetical teaching and learning trajectory
Focus group discussion four	April 2013	Adapted lesson study Designing of hypothetical teaching and learning trajectory
Lesson observation five at Red School	May 2013	Adapted lesson study: Observing implementation of hypothetical teaching and learning trajectory
Focus group discussion five	May 2013	Adapted lesson study Designing of hypothetical teaching and learning trajectory

Table 5.6 shows the actual focus group discussions and lesson observations that were held in the study. This is an indication of the challenging nature of lesson study in the SA context as the focus group discussions and lesson observations did not realize as they were planned.

Table 5.6: Schedule of actual focus group discussions and lesson observations held

Focus group	Date	Focus
Lesson observation one at the Red School	25 th April 2012	Metacognitive skills and mathematical language usage by teachers and learners
Lesson observation two at the Blue School	26 th April 2012	Metacognitive skills and mathematical language usage by teachers and learners
Workshop One: Metacognition and Mathematical language	8 th August 2012	- Metacognition - Mathematical language
Focus group discussion one	8 th August 2012	Discussion of first video- taped lesson
Focus group discussion two	27 February 2013	Adapted lesson study: Common understanding of trigonometric functions within the CAPS document Planning of study lesson and in particular the hypothetical teaching and learning trajectory
Lesson observation three at the Blue School	11 March 2013	Adapted lesson study: Observing implementation of hypothetical teaching and learning trajectory
Focus group discussion three	13 March 2013	Adapted lesson study Designing of hypothetical teaching and learning trajectory
Lesson observation four At the Red School	28 th May 2013	Adapted lesson study: Planning lesson together Observing implementation of hypothetical teaching and learning trajectory
Focus group discussion four	30 th May 2013	Adapted lesson study Designing of hypothetical teaching and learning trajectory
Lesson observation five at the Red school	30 th July 2013	Adapted lesson study: Observing implementation of hypothetical teaching and learning trajectory
Focus group discussion five	31 st July 2013	Adapted lesson study Designing of hypothetical teaching and learning trajectory

At the focus group discussions a video recording of the lesson that was given by one of the teachers was viewed by the school team as well as the university team in line with the value of videos in teacher education by (Sherin, 2004). These sessions can be seen as the planning phase as well as the reflecting phase in adapted lesson study (Lewis et al., 2006) which forms an integral part of this study. So might focus group discussion three for example be seen as the reflection of lesson two but also the planning of lesson three because lesson two was reflected upon while what should happen in lesson three was discussed, based on the analysis of lesson two at such a session. The lesson study group consisted of the six participant teachers, the researcher, the study leader and five other lecturers in the mathematics subject group where the researcher is based. On request of the researcher the participant teachers selected a common problem area in the teaching and learning of the mathematics curriculum in the FET phase, namely Trigonometric functions and the application thereof in solving problems. The focus of these sessions was on enhancing the metacognitive skills and mathematical language of the participant teachers in the teaching of trigonometric concepts and its implementation in solving problems.

5.5.4 Assessment task

For the learners: An assessment task that attempted to gauge the metacognitive skills employed by learners was developed by the researcher in collaboration with the study leader who has extensive experiences in developing standardized assessments for metacognitive skills. This task was given to the learners of the participant teachers to form part of the quantitative data in the study. The assessment highlighted the possible metacognitive activities which these learners engaged into in mathematics classrooms in the FET phase in rural schools in the North-West province. The assessment task was also developed in order to ensure that problem areas in the mathematical language be crystallized that are encountered by the learners in the learning of trigonometric functions and their application in solving problems. Upon completion of the assessment, it was given to colleagues in the mathematics subject group in the Faculty for validation.

