Critical analysis of knowledge produced through postgraduate mathematics education research in post-apartheid South Africa: the first decade

by

Barbara Busisiwe Goba

Submitted in partial fulfilment of the academic
requirements for the degree of
Doctor of Philosophy in the
School of Education
College of Humanities
University of KwaZulu-Natal

July 2024

ABSTRACT

The concept of 'knowledge systems' has led to a need for 'research on research'. Therefore, it is crucial to assess the knowledge generated by various knowledge societies, particularly within universities. This rationale drove the Project on Postgraduate Education Research (PPER) to investigate the research output in postgraduate education during the initial decade (1995-2004) following the end of apartheid in South Africa. Within the framework of PPER, this study scrutinized the body of masters and doctoral research conducted at 19 South African universities within the aforementioned period.

The study aimed to address the following main research question: *What forms of knowledge emerged from postgraduate studies in mathematics education research within South Africa during the years 1995 to 2004*?

Sub-research questions:

1.1 How were the titles of postgraduate studies in mathematics education (1995-2004) formulated and structured?

1.2 Which phenomena were more frequently explored, and which were less likely to be investigated within these postgraduate studies (1995-2004)?

1.3 What were the predominant research questions, and what assertions were made concerning these phenomena?

1.4 What were the prevalent research paradigms, designs, approaches, and methodologies employed in postgraduate studies on mathematics education (1995-2004)?

1.5 Which theories were commonly utilized and which were less frequently applied in postgraduate studies on mathematics education (1995-2004)?

For each of the sub-questions mentioned above, the study delved into the identities of the students responsible for generating this knowledge, along with details about their degrees and affiliations with respective institutions.

This study employed Giddens' structuration theory as its theoretical framework. It conducted an analysis of knowledge produced in a corpus of 190 postgraduate studies in mathematics education. This analysis encompassed various elements, starting from titles, research phenomena, questions, claims, methodologies, and extending to theories. The data from these theses was extracted using Suri's Methodologically Inclusive Research

Syntheses (MIRS). Additionally, interviews were conducted with a sample of supervisors overseeing these theses.

The main findings reveal that knowledge in mathematics education predominantly comes from white female postgraduates affiliated with historically white universities (HWUs). This challenges the prevailing notion that white males dominate research in this field. Notably, Wits University emerged as the primary contributor of mathematics education theses in the corpus, with a majority of these studies composed in English. When comparing this result with Khuzwayo's (2005) findings, which emphasized a focus on white education and teacher training in South African mathematics education research from 1948 to 1994, a similarity arises in terms of the demographic producing the majority of research by white postgraduates. However, this does not necessarily imply that white learners were the primary subjects of study. Instead, it suggests another way of 'objectifying' black learners and teachers, as Black Africans are frequently researched by predominantly white researchers. Additionally, the prevalence of white postgraduate students producing more mathematics education theses may result from the apartheid policy on mathematics education, where Verwoerd argued that Black African people did not need to study mathematics as it had no relevance in their communities. Verwoerd's stance remained largely unchanged in the first ten years of post-apartheid South Africa.

In the domain of postgraduate studies, the construction of titles employs various linguistic devices, methodological approaches, indication of the results and epistemological stances. Among these linguistic devices, the colon is the most frequently employed. Mathematics education postgraduate studies predominantly centre around five key research phenomena: the affective domain, assessment, knowledge, cognition, and epistemologies, as well as pedagogy and technology/resources. These studies from 1995 to 2004 were primarily small-scale. Each of these phenomena is examined in terms of the research claims posited. Notably absent are studies with a focus on primary mathematics education and rural education. This finding aligns with the results of reviews conducted by Venkat, Adler Rollnick, et. al., 2009; Adler, Alshwaikh, Essack, & Gcsamba, 2017. However, the most recent review of mathematics education journal articles by Morrison, Graven, Venkat, and Vale (2023) indicates an increase in research on primary mathematics education. A prominent theoretical orientation in postgraduate studies is constructivism, particularly within HWUs. Additionally, the preferred approach in mathematics education studies conducted in South Africa between 1995 and 2004 was the case study research design.

PREFACE

The work described in this thesis was carried out in the School Education, Cluster of Mathematics and Computer Science Education, University of KwaZulu-Natal, under the supervision of **Prof. Sarah Bansilal.**

This study represents original work by the author and has not otherwise been submitted in any form for any degree or diploma to any tertiary institution. Where use has been made of the work of others, it is duly acknowledged in the text.

Barbara Busisiwe Goba

July 2024

TABLE OF CONTENTS

ABSTRACT II

PREFACE..IV

TABLE OF CONTENTS V

LIST OF TABLES..XII

LIST OF FIGURES XV

ACKNOWLEDGEMENT XVII

DEDICATION..XVIII

CHAPTER 1 INTRODUCTION TO THE STUDY 1

1.1 INTRODUCTION AND BACKGROUND.. 1

1.2 SOUTH AFRICAN UNIVERSITIES IN THE IMMEDIATE AFTERMATH OF APARTHEID PERIOD 3

1.3 RATIONALE OF THE STUDY 9

1.3.1 What was happening in mathematics education research in South Africa in the first decade after democracy?.. *9*

1.3.2 Is the first decade aftermath apartheid in South Africa important?.. *14*

1.3.3 Why I chose a focus on postgraduate education research?.. *16*

1.3.4 Why I elected to conduct this study?.. *17*

1.4 SIGNIFICANCE OF THE STUDY 19

1.5 PURPOSE OF THE STUDY 20

1.6 KEY RESEARCH QUESTIONS 21

1.7 GIDDEN'S STRUCTURATION THEORY 21

1.8 RESEARCH DESIGN AND METHODOLOGY 22

1.9 LAYOUT OF THE THESIS 23

1.10 CONCLUSION..27

CHAPTER 2 KNOWLEDGE PRODUCTION THROUGH MATHEMATICS EDUCATION POSTGRADUATE THESES (1995-2004): LITERATURE REVIEW.. **28**

2.1 INTRODUCTION 28

2.2 RESEARCH ON POSTGRADUATE THESES 29

2.3 PREPARATION OF POSTGRADUATE STUDENTS FOR MATHEMATICS EDUCATIONAL RESEARCH 31

2.4 KNOWLEDGE SYNTHESES 34

2.5 MATHEMATICS EDUCATION AND RESEARCH 36

2.5.1 Mathematics education 36

2.5.2 International perspectives on mathematics education research: Insights and innovations from around the globe 38

2.5.3 Evolution of mathematics education research in South Africa (1948-2023): A historical perspective 41

2.5.4 Mathematics education research in South Africa (1948-1994) 42

2.5.5 Mathematics education research in South Africa (1995-2004) 43

2.5.6 Mathematics education research in South Africa (2000-2006) 44

2.5.7 Mathematics education research in South Africa (2007-2015) 45

2.5.8 Mathematics education research in South Africa (2003-2022) 46

2.5.9 Positioning my research within the historical context of mathematics education research in South Africa (1948-2023) 47

2.6 THEORY OF KNOWLEDGE 47

2.7 CONCLUSION 55

CHAPTER 3 UNDERSTANDING MATHEMATICS EDUCATION KNOWLEDGE PRODUCTION THROUGH POSTGRADUATE EDUCATION RESEARCH IN SOUTH AFRICA (1995-2004): THEORETICAL LENS 57

3.1 INTRODUCTION 57

3.2 STRUCTURATION THEORY 58

3.3 CONCLUSION 73

CHAPTER 4 EXAMINING KNOWLEDGE PRODUCTION IN MATHEMATICS EDUCATION POSTGRADUATE THESES (1995-2004): RESEARCH METHODOLOGY 74

4.1 INTRODUCTION 74

4.2 RESEARCH DESIGN USED IN REVIEWING MATHEMATICS EDUCATION THESES 76

4.2.1 Meta-family.....77

4.2.2 Meta-analysis..... 77

4.2.3 Meta-synthesis and meta-ethnography..... 82

4.2.4 Meta-study..... 84

4.2.5 Methodologically Inclusive Research Synthesis (MIRS)..... 85

4.3 RESEARCH APPROACH..... 86

4.4 POPULATION AND SAMPLE..... 87

4.5 SAMPLING TECHNIQUES USED IN MY STUDY..... 92

4.6 RESEARCH INSTRUMENTS USED TO GENERATE DATA..... 92

4.7 TRUSTWORTHINESS AND TRANSFERABILITY OF THE RESEARCH INSTRUMENTS..... 94

4.8 ANALYTICAL TOOLS AND FRAMEWORK..... 96

4.9 APPLYING GIDDENS' STRUCTURATION THEORY IN RESEARCH DESIGN: BRIDGING STRUCTURE, AGENCY, AND KNOWLEDGE PRODUCTION.....98

4.10 ETHICAL ISSUES..... 99

4.11 CHALLENGES OF UNDERSTANDING LARGE SCALE RESEARCH AT UNIVERSITIES..... 100

4.12 LIMITATIONS OF THIS STUDY..... 101

4.13 CONCLUSION..... 102

CHAPTER 5 DESCRIPTION OF THE MATHEMATICS EDUCATION POSTGRADUATE THESES IN SOUTH AFRICA (1995-2004)..... 103

5.1 INTRODUCTION..... 103

5.2 PPER DATA..... 104

5.3 MATHEMATICS EDUCATION THESES PRODUCED IN SOUTH AFRICAN UNIVERSITIES (1995-2004)... 108

5.4 DISCUSSION OF THE FINDINGS OF META-SYNTHESES OF EDUCATION AND MATHEMATICS EDUCATION POSTGRADUATE THESES PRODUCED IN SOUTH AFRICA (1995-2004).....116

5.5 CONCLUSION..... 121

CHAPTER 6 NAMING AND FRAMING OF MATHEMATICS EDUCATION POSTGRADUATE RESEARCH TITLES (1995–2004)..... 123

6.1 INTRODUCTION..... 123

6.2 GENERAL OVERVIEW OF TITULAR CONSTRUCTION IN MATHEMATICS EDUCATION STUDIES..... 124

6.3 LINGUISTIC DEVICES 128

6.4 RESEARCH DESIGN INDICATED IN TITULAR CONSTRUCTIONS 138

6.5 EPISTEMOLOGICAL STANCE 151

6.6 INDICATION OF RESULTS IN THE TITLES OF POSTGRADUATE STUDIES 156

6.7 SUMMARY OF EMERGING THEMES FROM THE ANALYSIS OF TITULAR CONSTRUCTION 165

CHAPTER 7 RESEARCH PHENOMENA, QUESTIONS AND CLAIMS SIGNALING KNOWLEDGE GENERATED FROM MATHEMATICS EDUCATION THESES (1995-2004) 167

7.1 INTRODUCTION 167

7.2 RESEARCH PHENOMENA AND QUESTIONS 168

7.3 MIRS OF RESEARCH PHENOMENA AND QUESTIONS IN MATHEMATICS EDUCATION THESES (1995-2004) 175

7.3.1 Pedagogy 175

7.3.2 Cognition, epistemologies and knowledge 184

7.3.3 Assessment 190

7.3.4 Technology & resources 195

7.3.5 Affective domain 199

7.4 SUMMARY OF THE TRENDS AND EMERGING ISSUES ON RESEARCH PHENOMENA, QUESTIONS AND CLAIMS IN THE THESES (1995-2004) 205

CHAPTER 8 RESEARCH METHODOLOGIES USED IN MATHEMATICS EDUCATION THESES (1995-2004) 209

8.1 INTRODUCTION 209

8.2 ANALYSIS OF RESEARCH PARADIGMS IN MATHEMATICS EDUCATION POSTGRADUATE THESES IN SOUTH AFRICA (1995-2004) 210

8.3 ANALYSIS OF RESEARCH DESIGNS IN MATHEMATICS EDUCATION POSTGRADUATE THESES IN SOUTH AFRICA (1995-2004) 215

8.3.1 Case study 215

8.3.2 Surveys 217

8.3.3 Experimental design 219

8.3.4 Comparison of the three research designs: Case study, survey and experimental design 220

8.4 ANALYSIS OF RESEARCH APPROACHES IN MATHEMATICS EDUCATION POSTGRADUATE THESES IN SOUTH AFRICA (1995-2004) 222

8.5 ANALYSIS OF RESEARCH METHODS IN MATHEMATICS EDUCATION POSTGRADUATE THESES IN SOUTH AFRICA (1995-2004) 227

8.5.1 Sampling strategies 228

8.5.2 Samples and sample size 230

8.5.3 Educational levels and contexts researched in the studies 231

8.5.4 Research instruments in the mathematics education postgraduate theses (1995-2004) 233

8.5.5 Research analytical tools used in mathematics education postgraduate theses (1995-2004) 238

8.6 SUMMARY OF THE TRENDS OF THE RESEARCH PARADIGMS, DESIGNS, APPROACHES AND METHODS IN THE MATHEMATICS EDUCATION POSTGRADUATE THESES (1995-2004) 241

CHAPTER 9 THEORIES USED IN MATHEMATICS EDUCATION POSTGRADUATE RESEARCH (1995-2004) 245

9.1 INTRODUCTION 245

9.2 ANALYSIS OF THEORIES USED IN MATHEMATICS EDUCATION POSTGRADUATE THESES IN SOUTH AFRICA (1995-2004) 246

9.2.1 Constructivism 249

9.2.2 Problem-based learning 255

9.2.3 Socio-cultural theory 258

9.2.4 Levels of geometric thought 260

9.2.5 Zone of proximal development 261

9.2.6 Co-operative learning theory 263

9.2.7 Why did the postgraduate students choose the theories used in their studies? 264

9.3 SUMMARY OF THE TRENDS AND EMERGING ISSUES ON THEORIES USED IN THE MATHEMATICS EDUCATION POSTGRADUATE THESES (1995-2004) 265

9.4 KNOWLEDGE PRODUCTION AND TRANSFORMATION IN MATHEMATICS EDUCATION THESES (1995-2004): PROGRESS, INEQUALITIES, AND SYSTEMIC CHALLENGES 267

CHAPTER 10 DISCUSSION OF THE FINDINGS OF THE MIRS OF KNOWLEDGE PRODUCED THROUGH MATHEMATICS EDUCATION POSTGRADUATE RESEARCH (1995-204) AND CONCLUSION........................ 269

10.1 INTRODUCTION.. 269

10.2 SUMMARY OF GIDDENS' STRUCTURATION THEORY 269

10.3 OVERACHING TRENDS IN THE CORPUS OF MATHEMATICS EDUCATION THESES PRODUCED IN SOUTH AFRICAN UNIVERSITIES IN THE FIRST DECADE OF POST-APARTHEID ERA......................... 271