For the teacher: Decision and implications of the decision: A very distinctive feature of design-based research is the design decisions in the study as well as how these impacted on the flow of the study. This decision came about as a aftermath of the Association for Mathematics Education of South Africa (AMESA) conference. The AMESA presentation in June 2012 on first results and progress in the project led to discussions about the use of an assessment task for teachers first to illuminate more clearly their metacognitive stance before the task can be given to learners. The researcher then deemed it necessary to have a workshop in which teachers were given the opportunity to complete one problem and reflect upon it (see Addendum D3). This decision was important as it put the focus more intensely on the metacognitive skills of the teacher as opposed to the metacognitive skills of the learners. It further illuminated the competencies of the teacher in terms of own subject knowledge and impacts on findings regarding teachers' subject knowledge as important contributor to effective teaching. It also shed more light on claims made by the teachers in their questionnaires on their own metacognitive skills.

5.6 DATA ANALYSIS

Just as in the case with the collection of the data, the analysis of the data in a design-based research study requires “*systematic documentation, analysis and reflection* of the design, development, evaluation and implementation process and their results” (Plomp, 2010, p. 31) in a cyclical process where the findings from the first phase should inform the second phase. Brown (1992) suggests that data are analysed on several levels in a design-based research study: Firstly analysis on the microgenetic level should provide specific indications of the relations between details of the design and incidents of learning. This input should then be used for adjustments which in their turn should accumulate to support higher-level theoretical statements. Secondly the Intermediate analysis level should take place between the cycles during which the design is revisited and activities for evidence are collected. These are then used for further adjustments which should allow the researcher to remove any frictions while simultaneously test conjectures emerging from the data and design elements based on the predictions. Lastly the reflective analysis takes all the micro genetic and longitudinal observations and reflects on them in light of existing theory. Brown (1992) suggests detailed personal longitudinal accounts of the design and experimentation processes and that these accounts tend to take a narrative form. Content, document and discourse analysis was employed with the help of ATLAS.ti, a computer-based programme for the analysis of qualitative data.

Data analysis within the study was a collaborative effort by the researcher mainly, the university team and a small part by the school team. The input from the study leader as a knowledgeable source in the field of metacognition and a co-project member in the field of lesson study was tapped into and proved to be valuable sources of information. Input from the Netherlands partner in the field of design-based research also contributed to the analysis of the data. A design-based research workshop offered by the Netherlands partner shed more light on the way the study should progress as design-based study. The services of knowledgeable co-lecturers were also employed for their knowledge of mathematics and in particular their knowledge of trigonometry.

5.6.1 The individual interviews

The individual interviews that were held with the two grade 10 teachers were transcribed verbatim by the researcher. The transcriptions were then given to the two teachers to member-check as a measure of trustworthiness. The two transcriptions were then analysed with the use of ATLAS.ti, a computer-based system for analysing qualitative data. Data gathered from the interviews were also useful in setting up the metacognitive performance profile of the two grade 10 teachers.

5.6.2 The lesson observations

The lessons were firstly observed by the researcher using the lesson observation schedule. These data were then portrayed against the nine critical aspects of a lesson, which included the teacher's knowledge and use of mathematical language (§3.5). The analysis of the first two lessons was the second set of data that contributed to setting up the metacognitive performance profile of the two grade 10 teachers. Both the frameworks for metacognitive instruction (§2.7) were also used to assess for teaching with metacognition and teaching for metacognition. Lastly the data were analysed using the different teaching models (§3.4). The analysis gathered after the video recordings of the lessons were observed by the lecturers together with the teachers informed the fine tuning of the teaching and learning trajectory. The video recordings were transcribed verbatim by a professional transcriber and afterwards reviewed by me. These transcripts were sent to the teachers for member-checking. Again ATLAS.ti was used to analyse the data gathered by the lesson observations and I assigned these MS word documents as primary documents into ATLAS.ti. The video recordings of the lessons were also assigned as primary documents to ATLAS.ti. The use of video recordings as data had the added advantage

that I could watch the lesson over and over in order to pay close attention to the discourse in the class, and this enabled me to show the lesson to my study leader for discussions.

5.6.3 The focus group discussions

The focus group discussions were also videotaped and transcribed verbatim and sent to participating teachers and lectures for member-checking. The transcriptions and video recordings informed the design of the hypothetical teaching and learning trajectory and the reflections on the lesson were indirectly also an analysis of the lesson. These transcriptions were MS word documents which were also entered into ATLAS.ti as primary documents. I also entered the video recordings of the focus group discussions into ATLAS.ti. The design principles (§3.9.6) were used to measure to which extent these principles factored into the lessons.

5.6.4 The assessment task

Firstly the analysis of the assessment tasks completed by the teachers illuminated their own metacognitive thinking when they themselves have to solve a problem. I only considered the assessment task completed by Teacher A and B for analysis. Secondly the assessment task completed by the learners of these two teachers might inform the extent to which the teachers did teach for metacognition in each lesson and thus informed the metacognitive profiles of the two grade 10 teachers. Information gathered from the task was also mapped against what transpired in the first two lessons by the two teachers and the interviews that were conducted with the two teachers.

The assessment tasks completed by the two teachers and the assessment tasks of three of teacher A and three learners of teacher B were also scanned and entered into ATLAS.ti as PDF-documents.

5.6.5 Analysing with ATLAS.ti 7

I attended two training sessions in which the use of ATLAS.ti 7 in qualitative research was discussed and demonstrated. The ATLAS.ti program was selected as “knowledge workbench” (Friese, 2013, p. 6) to analyse the complexity of the analysis process in this study with its 17 different data sets because the program is promulgated by Friese (2013, p. 9) as a powerful utility for the qualitative analysis of very large bodies of textual, graphical, audio, and video data. The main principles of the ATLAS.ti philosophy are best captured by the acronym VISE, which stands for Visualization, Integration, Serendipity and Exploration (Friese, 2013, p. 10). This

means that ATLAS.ti contains tools (i) to make visual images of relationships between objects constructed from the analysed data, (ii) to keep together all datasets in one project while incorporating them with each other, (iii) to make possible an intuitive approach to data and (iv) to provide a discovery-oriented approach.

Before a detailed outline can be given of how ATLAS.ti was employed in this study, the main concepts and their meanings are provided:

The Hermeneutic unit (HU) can be seen as the “intelligent container” (Frieze, 2013) in which all the data sets are kept, and is usually provided with a name and constitute the project.

The Primary documents / texts (PD / PT) is the term given to all the documents that are assigned to the HU which forms the “raw” data in the project. These files can take the form of text documents (such as transcripts of interviews, articles, reports); images (photos, screen shots, diagrams), audio recordings (interviews, broadcasts, music), video clips (audio-visual material e.g. lessons), PDF files (papers, brochures, reports), and geo data which refers to locative data using Google Earth (Frieze, 2013).

Quotations are interesting segments of the written text or instances in a primary document that have real relevance to the study.

A **Code** refers to “most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data” (Saldana, 2009, p. 3). Coding is the basis activity when using ATLAS.ti and can be equated to the manual marking and annotating of interesting parts of the data that have relevance to the inquiry (Frieze, 2013, p. 7).

Families refer to clusters of codes which can be grouped together for easier handling of groups that together form an idea (Frieze, 2013).