10.3.1 HWUs produced more mathematics education theses than HBUs.. 272

10.3.2 White female postgraduate students produced more mathematics education theses in South Africa in the period 1995-2004.. 275

10.3.3 Most of the mathematics education postgraduate theses (1995-2004) were written in English ………276

10.3.4 Understanding who, where and how mathematics education knowledges was generated in South Africa (1995-2004) through postgraduate theses using Gidden's structuration theory ……………………………………………………………………………………………….277

10.4 EXPLORING THE LANDSCAPE OF MATHEMATICS EDUCATION POSTGRADUATE RESEARCH IN SOUTH AFRICA 279

10.4.1 Research phenomena researched in mathematics education postgraduate research in South Africa (1995-2004).. 279

10.4.2 Research question posed in mathematics education postgraduate research in South Africa (1995-2004) 280

10.4.3 Research paradigms and designs framing the mathematics education postgraduate research in South Africa (1995-2004)... 281

10.4.4 Research instruments used to generate data in the mathematics education postgraduate research in South Africa (1995-2004) 283

10.4.5 Theories used in the mathematics education postgraduate research in South Africa (1995-2004) 284

10.4.6 Research claims reached in the mathematics education postgraduate in South Africa (1995-2004) 285

10.4.7 Exploring the landscape of mathematics education postgraduate research in South Africa (1995-2004) through the lens of Giddens' Structuration Theory 287

10.5 LIMITATIONS OF THE STUDY 290

10.6 CHARTING PATHS FORWARD: EVALUATING POSTGRADUATE MATHEMATICS EDUCATION RESEARCH IN POST APARTHEID SOUTH AFRICA'S FIRST DECADE 291

10.6.1 Post-apartheid era postgraduate students' perspectives 291

10.6.2 Longitudinal study of mathematics education reforms 291

10.6.3 Comparative analysis with pre-apartheid and post-apartheid eras 291

10.6.4 Quantitative analysis of educational outcomes 292

10.7 CONTRIBUTION TO MATHEMATICS EDUCATION RESEARCH 292

10.7.1 Methodologically inclusive research synthesis 293

10.7.2 The significance of the period (1995-2004) immediate post-apartheid era in South Africa.... 294

10.7.3 Postgraduate education in the post-apartheid era........ 295

10.7.4 Knowledge cultivated through mathematics education postgraduate theses........ 296

10.8 CONCLUSION 297

REFERENCES 299

APPENDICES 311

APPENDIX A PILOT SPSS 312

APPENDIX B ENDNOTE 313

APPENDIX C DOCTORAL AND MASTERS THESES USED IN THE STUDY 315

APPENDIX D RESEARCH PHENOMENA FROM THE CORPUS OF MATHEMATICS EDUCATION THESES....... 332

APPENDIX E CATEGORIES OF RESEARCH PHENOMENA 356

APPENDIX F THEORIES USED IN MATHEMATICS EDUCATION POSTGRADUATE STUDIES IN SOUTH AFRICA (1995-2004)........ 357

APPENDIX G ETHICAL CLEARANCE........ 360

APPENDIX H EDITOR'S LETTER 361

LIST OF TABLES

Table 1.1	*South African historical white universities which did not merge in 2004.*	4
Table 1.2	*Historical Black Universities*	6
Table 1.3	*South African historical white universities which did not merge in 2004.*	7
Table 1.4	*Merged universities in 2004 and 2005*	8
Table 1.5	*Former Technikons*	8
Table 2.1	*Theories of justification and nature of knowledge.*	52
Table 4.1	*Mathematics Education supervisors (1995-2004).*	91
Table 5.1	*Educational postgraduate theses (1995-2004) in the PPER database.*	105
Table 5.2	*Institutions where more education theses were produced by male students.*	107
Table 5.3	*Mathematics education postgraduate studies produced in South African HEIs in the period 1995-2004.*	109
Table 5.4	*Race and gender of authors of mathematics education theses (1995-2004)*	114
Table 5.5	*Pearson chi-squared value for gender and the number of masters and doctoral theses in the data*	115
Table 5.6	*Pearson chi-squared value for race and the number of masters and doctoral theses in the data*	115
Table 5.7	*Distribution of mathematics education postgraduate studies according to the language in which they are written*	116
Table 6.1	*Length of titles in mathematics education theses (1995-2005).*	126
Table 6.2	*Distribution of the theses with 15 or less number of words in the titles per HEIs*	126
Table 6.3	*Race and gender of authors of titles with 15 or less number of words*	127
Table 6.4	*Linguistic devices in titular construction*	129
Table 6.5	*Theses titles with a colon*	130
Table 6.6	*Research design in titular construction*	139
Table 6.7	*Theses using case study in titular construction*	140
Table 6.8	*Geographical areas mentioned in the titles of theses*	150
Table 6.9	*Indication of results of the study in titular constructions*	156

Table 6.10 *Identification of subject, action and objects in titles of postgraduate studies using effect of* 158

Table 6.11 *Identification of independent and dependent variable in titles of postgraduate studies* 159

Table 6.12 *Identification of subject, action and object in titles of postgraduate studies using impact of* 162

Table 6.13 *Identification of dependent and independent variables in titular construction with impact of* 163

Table 7.1 *Example of coded research phenomena from corpus of postgraduate mathematics education theses (see appendix C for the entire coded data)* 170

Table 7.2 *Categories of research phenomena and the number of theses which dealt with mathematics content* 171

Table 7.3 *Number of research questions posed per study* 173

Table 7.4 *Research phenomena and the three types of research questions* 175

Table 7.5 *Subcategories of pedagogy research phenomenon* 176

Table 7.6 *Distribution of pedagogy research phenomenon according to degree, participants, education level and location* 178

Table 7.7 *Knowledge, cognition and epistemologies research phenomena* 185

Table 7.8 *Distribution of knowledge, cognition & epistemologies research phenomenon according to degree, participants, education level and location* 186

Table 7.9 *Keywords for assessment research phenomenon* 191

Table 7.10 *Distribution of the keywords for assessment phenomenon according to degree, participants, education level and geographical context of the studies* 192

Table 7.11 *Gender and race of postgraduate students who researched assessment outcomes: performance/attainment/achievement* 193

Table 7.12 *Distribution of the keywords for technology and resources phenomenon according to degree, participants, education level and geographical context of the studies* 196

Table 7.13 *Distribution of the affective domain keywords according to degree, participants, education level and geographical context of the studies* 201

Table 8.1 *Research paradigms, designs, approaches, and methods coded into SPSS and EndNote* 211

Table 8.2 *An example of how research paradigms, designs, approaches and methods were coded* 211

Table 8.3 *Research paradigms used in the mathematics education postgraduate theses (1995-2004)* 212

Table 8.4 *Research phenomena of studies framed in the interpretive paradigm* 213

Table 8.5 *Research designs used in mathematics education postgraduate studies (1995-2004)* 216

Table 8.6 *Studies investigating research phenomena with qualitative, quantitative and mixed method approaches*) 224

Table 8.7 *Cross tabulation of the three prevalent research designs with the research approaches)* 224

Table 8.8 *Distribution of research approaches used in mathematics education postgraduate studies by degree and year of publication* 225

Table 8.9 *Sampling strategies used in the mathematics education postgraduate theses (1995-2004)* 228

Table 8.10 *Samples selected in the mathematics education postgraduate studies (1995-2004)* 231

Table 8.11 *Frequency distribution of the sample sizes of the participants in the postgraduate theses.* 231

Table 8.12 *Levels of the mathematics education postgraduate studies produced in South African HEIs in the period 1995 – 2004* 232

Table 8.13 *Geographical areas where postgraduate studies were conducted* 233

Table 8.14 *Research instruments used in the mathematics education postgraduate theses (1995-2004)* 234

Table 8.15 *Analytical tools used in the studies* 238

Table 9.1 *Example of theories used in the mathematics education postgraduate studies (1995-2004). The entire list of theories is in Appendix F* 250

Table 9.2 *Research phenomena theorised using constructivism in the mathematics postgraduate studies in South Africa (1995-2004)* 251

Table 9.3 *Use of constructivism theory in the mathematics education postgraduate theses in South Africa (1995-2004)* 253

Table 9.4 *Comparison of studies using constructivism from SU, UJ and Wits* 255

Table 9.5 *Research phenomena theorised using problem-based learning in the mathematics postgraduate studies in South Africa (1995-2004)* 256

LIST OF FIGURES

Figure 3.1 Key elements in the structuration theory (Adopted from Tuner 1986) 71

Figure 4.1 Meta-family of research designs of inquiry for reviewing primary research 78

Figure 4.2 South African map showing the location of the universities prior to 2011 89

Figure 5.1 Publication of education theses in South Africa (1995-2004) per degree 108

Figure 5.2 Mathematics education theses produced per year (1995-2004) per degree 113

Figure 6.1 Frequency distribution of the length of titles of mathematics 126

Figure 8.1 Year by year contrast of interpretive and positivism research 214

Figure 8.2 Contrast of interpretivism and positivism research paradigms in 214

Figure 8.3 Year-by-year analysis of mathematics education postgraduate 221

Figure 8.4 Distribution of case study, survey and experimental research design 221

Figure 8.5 Year by year distribution of research approaches used in 226

Figure 8.6 Distribution of research approaches used in studies by institution 226

Figure 8.7 Distribution of interviews, tests/activity, questionnaires and observations by year 237

Figure 8.8 Distribution of interviews, tests/activity, questionnaires and observations by institutions 237

Figure 8.9 : Year-by-year distribution of statistical, thematic and content analyses 240

Figure 8.10 : Distribution of statistical, thematic and content analyses by institution 241

ACKNOWLEDGEMENT

I am really grateful to God Almighty for protecting me over the course of this doctoral education. I could not have completed this task without His grace, love, and mercy. Additionally, I would like to express my heartfelt gratitude to my church, Zion Christian Church, for their unwavering spiritual support throughout this journey.

I'd also want to thank my former supervisors, Profs Renuka Vithal and Relebohile Moletsane, for their crucial advice and support throughout the composition of my thesis. Their guidance has been invaluable in shaping this work.

Furthermore, I am grateful for the assistance offered by my present supervisor, Prof. Sarah Bansilal, who was instrumental in completing this project. Your advice and encouragement have been helpful, and I am truly grateful.

A particular thank you to Mrs. Bongeka Mabaso for graciously offering her home to me while we worked on our theses. Your warmth and generosity are greatly appreciated. May the Almighty richly bless you for your kindness. I would also want to thank Mr. Ayanda Zondo for his technical support, which was critical to the completion of this work. Your experience was vital, and I am appreciative for your assistance.

My heartfelt thanks go to the PPER research team, notably Prof. Thabisile Nkambule, for their assistance during the data gathering phase of this work. Your assistance was critical to the success of this research.

Finally, I would want to thank my dear sister in Christ, Ms. Thembelihle Madondo, for her prayers and encouragement during this journey.

Dedication

This thesis is dedicated with love to my children, Nhlakanipho, Amanda, and Thapelo. I also extend this dedication to my dear dad, cherished mother, brother, adored grandchildren Miracle, Olam' uThingo, and Mnotho, my beloved sisters, and my entire family. Your unwavering support has been invaluable. Thank you.

CHAPTER 1

INTRODUCTION TO THE STUDY

> “Knowledge, is in many ways the most fundamental, and the most theorized, but the least researched…Knowledge-its discovery, expansion, analysis, interpretation, transmission and dissemination-is at the heart of what higher education is all about…. Why then is knowledge relatively under-researched”? (Tight, 2003, p.168)

1.1 INTRODUCTION AND BACKGROUND

Tight's (2003) assertion emphasizes the crucial role of knowledge in higher education, highlighting its multifaceted nature encompassing discovery, expansion, analysis, interpretation, transmission, and dissemination. Despite its paramount significance, knowledge remains relatively under-researched, a gap particularly notable within academia. Therefore, Tight's assertion prompts my investigation into the knowledge generated within postgraduate research in mathematics education during a specific period in South Africa, marked by the nation's reconstruction from the apartheid system.

If knowledge is indeed at the core of higher education (Tight, 2003, p.168), it becomes imperative to study its production, theorization, and dissemination. In essence, researching these aspects is essential to fulfil the fundamental mission of higher education, which is to advance knowledge and contribute to human progress. Certainly, the knowledge produced in higher education through research stems from academics, students' work, and "those outside who share a concern with higher education" (Tight, 2003, p.168). This knowledge is disseminated through various channels such as local and international journals, books, research project reports, and postgraduate theses. Given the vastness of this body of knowledge, it is beyond the scope of this research study to document its trends and patterns comprehensively. Therefore, this study specifically focuses on postgraduate research as a means of delineation.

The generation of knowledge from postgraduate studies holds significance as it represents the ideas and insights of the next generation of researchers. Furthermore, the examination of knowledge derived from postgraduate theses[1] is not common. The rationale for selecting postgraduate theses as the primary source of data is provided in the rationale section of this study. Postgraduate theses at universities are produced by students from different disciplines. However, this study concentrated on theses that were published in education discipline, particularly in mathematics education theses. This study delineated by selecting theses that were produced in the first ten years of democratic South Africa in higher education institutions (HEIs). The understanding of mathematics education knowledge that was generated in the first ten democratic years in South Africa is important, because it represent a foundational framework for shaping future educational policies and practices, ensuring equitable access to quality mathematics education for all learners. This is the period after an unjust apartheid system that racially[2] desegregated the South African population for years. During the period 1995-2004, South Africa tried to rebuild many of its systems from the apartheid era that transcended all spheres of society, including universities where knowledge production occurs. Throughout these decades, decisions about institution research capacity and productivity influenced the spaces where research is produced.

This is a historical study documenting postgraduate mathematics education knowledge that was produced when South Africa transitioned to the post-apartheid era. In the wake of historical transformations, South African universities embarked on a momentous journey in the immediate aftermath of apartheid, striving to redefine their roles in a newly democratic society. This chapter introduces the context and purpose of the study, delving into the pivotal period during which these institutions navigated the complex landscape of change. Focused on understanding the evolution of South African

[1] From now forth, the term "theses" encompasses both master's dissertations and doctoral theses.

[2] During apartheid, South Africans were divided into four racial groups: African, Coloured, Indian, and White. Africans, predominantly of African descent, faced the most severe discrimination. Indians, regardless of being born in Africa, and South Africa in particular, were labelled as Indian. White people, mainly of European descent, enjoyed the highest privileges. Coloureds, of mixed-race heritage, were categorized separately. The term "black people" encompassed Africans, Coloureds, and Indians.

universities post-apartheid, this research seeks to address key questions that illuminate the challenges and opportunities faced during this transformative era. By investigating the factors that shaped higher education and knowledge dissemination, this study aims to shed light on the broader implications for societal development. The rationale for conducting this research is to comprehensively analyse the multifaceted forces that influenced the reconfiguration of South African universities and their contributions to national progress. As such, the significance of this study extends to both academia and policymakers, offering valuable insights into the dynamics of educational reform. The purpose of this study is to explore the intricate interplay between policy, institutional responses, and the broader socio-political landscape, thus contributing to a deeper understanding of post- apartheid higher education. The subsequent sections of this thesis are structured to delve into the historical context, research methodology, findings, and implications, providing a coherent framework for the exploration of this crucial topic.