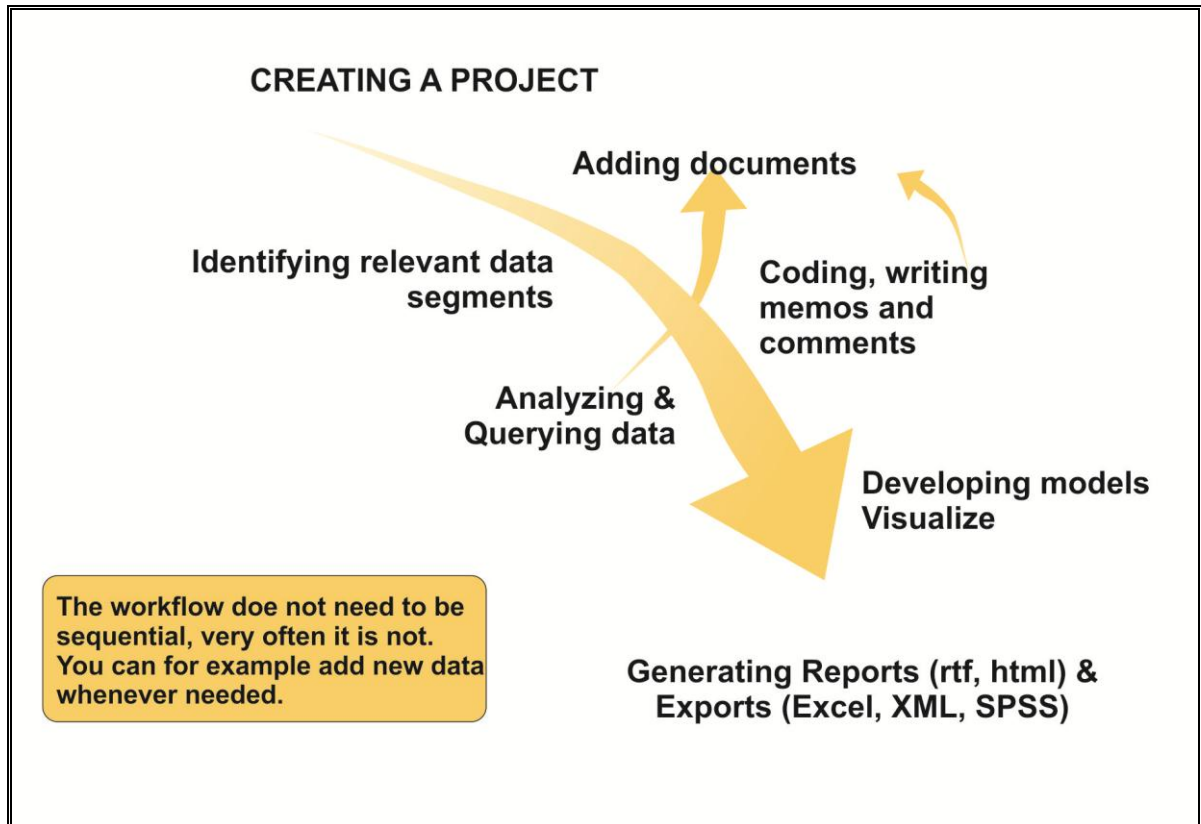
Relations have a linking function that connects codes meaningfully with each other.

Memos refer to written pieces that have some relevance to the data which can be personal, theoretical or methodological and help the user to remember his/her thinking with regard to the specific datum.

Comments explain the codes in more detail.

Network views can be seen as the visual diagram of relationships between codes, quotations, and memos (Frieze, 2013).

Figure 5.9 illustrates the steps to follow for successful data analysis with ATLAS.ti.



Source: Frieze, 2013, p. 25.

Figure 5.9: The ATLAS.ti main workflow

The steps that were followed in this study are subsequently addressed:

- Step one: Creating a code book (see Addendum E1):** Before I could start with the analysis of the data, I had to develop a code book from the literature and in particular from the theoretical framework that was used in the study. In my analysis of the data, I used a combined technique of inductive and deductive coding following the work of Fereday and Muir-Cochrane (2006) who used a hybrid approach of inductive and deductive coding for theme development in their study. To this end Creswell (2009) recommend the development of a preliminary code book that could change as the data analysis process proceed. According to Fereday and Muir-Cochrane (2006) coding can be done following a data-driven inductive approach or following the deductive a priori template of codes approach.
- Step two: Opening a new Hermeneutic Unit (HU):** First of all, I created a project by opening a new hermeneutic unit (HU) and naming it: *Analysing the metacognitive skills and mathematical language of mathematics teachers in three phases*.
- Step three: Assigning the Primary Documents (PDs):** I then assigned all the primary documents for only the first phase, comprising: the transcripts of the two individual interviews, transcripts of the first two lesson observations and the transcript of the first focus group discussion. I then scanned the assessment tasks completed by the two grade 10 teachers
- Step four: Discovering interesting passages:** In this step I entered a list of initial codes that I gathered from the literature review (chapter 2 and 3). After reading each document enough times and viewing the video recordings several times to secure a good understanding of each data set, I selected interesting and relevant passages and instances from the primary documents.

- Step five: Coding of the relevant passages and creating memos:** This step was a continuation of the previous step in that the passages which I had selected in step three were now coded using the list of initial coding from the code book (step 1). It must be noted that I added other codes as well which came from the primary documents which were not included by the list initially. Memos could be written at any stage from this step onwards. Saldana (2009) adds that coding is primarily an interpretive act and not a precise science *per se*. Saldana (2009) explains further that a code does not simply reduce data, but can sometimes summarize or condense the data. I have used one hundred and sixty three codes in this inquiry (see Addendum F20).
- Step six: Weaving concepts to networks and building theory:** In this step I used the codes and memos that were created, queried them and then made families indicating relationships that were available in ATLAS.ti. The families are also referred to as sub-categories. I then was able to use them to extract the categories. These categories were then grouped together to form themes which emerged as a result of relating different categories to each other. Importing all the codes, memos, categories and themes into the network view function, enabled visual images of how the themes were formed. This formed the most important part of theory building in ATLAS.ti. For Saldana (2009) this process entails a comparison of the major categories, resulting in an amalgamation of various ways in which one takes the “reality” of one’s data into a “higher” theoretical world of themes, concepts and theories.
- Step seven: Writing up results:** The final step in this workflow process comprised of exporting the networks that were created as graphic files and saving them in a folder to be used for data reporting and analysis. The theory building that was started in step five found exposition in later discussions which was done in Chapter Six.

It must be noted however, that as the analysis of Design-based research requires a cyclical process of moving between design and experiment within the different phases, the above process happened three times between the three phases.

Table 5.7 illustrates how I constructed one of the themes that emerged from the analysis by ATLAS.Ti.

Table 5.7 Example of theme-construction from generated data of the interviews, lesson observations assessment tasks and focus group discussions

Codes	Sub-categories	Categories	Themes
Definition, concrete, abstract, language, challenge	<i>From concrete to abstract.</i>	Category five: Challenges in the teaching-learning of trigonometric functions	Theme three: The hypothetical teaching and learning trajectory
Particular, general, practice	From particular to general		
Content language, Defying trigonometry as concept, academic language, symbolic language, mnemonic, explaining in another way, mathematical jargon.	<i>Context of any new concept before technicalities, intricacies and mathematical jargon.</i>		
Individual response, chorus answering, desire to know, critical thinking, interaction, incorrect solution, reading of from board.	<i>Favourable reactions from the students.</i>		

5.6.6 Content analysis

This strategy is normally used in the analysis of items such as brochures, books, written documents, news reports and transcripts of interviews or focus groups Nieuwenhuis (2007b:101). In this study I was able to utilise this strategy when I studied excerpts from the newly implemented CAPS Mathematics FET curriculum document from South Africa, transcriptions of interviews and transcriptions of focus group discussions.

5.6.7 Thematic analysis

According to Daly, Kellehear, and Gliksman (1997) thematic analysis is defined as a search for emerging themes which are relevant to the description of the phenomenon. Fereday and Muir-Cochrane (2006: 4) makes this definition clearer by maintaining that thematic analysis refers to “the process involving the identification of themes recognition within the data, where emerging themes become the categories for analysis”. This approach of data-analysis was embarked upon in the analysis of the interviews, lesson observations and focus group discussions.

5.7 ETHICAL ASPECTS OF THE RESEARCH

Leedy and Ormrod (2005) identify four criteria that should be met regarding ethics. They are: (i) Protection from harm; (ii) Informed consent; (iii) Right to privacy and (iv) Honesty. I have ensured that these criteria were met in the following ways:

(i) Protection from harm: Participants were informed that there were no known or anticipated risks associated with participation in this study. However, the lesson observation and adapted lesson study activities embarked upon in this project might entail some discomfort.