1.2 SOUTH AFRICAN UNIVERSITIES IN THE IMMEDIATE AFTERMATH OF APARTHEID PERIOD

In order to understand the South African higher education system in the aftermath of apartheid era, there is a need to discuss how universities were configured during the apartheid period. The apartheid government separated universities racially with language differentiate. The University of Cape Town (UCT) was the first historical white university (HWU) established in South Africa in 1829, it was a college before the university status. Most of the HWUs using the English medium of instruction were founded in the late 1800 and early 1900 (see table 1.1). The HWUs using Afrikaans as the medium of instruction were established later than the English HWUs. The fact that English HWUs were founded earlier than the Afrikaans medium HWUs could have contributed to a well-established postgraduate education sector and research output in the English HWUs. In addition, this could have contributed to the production of more English mathematics education theses in South African universities.

Table 1.1 ***South African historical white universities which did not merge in 2004.***

Type of university	South African universities after 1994	Founded
Historical White English	University of Cape Town (UCT)	1829
	University of South Africa (UNISA)	1873
	University of Witwatersrand (Wits)	1896
	Rhodes University (RU)	1904
Historical White Afrikaans	University of Pretoria (UP)	1908
	Stellenbosch University (SU)	1918

Information sourced from the websites of the South African universities mentioned above.

With the advent of democracy, the mandate for HEIs was to change their language policies to accommodate all students especially those who were previously excluded from HWUs. Post 1994, former Afrikaans universities became dual medium or taught in English. Not all the Afrikaans academics welcomed this language policy shift because they spent lot of time developing Afrikaans as a scientific language equally used with English in academia. Van Coller (2016) argues for Afrikaans universities pronouncing that, "Research is often conducted solely in English, as academic journals and conferences favour English. As far as teaching is concerned, handbooks are often available in English only and parallel- medium of instruction erodes time available for research" (p. 998). Van Coller's concern, was English becoming the *lingua franca*, which might have been a reason most mathematics education knowledge was generated mainly in English. In 2019, the University of Pretoria (UP), one of the Afrikaans HWUs, drastically changed its language policy to be English medium only as a way of attracting students from diverse language backgrounds. This was a positive move by UP to remove negative links to the apartheid system.

Besides the fact that English medium HWUs were founded first, the English and Afrikaans medium HWUs were based on different philosophies. The English HWUs were founded on the Anglo-Saxon philosophy while the Afrikaans HWUs were underpinned by Dutch philosophical traditions (Hay & Monnapula-Mapesela, 2009). These philosophical traditions, to some extent, influenced the epistemological and theoretical lenses in the two types of HWUs. Therefore, this study sought to understand whether there are patterns in the epistemological and theoretical lenses used in different universities by postgraduate students to generate mathematics education knowledge influenced by the type of a university prior to 1994. Jansen (1991) concurs with Tight (2003) recognising that universities are instrumental in knowledge production, dissemination and evaluation; therefore, the universities' philosophical traditions play a major role in knowledge generation:

> Africanisation and transformation should of necessity entail an interrogation of the curricula and language of instruction, its relevance and appropriateness in addressing itself to national objectives and societal demands. It is about the grounds for knowledge, about epistemology, and about objects of our intellectual inspiration (Jansen, 1991).

The language policy, in addition, catered for the inclusion of African[3] languages as medium of instruction at universities. This opened opportunities for writing of mathematics education theses in African languages. It is the intention of this study to observe how many mathematics education theses were written in African languages opening up ways of generating knowledge that are indigenous to South Africa. In fact, the study intended to observe whether "translanguaging and multilingualism as ways to address the issue of language in higher education institutions" (Swartz, Mahali, Moletsane, Arogundade, Khalema, Cooper & Groenewald, 2018, p.ix) promotes the process of knowledge generation in a country with diverse languages.

While early universities in South Africa catered mainly for white people, University of Fort Hare (UFH) established in 1916, admitted black[4] people (Herman, 2017). During the apartheid years, black South Africans were not allowed to study at the HWUs. In fact, early in the 1900s, the only university catering for blacks was UFH. Specifically, UFH was established four years after the African National Congress (ANC) was formed in 1912. Most black African elite were educated at UFH for example Nelson Mandela and Oliver Tambo who were both former ANC Presidents. The other historically black universities

[3] Besides English and Afrikaans, nine African languages are also official languages in South Africa. The nine African languages are isiNdebele, isiXhosa, isiZulu, SiSwati, Setswana, SeSotho, Sepedi, Xitsonga and Tshivenda.

[4] Blacks in South Africa refers to people designated as Africans, Coloured and of Indian origin. In particular Coloured people identify the population of mixed ethnic origin or sometimes identified (legally) as persons of mixed blood.

(HBUs) were founded much later (see table 1.2 below) after the Nationalist Party came into power in 1948 and passed the University Education Act (1959) underpinned by segregation of different races. Beale (1998) posits that, "apartheid university education was based on the principle that university education was not universal but should serve a particular ethnic community. The ethnically segregated, state-controlled university colleges…, provided different, inferior educational opportunities to the state- aided, more autonomous, universities" (p.ii). The HBUs did not enjoy institutional autonomy but were bureaucratically driven by whites supporting the apartheid regime. Mamdani (1999) contends:

> White intelligentsia that took the lead in creating apartheid-enforced identities in the knowledge they produced. Believing that this was an act of intellectual creativity unrelated to the culture of privilege in which they were steeped, they ended defending an ingrained prejudice with a studied conviction. The irony is that the white intelligentsia came to be a greater, became a more willing, prisoner of apartheid thought than its black counterpart.

For Evans (1990) the white domination was more prevalent in the research process sustaining racial domination. However, open minded and progressiveness of black intelligentsia was evident in research produced in HBUs such as UDW and UWC that was critical of apartheid education. There was an emergence of theories such as people's education shifting the research paradigms. Such research shifted the discourse in the country towards the liberation of blacks. Nonetheless, the progressive theories were counteracted by prolific use of constructivism in mathematics education in Afrikaans universities (Subotzky, 1997). Owing to this, it was the intention of this study to explore the theoretical lenses used by mathematics education postgraduate students when generating knowledge in the period aftermath apartheid education. Did the theoretical debates at the end of the apartheid era influence how mathematics education postgraduate students approached their studies during the first decade of democracy in South Africa? This question sets the stage for the research focus, which is elaborated later in the first chapter on page 20. The placement highlights a historical progression, illustrating how shifts in educational theory during the transitional period shaped the study's focus on the theoretical frameworks employed in post-apartheid mathematics education research.

Table 1.2 ***Historical Black Universities***

HBUs	Year founded
University of Fort Hare (UFH)	1916
University of Limpopo (UL)*	1959
University of Western Cape (UWC)	1959
University of Zululand (UNIZUL)	1960
University of Durban Westville (UDW)*	1961
University of Transkei (Unitra)*	1977
University of Venda (UNIVEN)	1982

**Denote universities which either merged or was renamed after university merger in 2004 and 2005*

Another legacy of the HBUs was poor funding in the apartheid era (Lategan, 2009). This resulted in HBUs from the then Homelands[5] having inferior resources, and which did not prioritise research. This lack of attention to research had consequence to staffing and supervision of postgraduate students. What was noticeable was that, despite having mainly black students in HBUs, most staff and composition of Senate and Councils were white (see table 1.3 adapted from Mbanjwa, 1975). Consequently, the aforementioned negatively impacted on the mathematics education knowledge that was generated by postgraduate students in the HBUs. Black students did not have role models of black academics who could supervise their studies. In addition, the fact that research was not prioritised in HBUs meant that few staff had doctorate degrees. There was limited capacity for supervision of doctoral students resulting in the universities producing more masters than doctorate theses.

Table 1.3 ***South African historical white universities which did not merge in 2004.***

HBUs	Senate		Council	
	Whites	Blacks	Whites	Blacks
UFH	51	7	15	4
UL	46	5	13	5
UNIZUL	49	6	11	4
UWC	45	1	11	5
UDW*	44	4	11	4

**UDW is an HBU which merged with University of Natal (HWU) in 2004 to form the University of KwaZulu-Natal*

Post 1994, South Africa had its first democratic elections with all its citizens having equal rights to access education. However, when equal citizenship was won, the complex legacies of the past were not erased. During the first democratic years, several policy shifts were implemented to address the imbalances of the past. The White Paper 3 (1995) led to Higher Education Act passed as law in 1997 and the Council on Higher Education (CHE) was established in 1998. Some of the changes in HE came with reducing the number of public institutions through mergers from 36 to 23 (see table 1.4) by combining them. Combined universities, in South Africa are those that were merged following the government's policy for transforming education to bring down the number of institutions (Baloyi & Naidoo, 2016). The goal of this initiative was to tackle disparities stemming from the apartheid era and enhance inclusivity and fairness, in education (Baloyi & Naidoo, 2016). Independent universities (not merged) are those that retained their autonomy post restructuring. The

[5] During the apartheid era, in South Africa homelands, also referred to, as Bantustans , were regions designated by the government for Black ethnic communities in efforts to enforce racial segregation by confining Black South Africans to separate territories based on their ethnicity. These designated areas were a component of the apartheid system that restricted individuals from living and working in urban zones reserved for white citizens while presenting them as supposedly "independent" republics representing the ancestral lands of Black South Africans. Each homeland was allocated to an ethnic group (e.g., Zulu, Xhosa, Tswana) under the pretense of promoting cultural autonomy. However, in practice, these areas were severely under-resourced, economically disadvantaged, and lacked true autonomy, with the South African government retaining ultimate control. Homelands were used to deny Black South Africans citizenship rights within South Africa, aiming to confine them to rural and impoverished areas while justifying racial segregation and disenfranchisement.

merger process that began in the 2000s signified a transition, from the emphasis on mass production to consolidating institutions (Jansen, 2003). This policy initiative was intended to support historically disadvantaged institutions but were met with criticism that seemed like mainly it was HBUs and Afrikaans universities which were merged (see table 1.4). The data collected for this study were from the merged institutions and those that did not merge. This impacted on the data collection and is discussed in chapter 4. Through mergers, the theses were moved from one institution to another, and some theses were lost in transition as they were only digitized after 2010 in South Africa.

Table 1.4 *Merged universities in 2004 and 2005*

Merged HEIs	**Founded**	**Year of merger**
North West University (NWU)	1869	2004
University of KwaZulu-Natal (UKZN)	1910	2004
Nelson Mandela Metropolitan University (NMMU)	1965	2005
University of Johannesburg (UJ)	1967	2005

The year in which these universities were founded is based on the oldest public institution forming part of the merger.

Another policy to rectify the structural flaws of apartheid higher education was that Technikons were given the same (see table 1.5) status of the universities and some were amalgamated with universities (Bunting, 2006). Despite Technikons receiving the university status, most of them did not produce research in the first ten years of democracy and focused on producing national diplomas in different fields. As a result, there were no mathematics education theses in some of the former Technikons who were excluded in this study.

Table 1.5 *Former Technikons*[6]

Former Technikons	Founded
Durban University of Technology (DUT)	1907
Cape Peninsula University of Technology (CPUT)	1920
Mangosuthu University of Technology (MUT)	1979
Central University of Technology (CUT)	1981
Tshwane University of Technology (TUT)	2004
Vaal University of Technology (VUT)	1966

The year in which these universities of technology were founded is based on the oldest public institution forming part of the merger.

[6] Technikons were institutions in South Africa offering mainly diploma and certificate courses in technical study fields. Technikons were renamed to universities of technology in South Africa. Universities of Technologies now offer undergraduate degrees up to doctoral degrees.

Although a radical shift in policy content and direction–occurred from apartheid to post-apartheid era, numerous problems continued to beset the higher education sector especially regarding implementation of policies. The policy weaknesses existed in various areas, such as funding, redress, and capacity building, both for HBUs and students, especially those from the disadvantaged backgrounds. These policy weaknesses have led to movements in the late 2015 such as "Fees must fall" and decolonisation of curriculum (Le Grange, 2016). The fees must fall movement came into being as students demanded that the government fund students from disadvantaged backgrounds who are struggling to access higher education. Without funding such students were and still are unable to complete undergraduate studies and register for postgraduate studies. In addition, while students demanded government funding, they started the debate of decolonising what they learn and how they learn to include African and indigenous knowledge systems (Le Grange, 2016). It will be interesting to observe whether African and indigenous knowledge systems are researched in mathematics education postgraduate theses subsequent to fees must fall and decolonisation of curriculum movements. However, this is outside the ambit of this study which focuses on the ten years aftermath of apartheid education.

1.3 RATIONALE OF THE STUDY

The rationale of the study is stated by addressing the following the questions: What was happening in mathematics education research in South Africa in the first decade after democracy? Is the first decade aftermath apartheid in South Africa important? Why I chose a focus on postgraduate education research?

1.3.1 What was happening in mathematics education research in South Africa in the first decade after democracy?

The understanding of what was happening in mathematics education in South Africa in the first ten democratic years is understood from outside and inside perspectives. From the outside perspective in the first decade after democracy, little was known about South African mathematics education. For example, Keitel (2005) reviewed SAARMSTE[7] proceedings to reflect on what was happening in South African mathematics education research from an international perspective. "Mathematics education research in South Africa? If somebody had asked me what it was some 15 years ago, I could not have answered this question" (Keitel, 2005, p.329). As a German mathematics educationist who co-edited the South African mathematics education research book, Keitel was of the view that South African researchers played a minimal role in the international mathematics education during the 1970s and 1980s. Those that could attend international conferences during the 1980s were mainly white researchers. Moreover, "they often presented pieces of research of great similarity and fully in accordance with well-established research paradigms of so-called Western Euro-American countries" (Keitel, 2005, p.329). By the late 1990s and 2000s, the contributions by mathematics educationists in South Africa changed tremendously.

Keitel contends by the early 2000s, international mathematics educationists begun to question the use of dominant theories arguing they "received more attention than they deserve" (Keitel, 2005, p.329). Evidently, prior to 1994, these theories did not apply in all contexts (Keitel, 2005), especially in South Africa, with glaring disparities in access to and success in mathematics for different races. Nevertheless, there were changes in South African mathematics education research during the late 1990s. By this time, South African researchers were "guided by the intention to integrate the scientific goal of…research in mathematics education with the political goal of improving access to, success in and quality of mathematics education for all" (Keitel, 2005, p.333). It is for this reason that I was interested in researching what theories, methodologies and phenomena were used in mathematics education research in South Africa in the period 1995 to 2004.