(ii) Informed consent: Three consent forms were developed: One form for the participant teacher (see Addendum C1), one form for the lecturer (Addendum C2) and one form to be completed by the learner or the parent in the case where the learner is younger than 18 (Addendum C3).

(iii) Right to privacy: Pseudonyms were used for the names of participants in the reporting of the findings from this study (such as Teacher A). The master list of participants' real names and their pseudonyms is kept in a locked cabinet in my office. One teacher withdrew from the study and data pertaining exclusively to this participant were destroyed.

(iv) **Honesty:** I assured participants of my honesty at all times and requested that they would also be honest. I informed them at the start of the study that they might withdraw from the study at any time

In addition to the above the following ethical measures were also taken:

A letter was written to the Regional Directorate of the North West Department of Education to request permission to involve the teachers in the research (Addendum A1). Permission was granted by the Department of Education to proceed with this study (Addendum A2).

5.8 TRUSTWORTHINESS

Barab and Squire (2004, p. 3) ask the following relevant question concerning trustworthiness in design-based research: “How do we control researcher bias in selecting evidence, in reporting observations, and in developing trustworthy claims?” This question is indicative of the importance of trustworthiness in design-based research. The issue here is whether the assertions that we make in our studies are going to be deemed credible to others.

5.8.1 Aspects of trustworthiness

According to Bakker and Van Eerde (2012) the meanings of the concepts validity and reliability in qualitative studies are somewhat different from their meanings in quantitative studies. Furthermore, it appears from extant literature as if the aspects of trustworthiness in the quantitative and the qualitative research approaches are defined differently. In quantitative studies the concepts **validity**, **reliability** and **generalizability** are used (Olsen, Warde, & Martens, 1998; Shields & King, 2001), while the qualitative research tradition uses the concepts **credibility**, **dependability** and **transferability** (Lincoln & Guba, 1985; Patton, 1987). Table 5.8 indicates the definitions of each aspect in the qualitative research tradition and the measures that were taken with regard to each aspect to ensure the trustworthiness of this study.

Table 5.8: Aspects of trustworthiness and how it was ensured in this inquiry

Aspect	Definition	Action implied by definition	Description of action by researcher
Credibility	<i>Credibility deals with the focus of the research and refers to the confidence in how well data and processes of analysis address the intended focus. (Graneheim & Lundman, 2004, p. 109)</i>	This implies selecting the most: (i) appropriate method for data collection and amount of data; (ii) suitable meaning unit; It also deals with how well categories and themes cover data and how similarities within and differences between categories are judged.	I made use of a variety of appropriate data collection instruments to ensure that sufficient evidence can be provided. The involvement of other knowledgeable people like the lecturers and study leader reflecting with me on what transpired during the lessons ensured credibility in the analysis. The assessment for the learners and the teachers was first peer-reviewed by the lecturers and piloted before given to the participants. I co-coded with my study leader which is seen as the coding process which ensures the most coding reliability (Nieuwenhuis, 2010, p. 114). I also made use of a code book, developed by me and revised by my study leader to ensure more coding consistency. Lastly I sent the transcriptions of the interviews, lesson observations and the focus group discussions to participants to member-check them.
Dependability	<i>Dependability seeks means for taking into account both factors of instability and factors of phenomenal or design induced changes. (Lincoln & Guba, 1985, p. 299)</i>	This refers to the degree to which data change over time and adaptations are made in the decisions of the researcher during the analysis process.	The interventionist nature of the methodology used in this study called for several adjustments to be made to the design after each of the iterations. I also used probing questions to narrow the focus of the interviews and focus group discussions.