From the internal South African perspective, it is not enough only to understand questions, methods and issues of theories used in mathematics education research. But

[7] SAARMSTE - Southern African Association for Mathematics, Science and Technology Education

understanding who was doing research on whom within the period 1995 to 2004 in mathematics education research in South Africa, was important, given we were coming out of apartheid education. Khuzwayo (2005) expatiates on this subject providing a historical overview of mathematics education research during the apartheid years (1948-1994). According to Khuzwayo (2005), white researchers conducted research on white schools during the early apartheid years. Research conducted around this period centred on the teaching of mathematics in predominantly white schools and the scarcity of proficient mathematics educators. According to Khuzwayo (2005), neither the learners nor the teachers were perceived as capable of questioning mathematics or mathematical knowledge; rather, the ultimate objective was for learners to accept it as an unquestionable truth (p. 314). This ontological standpoint carries significant implications for the methodology and discourse of educational research, particularly given the historical context in which mathematics was employed as a tool of racial segregation in South Africa.

Around the late 1970s to the early 1980s, there were changes in the participants in mathematics education research in South Africa while researchers remained the same. Khuzwayo (2005, p.315) suggests that around this period, research was conducted mainly by “whites-on-blacks”. There was a shift from researching white to black schools. Of interest are the results produced by research conducted on black schools. The results of these studies directly linked black learners’ poor performance in mathematics to their cultural background. “The culture of the child was to blame, for instance, in that he has difficulty in raising his thoughts to the abstract level and intellectually he actualizes himself inadequately” (Khuzwayo, 2005, p.317). These results and conclusions raise questions whether black mathematics education researchers would arrive at the same conclusion given that black researchers would most likely have shared and understood the culture of the black participants. One of the results from ‘white-on-black’ research by Groenewald (cited in Khuzwayo, 2005) clearly shows the comparison between races:

> Blacks are retarded as regards visual-perceptual development, that in contrast with Whites, they reveal an inability to report depth perception and to interpret three-dimensionally; that their concept of space differs radically from that of Whites; that they experience problems in perceiving pictures and figures analytically; that they do not have a clear understanding of concepts like circumference, length and width and generally find arithmetical concepts difficult to master (p.317).

This assertion raises questions about the use of one kind of a theoretical perspective in doing research. For example, Groenewald's study used psychological theories to understand the poor levels of mathematical concepts attainment for the black learners. It was conducted during a political unrest period in South Africa and at a time when the apartheid policies were in force for about 30 years. In fact, one of the apartheid policies namely Bantu Education Act of 1953, argued that black people should not be taught mathematics stating that:

> There is no place for [the Bantu] in the European community above the level of certain forms of labour...What is the use of teaching the Bantu child mathematics when it cannot use it in practice? That is quite absurd. Education must train people in accordance with their opportunities in life, according to the sphere in which they live (Kallaway, 1997, p. 92).

In contrast, had the political theories been used to frame Groenewald's study, maybe data analysis would yield different results. Currently, the results in Groenewald's study justified the apartheid policies, especially Verwoerd's statement (1954) of not allowing blacks to do mathematics. The idea of blaming the poor performance in mathematics of certain groups in society on their culture, race, gender, and class, has unfortunately not disappeared in research today. Some researchers use Bernstein's theory of classifications (Cooper & Dunne, 2000) to justify poor performance in mathematics for learners from low social class. From this perspective, such learners are unable to separate the context of the mathematical problem from the mathematical content needed to solve real-life mathematical problems. Thus, it was necessary to undertake research taking into cognisance the race and gender of the researchers juxtaposed against the research findings.

At the end of apartheid period, around the late 1980s to early 1990s, there was an "emergence of more black researchers who were not only involved in mathematics education but who were also interested in researching it" (Khuzwayo, 2005, p.320). During this period, there were significant changes in theories used in mathematics education research in South Africa. The debates in mathematics education were on educational reforms and the preparation for the end of apartheid era. The democratisation of knowledge (Khuzwayo, 2005) was on the mathematics education research agenda. Vithal (2000) articulates the process of democratisation of knowledge in her PhD thesis discussing different curriculum waves. People's Education for People's Power, challenged the dominant use of constructivism as the theory of understanding the teaching and learning of mathematics by certain former white universities. Despite the progress achieved during this period (1980s - 1990s) in mathematics education research, black researchers were still limiting their studies to black education. Nevertheless, "while it may be true that there has been a noticeable 'research vacuum' in mathematics education" by black researchers on white education, "there has always been some degree of interest in researching the state of mathematics in White education" (Khuzwayo, 2000, p.53). One such study conducted in mathematics education in the post-apartheid era (2001-2003) was the Learner Perspective Study (LPS). I was part of the researching team. Gaining access to researching a historically white school by black researchers was almost impossible without the participation of a white researcher. This experience in the LPS motivated me to understand 'who does research on whom' in mathematics education in the post-apartheid period and how is research conducted. In addition, it necessitated the race and gender analytical framework used in the analysis chapters.

As one might expect, this is not the first study in South Africa specifically addressing the issues of research at a meta-level from what research is done to how it was conducted. Besides Khuzwayo (2000) researching mathematics education in South Africa from 1948 to 1994, he later argued for "ending 'occupation of our minds'" (Khuzwayo, 2005, p.323). He cites the preoccupation of apartheid education for "a passive acceptance of authority rather than providing students with conceptual tools necessary for creative independent thought" (pp.323-324). Khuzwayo's work was used as the stepping stone for conceptualising this study in the post-apartheid mathematics education era within the period 1995-2004. Specifically, this study sought to understand, in the period immediate aftermath of apartheid, who were the producers of mathematics education knowledge from which universities, using which theoretical frames and methods. This was necessary to understand whether in the democratic South Africa, all races and HEIs contributed to generating mathematics education knowledge responding to the transformation agenda of the country.

Other scholars have documented mathematics education research issues in South Africa. Vithal, Adler and Keitel (2005) edited a book on different perspectives, practices, and possibilities of researching mathematics education in South Africa. In addition, in a special issue of African Journal of Research in MST education (AJRMSTE) in 2009 edited by Setati, Adler and Rollnick, several South African scholars reviewed mathematics and science education research from different perspectives. These perspectives included linking research to policy and practice, teacher education, curriculum policy implementation from journal articles published from 2000 to 2007. None of these research studies used postgraduate theses as the unit of analysis. Therefore, this study uses mathematics education postgraduate theses which might remain in the libraries and not documented.

1.3.2 Is the first decade aftermath apartheid in South Africa important?

Firstly, the period 1995 to 2004 was selected because the PPER was contextualized around this period and my study is part of the bigger project. Secondly, the period 1995 to 2004 was significant in South African history of education. Several educational policies were implemented signalling change in government. The educational policies were aligned with the new South African Constitution ensuring equality for all citizens. Some of the changes in education were the introduction of Outcomes Based Education (OBE) in 1998, the new philosophy through which the school curriculum was to be achieved. In addition, mathematics or mathematics literacy became compulsory up to grade 12 for all South African learners. Although this change in policy ensured that all learners, irrespective of race, were allowed access to some form of mathematics, however, its implementation faced several challenges that hindered its success. Beyond the shortage of qualified mathematics teachers, other issues, such as teachers' lack of content knowledge, insufficient resources, inadequate teacher training, and disparities in school support, also contributed to the policy's limited effectiveness in improving learners' mathematics outcomes. Over and above the aforementioned policies, a large corpus of educational policies were developed and implemented, sometimes without first piloting them (Sayed, 2000). These educational changes in schools, post 1994, made me interested in exploring whether they were prioritised in mathematics education research.

Thirdly, during the first democratic years in South Africa, there were also changes in higher education policies. South African universities merged, resulting in larger faculties of education with better human resources. Before 1994 universities were segregated along the racial lines. The historical black universities (HBUs) were not producing much research as they were not equally funded by the state as their historical white universities (HWUs) counterparts. It is for such reasons this study intended to explore whether the disparities in research generated in the newly reconfigured universities were minimised.

Fourthly, post 1994, learned societies were configured to integrate all racial groups in South Africa. The Association for Mathematics Education of South Africa (AMESA) was established bringing together all South Africans that were interested in mathematics education issues. Prior 1994, Mathematics Association of South Africa (MASA) catered mainly for white South African mathematics educators. At the same time, other races in South Africa had their own associations[8] for mathematics education. Similarly, South African Association of Research in Mathematics and Science Education (SAARMSE) later became (Southern African Association of Mathematics, Science and Technology Education (SAARMSTE) and was established at the beginning of this period. SAARMSE existed because prior to 1990, South Africa was excluded from the international activities because of its apartheid policies. Several countries around the world imposed sanctions on South Africa, affecting various sectors such as sports and economic trade. In fact, South Africa was isolated to pressurise the country to end apartheid. SAARMSTE was mooted after apartheid and sanction ended in South Africa. SAARMSTE became a unifying organization amongst all Southern African academics in the fields of mathematics, science and technology education who were interested in researching within their respective fields of study. Thus 1995 to 2004 was an interesting period to observe whether there were significant changes in mathematics education research because of changes within education system and the politics of the country at large.

---

[8] Association of Mathematics Teacher Educators of KwaZulu-Natal (AMTEK); Mathematics and Science Teachers Association (MASTA); Mathematical Association of Southern Africa (MASA); Mathematical Association of Transkei (MATRA); Mathematics Teaching Society (MTS); Natal Mathematics Teachers' Association (NMTA) and Northern Transvaal Mathematical Organisation (NOTMO).

1.3.3 Why I chose a focus on postgraduate education research?

Knowledge generation from the postgraduate studies represent the next generation of researchers and it is not common to synthesise postgraduate theses and dissertations. This is contrary to other studies examining conference research papers and journal articles. In this study, I elected to study postgraduate education research to provide a narrative of the corpus of research in the period 1995 to 2004. In the post-apartheid era, transformation at the South African universities and education in general implied a need for research supporting both policy and practice brought about our young democracy. There was a need to develop a teaching profession whose members are researchers and life-long learners (DoE, 2000). As a matter of fact, after 1994, there was a sharp increase in the enrolment into postgraduate studies (Ubogu, 2002; Subotzky, 2003). “In the year 2000, the higher education system enrolled 37 393 masters and 6 023 doctoral students, while the output was 5 776 masters and 815 doctoral graduates” (Skene cited in Ubogu, 2002, p.2). This meant there were a total of 6 591 theses produced in South Africa in the year 2000. If the throughput of masters and doctoral theses remained consistent at a percentage of slightly more than 15% nationally in the last five years of the period (1995-2004), there could be more than 30 000 theses.

Of importance to note is that the estimated figure includes theses from all faculties within South African universities. Therefore, the theses produced in faculties and/or school of education would be far fewer than the estimated number. As shown in chapter 5, there were 3776 education theses produced from 1995-2004. In addition, 190 mathematics education theses were published in the same period. It follows had I included papers published by academics, and research projects by different organizations like Human Sciences Research Council (HSRC), the sample size for this study would not be manageable. Further, it would have been difficult to track where the papers were published. Academics publish both nationally and internationally and some have studied their postgraduate studies in other countries during the period 1995-2004. Hence, I decided to focus on masters and doctoral theses published in South African universities.

Furthermore, at universities, research supervision is an expensive activity, a reason for a need to understand how it is done. What research questions are posed? Or are we leaving everything to chance assuming that important questions will inevitably be asked through the research process? Research supervision has implications for calculating research outputs. During the study period (1994-2004), the majority of research activities (Subotzky, 2003) were focused within HWUs.

> About 65% of research publications output and 61% of research and development funding allocations to Higher education are concentrated in five white universities (Cape Town, Natal, Pretoria, Stellenbosch, and Witwatersrand). By contrast, just 10% is produced in the HBUs combined, of which the major part is produced by the two non-African urban institutions, namely, the University of the Western Cape and the University of Durban-Westville. Research activities in technikons vary very widely but are generally very low (Subotzky, 2003, p.2).

Subotzky’s assertion necessitated a study where a meta-analysis of postgraduate mathematics education research in both HBUs and HWUs was conducted to ascertain whether there are changes in research publications contrary to Subotzky’s statement.

Moreover, injustices sometimes permeated academic work even for white students who were seen to oppose the apartheid philosophy. In particular, former political prisoner Prof Raymond Suttner’s Master of Laws (LLM) thesis was only accepted in 2018 at the University of Cape Town (UCT), almost 50 years after he completed it. “In 1969, Suttner's LLM thesis on legal pluralism in South Africa was refused because it quoted Jack Simons, who was banned as a listed communist” (Pitt, 2018). According to Pitt (2018), “Suttner's supervisor instructed him to remove the quotes prior to examination, he refused and instead withdrew the dissertation”. Such incidents motivated me to undertake a critical analysis of knowledge production in mathematics education theses. My aim was to explore how supervisors guided postgraduate students through the process of knowledge generation, particularly investigating whether postgraduate students had agency in determining the knowledge that comprised their theses.

1.3.4 Why I elected to conduct this study?

I developed an interest in undertaking this study based firstly on my undergraduate studies. I studied the Bachelor of Science degree majoring in mathematics and statistics. I was introduced to large scale quantitative research in my first qualification. My subsequent qualifications were in Education where I was introduced to different ways of generating new knowledge and understanding the world around me. I undertook courses in research methodologies that exposed me to alternate ways of knowing other than quantitative. During this time, I followed debates around best practices and more rigorous ways of generating new knowledge. Consequently, I deliberately conducted my masters research employing mainly qualitative approaches to research. It was not easy to analyse textual data however, during the write up for my master dissertation, I learnt a lot about analysing qualitative data.

Subsequently, I co-taught the research methodology module at the masters level, which sparked my interest in exploring how mathematics educationists use various research methodologies to advance knowledge in their field. While teaching the module, I noticed that many masters students struggled to select a specific research approach or theoretical framework for their proposals. This observation led me to investigate what factors influence postgraduate students' choices of research methodologies. I was interested in finding out if their choices are shaped, perhaps unintentionally, by their supervisors' theoretical orientations, methodological preferences, and philosophical perspectives? As Sierpinska (2003, p.11) succinctly argues:

> theories are not sufficiently examined, tested, refined, and expanded. A theory may be used mainly by its creators and their students rather than by a large number of independent and experienced researchers. It may be used for only one particular type of research study, of population, of methodology, or of context. (p.11).

Despite that no mathematics education postgraduate student was interviewed, a meta-analysis of the theories, methodologies, titles, research phenomena and results in theses (1995-2004) were surveyed. However, selected supervisors of the theses in the corpus were interviewed.

1.4 SIGNIFICANCE OF THE STUDY

This study holds significant value in understanding the historical development and transformation in mathematics education research in South Africa, particularly as the country transitioned from apartheid to post-apartheid. By examining the evolution of mathematics education knowledge production, this research sheds light on how the field adapts to and reflects major societal changes, offering a critical perspective on both continuity and change in educational priorities. This work is especially relevant to postgraduate students, novice researchers, and established scholars in mathematics education, as well as to policymakers and the Department of Higher Education.

Importantly, this study goes beyond mere statistics; it delves into the demographics of knowledge production in mathematics education, highlighting who conducted research on whom and exposing shifts in race and gender dynamics among researchers and research subjects. For example, data from the PPER database reveal that 91.3% of educational theses from 1995 to 2004 were produced in HWUs, while only 8.7% were from HBUs. Additionally, the overwhelming majority of these theses (98.5%) were produced at former universities rather than technikons, suggesting disparities in research resources and capacities between these institutions. Such findings provide a foundation for understanding the historical barriers that have shaped educational research outputs, and they underscore the need for policies addressing these imbalances.

The gender dynamics in mathematics education research during this period also reveal notable trends. Women, particularly white women, represented a significant proportion of postgraduate researchers (56% overall) during this period, contradicting the general stereotype of male dominance in research. Yet, in HBUs and Afrikaans-speaking HWUs, more male postgraduate students were producing educational theses, illustrating nuanced gender dynamics across institutional types. This trend speaks to broader societal shifts post-1994, as women increasingly entered postgraduate education, with a growing number specializing in mathematics education. However, racial and gender disparities remain an ongoing concern, as barriers to equality in higher education persist, especially for black women (Akala, 2019; Mabokela & Mawila, 2004).

The research also highlights the influence of institutional resources and specialized centers, such as Wits University's RADMASTE Centre and the Marang Centre for Mathematics and Science Education, in shaping mathematics education output. Wits, with its unique position within a Faculty of Science and its collaborative ties with pure mathematicians, produced a substantial portion of mathematics education theses in this period, more than double that of other institutions. This points to the significance of institutional culture, resource allocation, and research-oriented environments in fostering postgraduate success. Furthermore, the study illustrates how supervisory practices, funding availability, and institutional focus areas may influence throughput rates, especially at institutions like UP and UNISA, which produced a disproportionately high number of doctoral theses in mathematics education.

Another valuable contribution of this study is the development of a database cataloging the research agenda in South African mathematics education from 1995 to 2004. This database enables researchers and policymakers to assess the scope of research topics, identify ‘home-grown’ versus imported theoretical and methodological frameworks, and understand the alignment (or lack thereof) between research agendas and national imperatives. Additionally, the study opens avenues for future research on whether educational research has become more inclusive of South Africa’s official languages, as language policy changes post-2005 may have influenced the choice of language in postgraduate theses.

In short, this study serves as an essential resource for understanding the shifts in mathematics education research within a transforming society. Its findings will be of great interest to those aiming to develop more equitable, contextually relevant, and nationally aligned research practices in South African education.

1.5 PURPOSE OF THE STUDY

The purpose of this study is to critically analyze the mathematics education knowledge produced through postgraduate research in South Africa during the first decade after apartheid (1995-2004). The study aims to examine the nature, scope, and thematic focus of research conducted at the master's and doctoral levels across South African universities. By investigating how mathematics education knowledge was framed, structured, and disseminated, this research seeks to identify patterns in research titles, questions, methodologies, and theoretical orientations. A key focus is placed on understanding the demographic and institutional distribution of postgraduate research, particularly in relation to race, gender, and institutional legacy.

This study contributes to the broader discourse on knowledge production in post-apartheid South Africa by assessing how historical inequalities have influenced research output.

By utilizing Giddens' structuration theory, the study explores the interplay between institutional structures and individual agency in shaping mathematics education research. The findings provide insight into the transformation of higher education and the role of postgraduate research in advancing equitable and contextually relevant mathematics education. Furthermore, this study informs future educational policies, curriculum reforms, and research practices by highlighting gaps and opportunities in mathematics education research during a critical period of educational restructuring in South Africa.

1.6 KEY RESEARCH QUESTIONS

The main research question for this study is: *What forms of knowledge emerged from postgraduate studies in mathematics education research within South Africa during the years 1995 to 2004?* Sub-Research Questions:

1.1 How were the titles of postgraduate studies in mathematics education (1995-2004) formulated and structured?

1.2 Which phenomena were more frequently explored, and which were less likely to be investigated within these postgraduate studies (1995-2004)?

1.3 What were the predominant research questions, and what assertions were made concerning these phenomena?

1.4 What were the prevalent research paradigms, designs, approaches, and methodologies employed in postgraduate studies on mathematics education (1995-2004)?

1.5 Which theories were commonly utilized and which were less frequently applied in postgraduate studies on mathematics education (1995-2004)?

In addressing each of the above sub- research questions, this study examined the identities of the students who generated this knowledge, detailing their degrees and institutional affiliations. Through these inquiries, the study aimed to uncover trends and patterns within the corpus of postgraduate research in mathematics education produced in South Africa between 1995 and 2004.

1.7 GIDDEN'S STRUCTURATION THEORY

This study employs Gidden's structuration theory as the theoretical framework to guide the analysis. Giddens' structuration theory provides a framework for understanding the interplay between social structures and individual agency in shaping human behaviour and societal practices. This theory offers a valuable lens to analyse the complex dynamics at play. According to Giddens, structures refer to the enduring patterns of rules, norms, and resources that guide social interactions. These structures are not fixed, but are continually reproduced and transformed through the actions of individuals. Agency, on the other hand, pertains to the capacity of individuals to act purposefully and make choices within the constraints and opportunities provided by these structures. In the context of postgraduate mathematics education research in post-apartheid South Africa, Giddens' theory can be applied to scrutinize how institutional arrangements, educational policies, and socio-cultural factors influence the production of knowledge. It helps to uncover how researchers and educators navigate these structures, while also contributing to their reproduction or transformation. By employing Giddens' structuration theory in this study, the intricate relationship between the historical legacy of apartheid, educational policies, and the knowledge generation processes in postgraduate mathematics education is elucidated. This approach enables a nuanced understanding of how broader social structures impact the research landscape in this specific context.

1.8 RESEARCH DESIGN AND METHODOLOGY

This study investigates knowledge production within mathematics education postgraduate theses across South African universities between 1995 and 2004. The study utilizes Suri's (2004) Methodologically Inclusive Research Synthesis (MIRS) framework, a comprehensive approach that considers the variety of paradigms and methodologies in education research. The MIRS framework involves several steps, including identifying relevant studies, evaluating evidence, interpreting findings, and sharing results with an audience. By applying MIRS, this study seeks to capture a complete view of mathematics education scholarship in South Africa, incorporating all relevant postgraduate theses without excluding any based on quality, as supervision and examination processes were assumed to ensure this. A mixed-methods approach, particularly the explanatory design outlined by Creswell and Creswell (2018), guided the research. This design begins with quantitative data collection and analysis, followed by qualitative data to expand on the quantitative findings. The quantitative data provided an overarching view of the scholarship trends, while qualitative data from interviews with supervisors added depth and context.

The population sampled in this research consisted of postgraduate mathematics education theses from 19 out of 23 South African higher education institutions (HEIs), with data collected primarily through the Postgraduate Project in Education Research (PPER). Initial data was gathered from 11 institutions in 2007 and later expanded to additional HEIs. Due to restrictions, some institutions were excluded, including Walter Sisulu University, which declined access to its postgraduate theses. Sampling methods varied for different research questions, using convenience sampling for the quantitative aspects and purposive sampling for qualitative interviews with five supervisors. Interviews and theses provided demographic data, including authors' race and gender, to contextualize findings within South Africa's post-apartheid educational landscape. Analytical tools, such as SPSS and ENDNOTE, helped systematically code, analyze, and validate the data.

Ethical considerations included partial anonymity for participants, member checking, and institutional permissions. Challenges encountered included maintaining data uniformity, gaining institutional access, and handling secondary data collected by multiple researchers. Limitations included missing theses due to language barriers and institutional policies, as well as challenges related to the timeframe, which may not reflect later developments in mathematics education research post-2004. This study ultimately offers a valuable overview of trends and priorities in South African mathematics education research, reflecting shifts in the educational field in the post-apartheid era.

1.9 LAYOUT OF THE THESIS

CHAPTER 1: Introduction to the study

This chapter set the scene and discussed the contextual background and the rationale that motivated this study. This was achieved by discussing mathematics education research undertaken during the apartheid and post-apartheid period in South Africa. Arguments of the need for this study located within the first ten democratic years in South Africa were presented. The chapter argued for the understanding of mathematics education knowledge that was generated in the period of educational reforms in South Africa that redressed the inequities of the past, especially access to mathematics. This chapter also presented the purpose of the study, research questions, and brief discussion of theoretical framework framing this study.

Chapter 2: Knowledge production through mathematics education postgraduate theses (1995-2004): Literature Review

The literature review chapter focus on knowledge production within the realm of mathematics education postgraduate theses spanning from 1995 to 2004. The introduction set the context for the study, highlighting the significance of mathematics educational research and its role in generating knowledge. The review encompass research conducted on postgraduate theses, shedding light on methodologies, trends, and outcomes. A critical aspect addressed was the preparation of postgraduate students for conducting effective research in mathematics education, emphasizing the importance of equipping them with appropriate skills and methodologies. Knowledge synthesis is identified as a pivotal process in this context, where researchers amalgamate, interpret, and communicate findings. The discourse also delved into the intricate relationship between mathematics education and research, exploring how one informs and enriches the other. Lastly, the review engaged with the theory of knowledge, contemplating how epistemological frameworks underpinning research methodologies influence the generation and dissemination of knowledge in the realm of mathematics education.

Chapter 3: Theoretical framework

This chapter discuss the theoretical framework related to the research problem and purpose of this study. In this study, knowledge generation was conceptualised as a social construct depicting the political dispensation of the period 1995-2004 authors racial and gender identities, institutions playing an influential role. Accordingly, Giddens's structuration theory was used as lens for understanding mathematics education knowledge production through postgraduate education research in South Africa (1995-2004). What knowledge was produced, by whom, where, and how, was dependent on the social interactions, systems, time, space, material resources and power differentials in the institutions (Taylor, 2003).

Chapter 4: Research design

This chapter provides an overview of the research design appropriate for analysing meta-reviews studies. In this chapter, the choice for employing Suri's (2014) Methodologically Inclusive Research Syntheses (MIRS) extending the meta-family are discussed. In addition, the issues of sampling the HEIs, mathematics education theses, supervisors are examined. The challenges of secondary data analysis and researching up are considered. Moreover, the limitations of this study and ethical issues are discussed. Finally, the chapter concludes with a discussion of the analytical framework for analysing knowledge produced in postgraduate mathematics education research (1995-2004).

Chapter 5: Description of the mathematics education postgraduate theses in South Africa (1005-2004)

This is the first of the five analysis chapters. This chapter begins with the quantitative description of the corpus of the education theses collected for the PPER and then the mathematics education studies. Attention is paid to where the postgraduate studies were produced in South Africa (1995-2004). Although 19 HEIs had education theses collected for the PPER, only 14 HEIs produced mathematics education theses. Subsequently, the identity of the authors of the postgraduate studies in terms of race, gender, language, and degree are documented. As mentioned in this chapter, prior to 1994, South African government system and universities were racially divided. This study seeks to understand whether the racial divisions had an influence on the knowledge produced in South Africa in the first ten years of democracy. I further explain how data was gleaned from the collected education theses for the PPER and captured on ENDNOTE. The data read from the education theses for the PPER was shared with the participating HEIs. Moreover, five supervisors who supervised the mathematics education theses were interviewed to triangulate the findings of the quantitative data. This chapter ends with the discussion of the findings of the meta-syntheses of education and in particular mathematics education theses.

Chapter 6: Naming and framing of mathematics education postgraduate research titles

This is the second analysis chapter focusing on the titular construction in the mathematics education theses. The titles data is analysed using Jäger's (2001) critical discourse as a methodological tool, and not theory. First, the length of titles (Anthony, 2001), and the words depicting mathematics content were searched on the data captured on ENDNOTE. Second level analysis of titles dealt with linguistic devices (Bengesai, Goba & Karlsson, 2011; Anthony, 2001), research design, epistemological stance, and indication of results in titular construction. This chapter ends with the summary of emerging themes from the analysis of titles in mathematics education theses.

Chapter 7: Research phenomena, questions and claims

This is the third analysis chapter exploring the research phenomena, questions and claims gleaned from the mathematics education theses (1995-2004). This chapter addresses the second and third sub-questions of the main research questions namely: Which phenomena were more frequently explored, and which were less likely to be investigated within these postgraduate studies (1995-2004)? What were the predominant research questions, and what assertions are made concerning these phenomena? The analysis of the research questions used Fawcett and Downs (1986) conception of the types of research namely descriptive, relational, and explanatory. In addition, a methodologically inclusive research synthesis (MIRS) of the phenomena corresponding to the research questions/ aims/ objectives/ hypotheses and claims was done. The trends and patterns of the participants, contexts, and education levels that were selected in the mathematics education postgraduate studies (1995-2004) researching the phenomena identified above were explored. Further, the investigation of who researched the identified phenomena and questions from which HEIs was done. This chapter ends with the summary of the trends and emerging issues on research phenomena, questions and claims in the mathematics education theses (1995-2004).

Chapter 8: Research paradigms, designs, approaches, methods and research sites used in mathematics education theses (1995-2004)

This is fourth analysis chapter investigating the research paradigms, designs approaches, methods and research sites gleaned from the mathematics education theses (1995-2004). The analysis begins with the identification of the aforementioned methodological considerations addressed in the mathematics education postgraduate theses and the silences. The methodological considerations in the theses were linked to the research phenomena and questions. The findings of methodological considerations in the theses were triangulated with the interview data of some of the supervisors of the mathematics education postgraduate studies (1995-2004). The chapter ends with the summary of the trends of the research paradigms, designs, approaches, and methods utilised in the mathematics education theses (1995-2004).