Transferability	<i>Transferability refers to the extent to which the findings can be transferred to other settings or groups.</i>	Transferability is facilitated when a clear and distinctive description of the culture, context, selection and characteristics of participants, data collection and process of analysis, and a rich presentation of the data together with appropriate quotations are provided	I have ensured this aspect of trustworthiness by: (i) Providing clear criteria for selecting the schools and explained how I did arrived at my sample in great detail (§ 5.4). (ii) Outlining the data collection and analysis processes that were embarked upon in this inquiry in as much detail as possible (§ 5.5 & § 5.6). (iii) Presenting the themes in diagrammatical form (Figures 5.1-5.11) and the findings in tabular form (Table 6.1) as well as providing a synopsis of the key findings (§6.3).
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Source: Fransman (2010, p. 105) Table adjusted

Additionally to the measurements taken to ensure trustworthiness reflected in Table 5.8, the following steps were also followed to further enhance the trustworthiness of this study in line with what McMillan and Schumacher (2001, p. 393) advocate for the trustworthiness of a study:

- *Lengthy data collection period:* In the nearly three years that I was busy with this study, I visited the two schools three times each for information sessions, twice for individual interviews, five times for the lesson observations and four times for administrative purposes. My visits to the schools were in total 17 times.
- *Participant's language:* I have ensured that the exact words, including Setswana words, of all participants were used in the data-analysis.
- *Field research and observation:* The interventionist nature of design-based research required working in the natural setting of a real time classroom.
- *Disciplined subjectivity:* I have made extensive use of what other researchers (lecturers) and teachers were saying about the lesson, and did not only use my own subjective observations.
- *Participant review:* I did send the transcripts of the video recordings of all the lessons as well as the focus group discussions to my participants to member-check.

5.8.2 Crystallization and Triangulation

Triangulation refers to the converging of themes by employing diverse methods of data-collection to support either a theory, in the case of qualitative studies, or a hypothesis for quantitative studies (Leedy and Ormrod, 2005, p. 99). For Richardson (1997) triangulation is too rigid to be used in qualitative studies while a crystal, on the other hand, provides a dynamic and deeper understanding of the phenomenon (Nieuwenhuis, 2010), because it is all about symmetry and content combined in an endless variety of dimensions and angles of approaches. In this inquiry I have used crystallization in this inquiry in order to provide a deeper understanding of the phenomenon.

5.8.3 Trustworthiness in coding and interpretation

Coding forms the basis of the data-analysis process in qualitative studies (Frieze, 2013), and trustworthiness in coding can be enhanced by using multiple coders. According to Nieuwenhuis (2010) inter-coder reliability can be seen as the extent of consistency among different coders, while intra-coder reliability is the extent of consistency within a single idea. Coding consistency during my analysis was ensured by making use of inter coding by co-coding with my study leader.

Graneheim and Lundman (2004) is of the opinion that trustworthiness regarding interpretations in qualitative research refers to arguments for the most likely interpretations. Therefore trustworthiness is enhanced if the findings are presented in a way that allows for alternative interpretations in line with what Graneheim and Lundman (2004, p. 106) advocate:

A text always involves multiple meanings and there is always some degree of interpretation when approaching a text. This is an essential issue when discussing trustworthiness of findings in qualitative content analysis.

In this study I ensured trustworthiness in my interpretations by careful reading of the transcripts and allowing myself to think about other possible interpretations.

5.9 SUMMARY OF THE CHAPTER

This chapter was the most challenging chapter to write as it involved careful descriptions and explanations of how I have merged adapted lesson study with design-based research. At the early stages of my study, I experienced this to be a daunting task. Several design-based researchers allude to the fact that the interventionist nature of design-based research demands systematic documentation, reflection, data collection and analysis of the data (Plomp & Nieveen, 2010). In this chapter I stated my ontological and epistemological position and argued why this research is done in the pragmatist paradigm (§5.2). I also motivated why educational design-based research was the most appropriate design to address the research problem (§5.3). I explained the population and my sample, as well as the criteria that were used (§5.4). Next I provided a biographical sketch of all the teachers and lecturers who participated in my study. I briefly described the instruments (§5.5) that were developed for the data gathering, followed by a discussion on how data were analysed using ATLAS.ti 7 (§5.6). Some ethical aspects (§5.7) and trustworthiness issues (§5.8) were then discussed.