Chapter 9: Theories used in mathematics education postgraduate research (1995- 2004)

This is the last analysis chapter synthesising the theories framing the mathematics education studies (1995-2004). The following questions directs the analysis: Which theories were commonly utilized and which were less frequently applied in postgraduate studies on mathematics education (1995-2004)? What were the identities of the students who conducted research using theories identified in the previous question? Which HEIs had mathematics education theses using theories identified? What research phenomena were investigated using the predominant theories in the mathematics education theses? What kinds of research questions were phrased in the theses with the prominent theories? How were the theories used in the discussion of the findings in the postgraduate studies? Were the theories revisited or not? If they were revisited, were they modified, refuted, or supported (Tsatsaroni, Lerman & Xu, 2003)? This chapter ends with the summary of the trends and emerging issues on theories framing mathematics education theses (1995-2004).

Chapter 10: Discussion of findings of the research syntheses and conclusion

The final chapter serves as the culmination of the research journey, delving into a comprehensive analysis and interpretation of the synthesized findings. This pivotal chapter presents a thorough examination of the data collected, highlighting key patterns, insights, and relationships extracted from the amalgamation of research studies. Through a meticulous exploration of these findings, the chapter aims to provide a coherent and well- founded understanding of the research subject. Furthermore, it steers towards a conclusive endpoint, offering a synthesized perspective that draws together the various threads of inquiry. This synthesis of insights sets the stage for the conclusive remarks and recommendations, encapsulating the essence of the research endeavour and its potential implications for both academia and real-world applications.

1.10 CONCLUSION

In conclusion, Chapter 1 has laid the foundational framework for my exploration into the landscape of postgraduate mathematics education research within South African universities during the first decade, following the dismantling of apartheid. The introduction has set the stage for the investigation, highlighting the importance of understanding the knowledge production dynamics in a transformative period. I delved into the unique context of South African universities in the aftermath of apartheid, underscoring the pivotal role they played in shaping the nation's academic trajectory. The formulation of key research questions has directed the inquiry towards the heart of this study, providing a roadmap for exploration of this study. The rationale of the study underscores the necessity of unravelling the complexities surrounding knowledge generation within postgraduate mathematics education research. Moreover, the significance of the study illustrates the potential contributions of this research to the broader fields of education, social transformation, and research methodologies. Lastly, the purpose of the study crystallizes my intent to critically analyse the intricate interplay of historical, social, and academic factors that have influenced the production of knowledge in this critical domain. Chapter 2 delves into a critical examination of the literature pertaining to the phenomenon under investigation. This marks the beginning of my exploration into the complex landscape of post-apartheid mathematical scholarship in South Africa, focusing on postgraduate theses as primary sources.

CHAPTER 2

KNOWLEDGE PRODUCTION THROUGH MATHEMATICS EDUCATION POSTGRADUATE THESES (1995-2004): LITERATURE REVIEW

2.1 INTRODUCTION

This literature review delves into a critical analysis of the knowledge produced within the field of postgraduate mathematics education research during the first ten years of this transformative era to gain deeper understanding of the complex interactions between postgraduate mathematics education research and the changing politics in the post- apartheid South Africa. This chapter seeks to engage in a critical discussion with existing literature on the many facets of research on postgraduate theses, the synthesis of knowledge, the dynamics of mathematics education, and the underlying theories of knowledge generation through the scholarly landscape. This study aimed to understand the subtle threads that contribute to the fabric of knowledge generation, distribution, and application in the context of an ever-changing world by traversing the scholarly domain spun by researchers. Postgraduate mathematics education research assumes a profoundly significant role in a socio-political context in transition, by providing an analytical study of the various techniques, epistemological viewpoints, and educational paradigms that intersect to generate a dynamic domain of knowledge. This literature review strives to highlight the transformational potential embedded within postgraduate research undertakings.

The first section explores the landscape of research on postgraduate theses by engaging with the theoretical, methodological, and empirical foundations that define this body of work. I evaluate the research gaps, trends, and new paradigms that have come to characterize postgraduate mathematics education research through a critical lens. This investigation prepares the way for a thorough examination of knowledge synthesis, the process by which several research threads are brought together to shed light on new ideas, dispel myths, and encourage the development of knowledgeable educational practices.

Further, this chapter explores the complex relationships between pedagogy, curriculum design, and societal change in the context of mathematics education. By dissecting the evolving theories and practices that inform mathematics education in post-apartheid South Africa, this study aims to explore the complexities that educators grapple with as they navigate the dual imperatives of knowledge transmission and socio-cultural responsiveness. This section serves as a bridge, linking the broader landscape of education to the specific domain of mathematics, showcasing the unique challenges and opportunities that arise in this critical field. Finally, the exploration of the research and theory of knowledge forms the culminating section of this chapter. Here, I embark on a philosophical journey, delving into the epistemological foundations that underpin the construction, validation, and dissemination of knowledge. By interrogating the diverse lenses through which researchers conceptualize knowledge, I endeavour to illuminate the underlying assumptions that shape the contours of postgraduate mathematics education research.

This section supports critical engagement with questions of objectivity, subjectivity, and the ever-evolving nature of knowledge in an era marked by rapid technological advancement and global interconnectedness. In navigating these distinct but interconnected subheadings, this literature review embarks on an intellectual journey, traversing the theoretical, empirical, and philosophical landscapes that−comprise the intricate field of postgraduate mathematics education research in post-apartheid South Africa's first decade. Through a critical analysis of these dimensions, I aspire to unravel not only the scholarly contributions but also the broader societal implications of this body of work, shedding light on the transformative potential that resides within the nexus of education, research, and socio-political change.

2.2 RESEARCH ON POSTGRADUATE THESES

This study was conducted as part of a big research Project on Postgraduate Educational Research (PPER) at the University of KwaZulu-Natal's Faculty of Education. The PPER examined issues, trends, and reflections on educational research produced by postgraduate students in South African Higher Education Institutions (HEIs) from 1995 to 2004 (Balfour, Moletsane, Karlsson, Pillay, Rule, Nkambule, Bengesai, Davey, Lekena, Molefe, Madiya, & Goba, 2008). By employing masters and doctorate theses as the unit of analysis, PPER aimed to provide a "reflexive narrative of developments" (Balfour et al., 2008) in educational research. The choice of this unit of analysis was justified on the following grounds: postgraduate theses show a certain institution's methodological emphasis. Furthermore, the theses contribute to the narrative of the research aims and values of educational research in South Africa. The PPER findings indicated significant concerns about the character of postgraduate research supervision in South African HEIs from 1995 to 2004. There were instances of plagiarism in several universities, with education postgraduates researching the same issue in the same year and arriving at the same conclusions (Balfour, Moletsane, & Karlsson, 2011, p.197). It was found that certain HEIs had developed significant research and specific interests over time, space, and resources. Furthermore, the PPER findings indicated a social turn in South Africa, recognizing the significance of political and educational developments while questioning the nature of those changes (p.201).

The realm of postgraduate theses research has often been characterized by a notable dearth of comprehensive studies and analyses. While notable contributions have been made by scholars such as Hallinger (2011), who meticulously reviewed three decades of doctoral studies in the field of educational leadership, and Mullins and Kiley (2002), who delved into the examination processes associated with theses, a significant gap persists in understanding various facets of this academic endeavour. Addressing this gap, Budden (2016) explored the utilization of electronic resources by curriculum studies postgraduates during the composition of their master's dissertations, shedding light on the evolving digital landscape's impact on research practices. Moreover, Pillay and Karlsson (2013) turned their attention to the exploration of novel avenues for researching postgraduate education within the context of South Africa, highlighting the need for more localized perspectives in the scholarly discourse. Despite these commendable efforts, the dearth of research in this domain underscores the ongoing need for comprehensive investigations to enrich our understanding of the multifaceted dimensions of postgraduate thesis composition and evaluation.

Despite some efforts to explore various aspects of mathematics education through postgraduate theses, the field still presents a significant gap in comprehensive and diverse studies. While the study by Şahin, Calp, Bulut, and Kuşdemir (2013) contributed valuable insights into Turkish postgraduate theses focused on Primary Mathematics Teacher

Education (2005-2010), it remained confined to a specific regional context and timeframe. Additionally, the international research landscape, as exemplified by the works of Lerman, Xu, Tsatsaroni (2003), and Suri (2007), has predominantly centred on journal article synthesis and meta-analyses, often focusing on specific subtopics such as cooperative learning or selected aspects of mathematics education. Similarly, the review conducted in the African Journal of Research in MST Education (Special Issue, 2009) shed light on mathematics and science education research in South Africa (Setati, Adler & Rollnick, 2009) but might not provide a comprehensive global perspective. Hence, there remains a pressing need for more extensive and diverse studies that delve into mathematics education postgraduate theses across various regions, themes, and contexts to better inform educational practices and policies on a broader scale.

Particularly, this study is dedicated to the comprehensive exploration of knowledge generated in the mathematics education postgraduate theses, in the period when educational landscape underwent significant transformations in South Africa, between 1995 and 2004. During this pivotal period, the educational field witnessed a profound shift, marked by the introduction of ground-breaking methodologies such as outcomes-based education (OBE), which aimed to redefine the very essence of learning and evaluation (Botha, 2002; Soudien & Baxen, 1997). In conjunction with this paradigm shift, a momentous development took place with the opening up of access to mathematics subject in high schools, for all South African learners. Jojo (2020) argues that "in the post- apartheid era in the country, a redress was effected to ensure that all students will have been exposed to some form of mathematics by the time they complete matric" (p.1). These changes, among others, represent a critical juncture in the evolution of education, and this study sought to analyse the produced knowledge during this transformative era. By delving into the theories, and insights generated during this timeframe, the research aims to provide valuable insights into the lasting effects of these educational reforms, contributing to a deeper understanding of the contemporary educational landscape and its foundations. This study tried to achieve this goal, albeit on a small scale, where the focus is on postgraduate mathematics education research.

2.3 PREPARATION OF POSTGRADUATE STUDENTS FOR MATHEMATICS EDUCATIONAL RESEARCH

The literature reveals there are differing views about the best practice for preparing postgraduate students for educational research in mathematics education (Enders, 2005; Neumann, 2005; Pallas, 2001; Samuel & Vithal, 2011; Taylor, Hagen, Liljedahl, & Moshe, 2007; Vithal & Goba, 2016). These views cover the kinds of research supervision offered to postgraduate students, namely: “facult[ies]’ struggle to decide whether or not to require all [postgraduate] students to study both quantitative and qualitative research methods, regardless of students’ diverse talents, interests and career aspirations” (Pallas, 2001, own addition); preparing postgraduate students for epistemological and paradigmatic diversity; transdisciplinarity as a way of producing knowledge, and the arguably higher value of a PhD as opposed to a professional doctorate. A further issue is whether the mathematics education PhD programme belongs in a mathematics department (Taylor et al., 2007).

Pallas (2001, p.7) argues that inducting postgraduate students into the world of research through “communities of practice” exposes doctoral and masters’ students to diverse epistemologies, methodologies, theories, and disciplines and is the best practice. He warns, however, that “it may be surprising that it is difficult to characterize the faculty of a particular school of education as a community of the practice of educational research” (p.7). In this framework, postgraduate students learn about research practices from several faculty members who form a community of practice. This framework is supposed to assist expedite the period that postgraduate students take to complete their theses. In this sense, the throughput rate of postgraduate theses might be higher than the case when students study through one-on-one supervision, where the throughput rate on completion of theses, is lower. However, the quality of the theses might be questioned by those who are sceptical about the number of postgraduates graduating. Nonetheless, in my experience, learning from a community of researchers in the doctoral cohort system (Samuel & Vithal, 2011) within the School of Education at the University of KwaZulu-Natal (UKZN) has exposed me to diverse research methodologies and theoretical orientations.

Opting for a professional doctorate degree is often favoured over a traditional PhD by individuals seeking a practical and applied approach to their field of expertise. Neumann (2005, p.173) eloquently spelled out why there is always a preference amongst faculties for a PhD or a professional doctorate degree or vice versa. She pointed to three issues that makes students choose one of the two: the recruitment and selection of students (a PhD degree does not need a student to have a teaching qualification and practical experience as a teacher); the length of the thesis (a PhD which is 120 000 words is 20 000 words more than a professional doctorate), and the perception that the PhD has a higher status than a professional doctorate. Enders (2005) alluded to the fact that the PhD is valued in society. A person with a PhD is believed to possess “special potential to run society” (Enders, 2005, p.121). This signals a fundamental relationship between society and the universities to produce people with training in research, who will be able to “solve or contribute significantly to the solution of the major problems facing the nation" (Enders, 2005, p.119).

Over and above the question of which doctorate has more value than the other, is a further question: where does the mathematics education PhD belong, in education or mathematics departments? (Taylor, Hagen, Liljedahl, & Moshe, 2007; Vithal & Goba, 2016) But before Taylor et. al. (2007, p.290) answer this question, they clarify the difference between mathematics education and mathematics: "Mathematics education is not mathematics. It is a domain of professional work (Bass, 2005, p.418). It has its own canon of knowledge, its own theories, traditions, and practices, and it has its own requirements for PhD students" (Taylor et al., 2007, p.162). Regardless, Taylor et al. (2007) believed that the mathematics education PhD has a place in the Mathematics Department. Gjone (1998) differed from Taylor et al. and believed there should be two different research programmes for students with a mathematics background but who lacked a background in educational theories, and those who have an educational background but lacked depth in mathematics. Gjone (1998), argued:

> Students with a background in mathematics have had little or no contact with educational research. They are not used to giving written presentations as essays; however, they have knowledge of mathematics to a certain degree. The weakness of the second group [mathematic education students] is often lack of knowledge of mathematics. On the other hand, they may have had some method courses in education…and some training in writing presentations…. The discussion above suggests that at least two different programs should be considered (p.121).

This study did not focus on whether a PhD thesis was produced by a student who has either a Masters in Education or a Masters in Science (with research in pure mathematics). Rather, it explored the methodologies, theories, research questions, claims and contexts of the mathematics education research studies.

In South Africa, the earliest doctoral theses in mathematics education emerged in the 1940s. Notably, Van Zyl's (1942) ground-breaking work, titled "Mathematics at the Crossroads: A Critical Survey of the Teaching of Mathematics in the Secondary Schools of the Union of South Africa with Suggestions for Reorganization," marked the inception of doctoral theses in South African mathematics education. It is worth mentioning that Van Zyl's thesis was completed at Columbia University (New York, USA). In contrast, Geevers (1944) contributed to the field with his doctoral thesis, "The Syllabus of Transvaal Secondary School Mathematics: A Historical and Critical Study," which was published at the University of Pretoria. The early decades saw most doctoral theses in mathematics education in South Africa authored by White postgraduate students. Notably, it wasn't until 1965 that Setidisho, a black scholar, achieved a milestone by obtaining a doctorate in mathematics education from the University of South Africa, with his thesis titled "An Empirical Study of Mathematical Ability in School." The subsequent decades witnessed a growing number of doctoral theses in mathematics education, with two in the 1970s, three in the 1980s, and a notable surge from the 1990s into the early 2000s.

2.4 KNOWLEDGE SYNTHESES

There has been a growing interest in academia on researching knowledge generated from various studies in the same discipline over a certain period. The literature alludes to different ways of bringing together numerous studies to signal what is known within a discipline or what areas of knowledge are under researched. These include meta-analysis, systematic, integrative, critical literature, multivocal literatures reviews, content and discourse analysis (Cohen, Manion, & Morrison, 2018; Kearney, 2001; Neuman, 2006; Ogawa & Malen, 1991). However, the aforementioned was discussed in-depth in chapter 4. In this subsection, research integrating findings across studies are discussed.

Research syntheses is dominant in the field of medicine (Agudelo-Suárez, Gil-González, Vives-Cases, Love, Wimpenny & Ronda- Pérez, 2012; Haidet, Jarecke, Adams, Stuckey, Green, Shapiro, Teal & Wolpaw, 2016; Linquist, Engardt & Richardson, 2010, Türk & Cihangiroğlu, 2018). The results of several studies in medicine are aggregated using mainly meta-analysis by applying statistical calculations. The number of aggregated studies may range from single digits to thousands depending on the criteria used to eliminate studies not fit for synthesis. For example, Türk et al. (2018) used thematic and methodological investigation of 268 applied postgraduate theses on psychological counselling and guidance. Agudelo-Suárez et al. (2012) synthesised 36 qualitative studies on access to health services using metasynthesis while Haidet et al. (2016) used content analysis on 49 articles to maximise the use of arts in medical education. It is not always that many studies are synthesised. Linquist et al. (2010) meta-synthesised four qualitative studies of learning to be a physiotherapist. Not only are various studies brought together to determine the trends and patterns in medicine knowledge production, there is considerable take up of such a research activity in education.

In the dynamic realm of education, the synthesis of knowledge stands as a pivotal endeavour, bridging the intricate tapestry of studies across diverse disciplines within the field. Such synthesis serves as a formidable tool, weaving together threads of research from various corners of educational exploration, ultimately yielding a more comprehensive and nuanced understanding of the intricate challenges and evolving paradigms that shape the educational landscape. As scholars and practitioners continue to strive for greater insights, the process of synthesizing research findings assumes a multifaceted nature, accommodating a spectrum of temporal scopes and methodological focal points.

Research synthesis, as a scholarly endeavour, represents a deliberate and purposeful effort to integrate, analyse, and interpret existing studies, contributing to a collective body of knowledge that transcends individual research endeavours. At times, such synthesis ventures span across the annals of educational history, tracing the evolution of pedagogical principles and practices over time (Rollnick, Adler, & Setati, 2009). These extensive reviews illuminate trajectories of change, continuity, and transformation, while also shedding light on the contextual factors that have shaped and reshaped educational paradigms.

Conversely, some research synthesis undertakings pivot around the refinement of temporal boundaries, honing in on specific eras, educational periods, or contemporary snapshots. Scruggs, Mastropieri and McDuffie (2007) synthesised qualitative research from journal articles and theses on co-teaching in inclusive classrooms without putting a time limit on their research. On the other hand, O' Connor (2010) analysed four decades of Australian postgraduate theses on curriculum scholarship. Then, Earley's (2014) article analysed 89 studies spanning 26 years from several countries, including South Africa. By delving into the intricate interplay between historical, social, and cultural forces, these studies offered insights into how education has responded to shifting societal needs and priorities, thereby enriching the discourse on educational development and reform.

Furthermore, the synthesis of research findings extends its embrace to the methodological underpinnings of primary studies. In these instances, scholarly attention is directed towards dissecting and juxtaposing various research approaches, methodologies, and paradigms employed across the educational spectrum. Such analyses enable a deeper appreciation of the epistemological foundations that underlie educational inquiries, fostering critical reflections on the strengths, limitations, and implications of distinct research methodologies. Şahin, Calp, Bulut and Kuşdemir (2013) conducted a document analysis of Turkish postgraduate theses in the field of Primary Mathematics Teacher Education (2005-2010). While Halai (2011) and Earley (2014) synthesised studies on research methods in education, Halai's paper focused on 20 science education masters theses researching action research.

The most recent investigations into the synthesis of mathematics education postgraduate theses have been carried out by İnan (2022), and Reotutar (2020). İnan (2022) specifically conducted a thematic analysis of theses centred on mathematics education with gifted and talented students in Turkey, offering a comprehensive overview of studies within this domain. ÖVEZ (2022) undertook a systematic review of postgraduate theses addressing pedagogical content knowledge in mathematics education in Turkey. This review highlighted a noticeable gap in the detailed scrutiny of certain subcomponents of pedagogical content knowledge in the existing studies. Reotutar (2020) contributed to the discourse by conducting a systematic review of graduate mathematics theses and dissertations in Region I of the Philippines. The study identified determinants of mathematics achievement as the most extensively researched topic and provided valuable recommendations for prospective research directions. Additionally, Nuangchalerm (2021) assessed the quality of theses within the teaching science and mathematics program at Mahasarakham University in Thailand. The findings revealed that most theses focused on action research and utilized teaching strategies such as problem-based learning and STEM education. In summary, these papers collectively offer insights into the diverse topics, methodologies, and quality standards observed in mathematics education postgraduate theses. They shed light on specific areas of concentration within the field and suggest potential avenues for future research. This body of work contributes to a nuanced understanding of the current landscape in mathematics education research, guiding researchers towards fruitful directions for further exploration (Inan, 2022; Nuangchalerm, 2021; ÖVEZ, 2022; Reotutar, 2020).

As I embark on a journey through the intricate web of research synthesis in education, this exploration sought to unravel the intricate tapestry of temporal variations, and methodological considerations. By delving into these dimensions, I aim to illuminate the synergies, tensions, and evolving trajectories that characterize mathematics educational research synthesis, ultimately unveiling a panoramic view of knowledge synthesis that informs and empowers educational scholarship and practice.

2.5 MATHEMATICS EDUCATION AND RESEARCH

2.5.1 Mathematics education

In order to understand the nature of mathematics knowledge produced through postgraduate education research, it is imperative to understand the field of mathematics education. According to Bishop (1996), mathematics education is a relatively young disciplinary area which has been around for the last thirty years. As noted, Taylor et al. (2007) alluded to mathematics education as different from pure mathematics. It is an area which focuses on teachers' professional work (Bass, 2005). It has its own knowledge, theories, traditions, and practices that are different from pure mathematics, though mathematics content links the two. However, mathematics education as a young discipline is still grappling with its identity (Sierpinska & Kilpatrick, 1998; English & Sriraman, 2005), a view that was reiterated by English and Sriraman (2005, p.170) when they state:

> Although we have made a significant advances in mathematics education research, our field has been criticized in recent years for its lack of focus (Steen, 1999). At the dawn of this new millennium, the time seems ripe for our community to take stock of the multiple and widely diverging mathematical theories, and chart possible courses for the future. In particular, we need to consider the important role of theory building in mathematics education research.

The International Handbook of Mathematics Education, edited by Bishop, Clements, Keitel, Kilpatrick and Laborde (1996), divides the field into four categories which assist in understanding how broad it is and the range of research priorities of postgraduate education studies in mathematics education. These categories included Curriculum, goals, contents and resources; Teaching & learning mathematics; Perspectives & interdisciplinary contexts, and Social conditions & perspectives on professional development. They assisted in answering questions such as what is prioritized or neglected in mathematics education research in South Africa. The handbook has 39 chapters dedicated to mathematical content, pedagogy of mathematics, philosophies of mathematics, research, and professional development of mathematics teachers. The mathematics education field is wide, as a result, postgraduate students can focus their research studies in any specialisation within the discipline.

The analysis of mathematics education theses in South Africa during the post-apartheid era provides a valuable lens through which to understand the evolution and dynamics of the broader field of mathematics education. These theses reflect the transformative efforts in South African education, mirroring the nation's journey towards inclusivity and equity. Exploring these theses allows for an examination of the innovative pedagogical approaches, curriculum reforms, and socio-political considerations that have shaped mathematics education in a rapidly changing society. This localized analysis finds resonance in the International Congress on Mathematics Education (ICME), where scholars from across the globe converge to share their research findings and pedagogical innovations. The ICME serves as a microcosm of the field's diversity, capturing the myriad ways in which mathematics education is investigated, practiced, and refined. As ICME continues to push the boundaries of mathematical education, it not only advances the field but also enriches the educational experiences of students worldwide. By juxtaposing the South African theses and the ICME platform, a rich dialogue emerges between the local and the global, shedding light on the universal goals and challenges of mathematics education in fostering numeracy, critical thinking, and societal progress.

2.5.2 International perspectives on mathematics education research: Insights and innovations from around the globe

In the exploration of international perspectives on mathematics education research, it becomes evident that a comprehensive framework for research in this field necessitates three fundamental components: enquiry, evidence, and theory. By examining how these elements are utilized across different cultural and educational contexts, we gain valuable insights into the diversity of approaches and methodologies employed in advancing our understanding of mathematics education (Bishop, 1996). Bishop succinctly argues that:

> To qualify as research in mathematics education, I believe a study needs three components, the first of which is 'enquiry'. It is the reason for research activity. It is the systematic quest for knowledge, research for understanding, and it gives the dynamic to the activity. Research has to be intentional, and it is enquiry focused. The second component is 'evidence' This is very necessary in a field like mathematics education, in order to keep the research related to the reality of the mathematical education situation that you are studying, be it classrooms, syllabuses, textbooks, or historical documents. Evidence must sample the reality on which the theorising is focused. Then we have the third component, 'theory'. Theory recognizes the existence of values, assumptions, generalised relationships. It is the way to represent knowledge and the understanding that comes from any particular research study…Theory is for me the essential product of research enquiry and theorising is therefore its essential goal. (Bishop, 1992, p.46)

Bishop's view indicates that in essence, mathematics education research begins with a problem to be investigated. For the problem to be investigated, there needs to be data produced as evidence for the claims made about the problem which leads to knowledge production through a process of theorizing. This implies a need to focus on methods and theories that are and were used in mathematics education research. In the next subsections, I discuss how mathematics educationists understand the issue of methodology and theory in mathematics education research.

Mathematics education research uses methodologies that are generic to educational research. Gjone (1998, p.119) however, suggests that "a reflection on method is usually not a dominant theme in published mathematical research". This is why this study seeks to investigate the research methods that were used in mathematics education research between the periods 1995 - 2004. Schoenfeld (2000, p.644) argues that of late qualitative research methods are often used in mathematics education research, even though there is a "long-standing quantitative tradition" in mathematics education research. He argued, that "those that are new to educational research tend to think in terms of standard experimental studies, which involve experimental and control groups and the use of statistics to determine whether or not results are significant". But, "the use of statistics in education is much more complex than one might think..." (p.645). Ernest (1998, pp. 77-79) discussed three paradigms in educational research which he suggests have been "paradigmatic wars" around their preference. These are the scientific research paradigm, which focuses on the process-product research by examining "classroom and learner variables and seeks to correlate them with mathematics learning outcomes". The second is the interpretive paradigm, evident in the experimental work of constructivist researchers. The third is the critical-theoretic paradigm, which is "reflected in the work of Gerdes (1985) in Mozambique and researchers such as Mellin-Olsen (1987), and Skovsmose (1985, 1994)" (Ernest, 1998, p.78). Given this scenario, this study explored the kinds of methods used and dominant in mathematics education research in South Africa during the period 1995 to 2004.

Lester (cited in Sriraman and English, 2005) suggests that although mathematics education research was largely atheoretical thirty years ago, this has changed in recent years, as evidenced by the published papers in major mathematics educational research journals. Theory, theorizing, and theoretical frameworks are an integral part of knowledge production in mathematics education. Sriraman and English (2005, p.453) argued that the surveys of the theories used in mathematics education research conducted by Furinghetti, 2003; Lerman, 1998, 2000; Schoenfeld, 2000, showed mathematics education research to be "concerned with the cultural and social aspects of learning" much as with cognitive aspects of learning. The theories vary from one geographical area to another.

During the 1980s, the landscape of educational theories witnessed distinct dominance in various regions, shaping the pedagogical approaches and research priorities of the time. Brousseau's theory of didactical situations gained prominence as a social theory and found significant utilization among mathematics education researchers in France, emphasizing the interaction between teacher, student, and subject matter. In Germany, the Bauersfeld theory, which underscored the social dimensions of teaching and learning, became a focal point for mathematics education researchers. In Canadian universities, the works of theorists like Piaget, Dienes, and Bruner held sway, forming the foundation for discussions on mathematics education. Meanwhile, in the United States, the constructivist theory of learning, rooted in Piaget's work, took centre stage, reshaping American educational practices. Another influential strand, social constructivism, drew from Vygotsky and Wittgenstein, capturing global attention. However, debates regarding whether social constructivism was a cognitive stance or a methodological perspective persisted, as pointed out by Ernest (cited in Sriraman and English, 2005). Alongside these theoretical orientations, the integration of models and modelling perspective, closely tied to situated cognition, also gained traction in mathematics education research, contributing to the evolving landscape of educational theories and practices. All these controversies offered reasons why I am interested in what theories, both inside and outside mathematics education, are used by South Africa postgraduate students when researching mathematics education research.

Cobb cited in English and Sriraman (2005, p.177) states that theoretical perspectives used in mathematics education research…:

> Include radical constructivism, sociocultural theory, symbolic interactionism, distributed cognition, information-processing psychology, situated cognition, critical theory, critical race theory, and discourse theory. To add to the mix, experimental psychology has emerged with a renewed vigor in the last few years…In the face of this sometimes-bewildering array of theoretical alternatives, the issue…is that of how we might make and justify our decision to adopt one theoretical perspective rather than another.

I began this subsection by discussing what counts as mathematics education research. It suffices to note that this question has been on the agenda of the International Congress on Mathematical Instruction (ICMI) as well. In 1994, the ICMI study conference that dealt with the questions what is research in mathematics education, and what are its results, was held in Washington, DC (Sierpinska & Kilpatrick, 1998). Over 81 participants attended from over 24 countries sometimes with over 8 participants from one country. Unfortunately, South Africa was not part of this study conference, nor any country from the African continent. Of concern is the non-participation by African countries and I wondered whether this means that mathematics education research conducted in those countries is not important, or so insignificant that it cannot be included in a study conference that was held as recently as 1994? Is the view that too little research is conducted in South Africa? Or, that the research conducted is not of the highest rigor? Or that it is in the mould of other countries, therefore not new and innovative? Does this signal ultimately, that mathematics education in Africa is not at the stage that can be considered “community of practice”? Perhaps this situation supports the observation made by Keitel (2005) earlier in this study, that mathematics education research conducted in South Africa was not known in the international community of mathematics education until recently. She suggested that only white researchers “presented pieces of research of great similarity and fully in accordance with well-established research paradigms of so- called Western-Euro and American countries” (p.329). As a result, research focusing on the nature of knowledge produced in mathematics education in South Africa, using a variety of theories, methodologies and contexts is important, and must be undertaken.

2.5.3 Evolution of mathematics education research in South Africa (1948-2023): A historical perspective

The landscape of mathematics education research in South Africa has undergone significant transformations over the past seven decades. This subsection delves into the pivotal studies and publications that have shaped the discourse surrounding mathematics education within this dynamic socio-political context. The journey commences with Khuzwayo's seminal doctoral thesis in 2000, which meticulously examined the trajectory of mathematics education in South Africa from 1948 to 1994. Khuzwayo's work served as a cornerstone, offering profound insights into the complex interplay between education and politics during the era of apartheid. Building upon Khuzwayo's foundational research, Vithal, et al’s. (2005) publication further expounds upon the intricate relationship between mathematics education and the political climate in South Africa during the apartheid years. Their editorial work sheds light on how mathematics education emerged as a potent tool for dismantling the injustices perpetuated by apartheid-era educational policies. Through critical analyses, Vithal et al’s. editorial work illuminate the transformative potential of mathematics education in fostering equity and inclusivity across racial lines.

As I traverse through the publications of South African mathematics education research, a notable shift in perspective emerged. Rollick, Adler, and Setati's 2009 editorial work, featured in a special edition of the African Journal of Research in Mathematics, Science and Technology Education, marked a turning point. This publication presented a comprehensive review of mathematics and science journal articles that were published by South African scholars, offering a panoramic view of the prevailing research landscape from 2000 to 2006. It stood as evidence to the evolving thematic foci within South African mathematics education. Subsequently, two more seminal reviews have interrupted this narrative. The review by Adler, Alshwaikh, Essack, and Gcsamba in 2017 focused on mathematics journal articles that were published from 2007 to 2015, providing a contemporary snapshot of the research trends within the field. Following suit, Morrison, Graven, Venkat, and Vale's comprehensive review in 2023 casts an even wider net, encompassing mathematics education journal articles published from 2003 to 2022. These reviews serve as invaluable compasses, guiding us through the rich tapestry of South African mathematics education research, offering insights into its evolution, trends, and areas of enduring concern.

In the subsequent sections, I embarked on a chronological exploration of the distinct phases, unravelling the intricate threads that have woven the fabric of mathematics education research in South Africa. Through a sequential analysis, I aim to provide a comprehensive understanding of the developments, challenges, and triumphs that have shaped this critical field of inquiry.

2.5.4 Mathematics education research in South Africa (1948-1994)

Khuzwayo's (2000) doctoral thesis provided a comprehensive review of mathematics education in South Africa spanning the years from 1948 to 1994. The central research questions that guided his inquiry were twofold: first, whether apartheid as an ideology exerted an influence on the way mathematics was taught and learned in the past; and second, the role that mathematics played within Black schooling. Khuzwayo's investigation revealed that during the apartheid era in South Africa, mathematics education was primarily concerned with the education of white learners. This orientation stemmed from Verwoed's apartheid policy, which disproportionately prioritized the educational needs of white learners, marginalizing the concerns of Black learners in the realm of mathematics education. Furthermore, in the 1970-1980s a critical issue arose regarding the scarcity of mathematics teachers, and the enrolment of learners in mathematics remained notably low. Consequently, research efforts predominantly concentrated on enhancing the quality of mathematics teaching, particularly in the domain of teacher training (Khuzwayo, 2000).

To address these pressing concerns, initiatives were implemented, most notably the amendment of the National Education Policy Act of 1967, that was introduced by Verwoerd in 1973. This legislative move was a deliberate response to the shortage of qualified and proficient mathematics educators, as emphasized by van der Berg (1976) and Thobejane (2013). The late 1970s and early 1980s witnessed the Soweto uprising, a pivotal moment in which Black learners vehemently protested against being instructed in Afrikaans. This uprising culminated in the establishment of the De Lange Commission, which included a subcommittee dedicated to scrutinizing the teaching of mathematics and science. The Commission's findings were unequivocal: mathematical proficiency among learners in the 'homeland states' was alarmingly deficient, as underscored by Khuzwayo (2000).

The period spanning 1985 to 1990 was characterized by discussions regarding the future of a democratic South Africa. This discourse paved the way for the inception of People's Education for People's Power (PEPP), an educational movement rooted in the principle of democratizing knowledge. Within the PEPP framework, mathematics was conceptualized as a human construct, one that had evolved over time to meet the diverse needs of its creators (Mphahlele & Khan, 1993). However, the efforts to forge an alternative research agenda for mathematics education were hindered by the imposition of a state of emergency by the apartheid government in 1986. With the advent of a new, democratic South Africa, there was a concerted effort to restructure mathematics associations to be inclusive of all racial groups. Notably, the Mathematics Association of South Africa (MASA) underwent a transformation, becoming the Association for Mathematics Education of South Africa (AMESA). Additionally, the South African Association for Research in Mathematics, Science, and Technology Education (SAARMSTE) was established, reflecting a pivotal moment of inclusivity and progress in the landscape of mathematics education in the country.

2.5.5 Mathematics education research in South Africa (1995-2004)

Macrae's (1994) article delved into the issue of learners' underperformance in mathematics and the accompanying challenges in resourcing mathematics education during the early stages of the post-apartheid era in South Africa. The study highlighted the far-reaching consequences of this underperformance, which extend beyond personal and social setbacks, encompassing significant economic losses due to a failure to establish an environment conducive to the cultivation of a suitably numerate population. This economic wastage emerged from a collective neglect in fostering the necessary conditions for the development of mathematical proficiency among learners (Macrae, 1994). Building upon Macrae's (1994) critical examination of learners' underperformance and resourcing in mathematics education in post-apartheid South Africa, Vithal, Adler, and Keitel (2005) edited a book that offered a comprehensive exploration of research methodologies and perspectives in the field of mathematics education within the specific context of South Africa.

In 2005, Vithal, Adler, and Keitel published a comprehensive book delving into mathematics education in South Africa, titled "Researching Mathematics Education in South Africa: Perspectives, Practices, and Possibilities." This collaborative effort involved 18 authors. The book centres around three core themes: research, curriculum innovation and change; investigating teacher education with its various orientations, converging messages, and incorporating psychological, sociological, and historical research perspectives. It shed light on the significant transformations that occurred in South Africa between 1995 and 2005, particularly focusing on the evolution of mathematics education post-apartheid (p.335). The narrative emphasizes the imperative link between mathematics education and the political landscape of South Africa at the beginning of the democratic era. It openly confronted and dissected the complex issues of poverty, violence, and disruption, recognizing their profound impact on mathematics education, research, and practice. Unlike the international scenario, the book critically scrutinizes both the promises and pitfalls of information technology, along with its socio-political realities and fictions. Furthermore, it unapologetically addresses the contradictory demands and benchmarks for the novel facets of mathematics teaching, learning, and research in mathematics education, sparking diverse critical dialogues (p.336).

2.5.6 Mathematics education research in South Africa (2000-2006)

Rollnick, Adler, and Setati (2009) edited a special journal that focused on research in mathematics and science education within the context of South Africa. This special journal, ARJMSTE, featured contributions from 21 authors and played a pivotal role in reshaping the landscape of mathematics education research in South Africa during the early 2000s. Rather than centering on democracy and mathematics education, this journal conducted a comprehensive review of articles that were published between 2000 and 2006 in mathematics and science education. It addressed themes such as relevance, language barriers, mathematics pedagogy, and teacher education in the field. The review's findings highlighted an "inevitable dislocation between policy and curriculum implementation" (Lelliott, Mwakapenda, Doidge, du Plessis, Mhlolo, Msimanga, Mundalamo, Nakedi & Bowie, 2009, p.47). Notably, the research that was conducted in South Africa primarily comprised of small-scale qualitative studies within urban settings. Additionally, South African research aligned with contemporary international research agendas, theoretical frameworks, and methodological approaches. Furthermore, the examination of papers on multilingualism revealed conflicting perspectives between small- and large-scale research. While large-scale research advocated for enhancing learners' fluency in English to boost their mathematics achievement, small-scale research posits a different stance (Rollnick, Adler & Setati, 2009).

2.5.7 Mathematics education research in South Africa (2007-2015)

Adler, Alshwaikh, Essack, and Gcsamba (2017) followed in the footsteps of Rollnick, Adler, and Setati's seminal work (2009) by conducting an extensive review of mathematics education journal articles spanning the years 2007 to 2015. Building upon the foundation laid by their predecessors, Adler et al. (2017) assert that the trends observed in prior reviews continue to dominate. They underscore that the landscape is still predominantly characterized by small-scale qualitative studies that focused on the intricacies of secondary-level mathematics teaching and learning.

However, in a notable shift, Adler et al. posit that the mathematics education community has witnessed substantial growth and maturation since the previous review periods (2000-2006). This is evidenced by a noteworthy doubling in the volume of scholarly papers, signifying a heightened level of engagement and scholarly output within the field. Such an expansion underscores the growing vitality and scholarly depth of mathematics education research. Furthermore, the review identifies a discernible uptake in research dedicated to primary mathematics education during the period of 2007 to 2015. This shift reflects an increasing recognition of the pivotal role played by foundational mathematics instruction in shaping the educational trajectory of learners. It speaks to a growing acknowledgment of the importance of establishing strong mathematical foundations early on in a learner's academic journey.

In essence, Adler, Alshwaikh, Essack, and Gcsamba's (2017) review not only serves as a continuation of the scholarly inquiry initiated by their predecessors but also offers a valuable snapshot of the evolving landscape of mathematics education research. Their findings illuminate a field that is not only steadfast in certain established trends but also dynamic and responsive to emerging areas of inquiry. The heightened scholarly output, coupled with the expanded focus on primary mathematics education, bears testament to the enduring relevance and evolving nature of mathematics education research in the contemporary educational landscape.

Rollnick, Adler, and Setati (2009) along with Adler, Alshwaikh, Essack, and Gcsamba (2017) conducted comprehensive reviews of journal articles in mathematics education within the post-apartheid era. Their collective efforts sought to understand the state of mathematics education in South Africa. In a parallel endeavour, Waller and Maxwell (2017) delved into the pedagogical landscape of mathematics across public and private school domains in the post-apartheid South Africa. Their investigation adopted a critical theory framework, aiming to cultivate critical consciousness and dismantle entrenched institutional constructs persisting long after apartheid's ending. The study by Waller et al. (2017) unearthed pertinent issues in the teaching and learning of mathematics in these opposite spaces. “Although more than 20 years has passed, we still see similar disparities within the schools as those that existed during the apartheid period. Although not as severe as the conditions were during the apartheid, there still exits a great divide in financial, educational, and physical resources” (Waller et.al., p.756). This comprehensive inquiry shines a light on the intricacies of mathematics education in South Africa's post- apartheid milieu, providing valuable insights for ongoing reform efforts.

2.5.8 Mathematics education research in South Africa (2003-2022)

Building on the foundations laid by previous reviews, Morrison, Graven, Venkat, and Vale's (2023) extensive analysis covered nearly two decades of mathematics education research, spanning from 2003 to 2022. Their comprehensive review delved into critical aspects of the field, including teachers and teaching, learners and learning, language and multilingualism, and assessment. Remarkably, their findings echo those of previous reviews, particularly in the notable surge of primary mathematics education research that is observed from 2013 onwards. Morrison et al. (2023) posit a compelling explanation for this surge, attributing it to the establishment of the South African Journal of Childhood Education. This development has undoubtedly catalysed a proliferation of scholarly output in the realm of primary mathematics education. The advent of this dedicated journal has provided a vital platform for researchers to share their insights and findings, thereby nurturing a fertile ground for robust discourse and exploration within the domain of early childhood mathematics education. This noteworthy surge in research output aligns with broader trends observed in the field, indicating a growing recognition of the foundational importance of mathematics instruction during the early years of a learner's educational journey. It also underscores the increasing sophistication and maturation of the mathematics education research community in South Africa.

The cumulative effect of these successive reviews, spanning from Rollnick, Adler, and Setati's seminal work in 2009 to Morrison et al.'s expansive analysis in 2023, paints a story of the evolving landscape of mathematics education research in South Africa. The enduring themes, such as the prominence of small-scale qualitative studies and the persistent focus on primary mathematics education, stand alongside the dynamic shifts catalysed by initiatives like the South African Journal of Childhood Education. Together, these reviews not only offer invaluable insights into the field's trajectory but also serve as evidence to the vibrant scholarly community dedicated to advancing mathematics education in South Africa.

2.5.9 Positioning my research within the historical context of mathematics education research in South Africa (1948-2023)

My research study distinguishes itself from prior studies that have explored the historical perspective of mathematics education research in South Africa from 1948-2023 in several key ways. Firstly, it employs a meta-synthesis approach, focusing on mathematics education postgraduate theses rather than journal articles. This choice of unit of analysis sheds light on the methodological priorities of supervisors and institutional cultures. Moreover, these theses contribute significantly to the overarching narrative regarding the research objectives and values within South African educational research. Secondly, my study delves into the examination of theses titles and the theories employed within mathematics education postgraduate works.

This study aligns with the approaches taken by Khuzwayo (1948-1994); Vithal, Adler, and Keitel (2005); Waller and Maxwell (2017), emphasizing the socio-political lens through which mathematics education is viewed. It specifically addresses the pivotal role of gender and race in knowledge production within mathematics education during the first decade of democracy in South Africa. Additionally, my research shares similarities with the edited work of Rollnick, Adler, and Setati (2009), as well as the reviews conducted by Adler, Alshwaikh, Essack, and Gcsamba (2017), and Morrison, Graven, Venkat, and Vale (2023) concerning journal articles published in mathematics education. Like these later studies, my research aggregates and synthesizes findings, although it focuses exclusively on the domain of mathematics education theses.

2.6 THEORY OF KNOWLEDGE

For centuries, philosophers have engaged themselves with the understanding of the concept knowledge. Plato was among the first philosophers to defined knowledge in his works of dialogues: *Meno, Phadedo, Symposium, Republic, Cratylus, Thaeatetus, Phaedrus, Timaeus, Sophist, Politicus, Philebus, Laws* (Gulley, 1962, p.1). Plato's dialogues signal that knowledge is based on *justification*, *truth* and *belief.* Throughout his works, he showed how justified true belief linked to the theory of knowledge. For example, in the *Sophist*, he discussed issues of statement and belief; in *Timaeus*, he contemplated about knowledge and belief (Gulley, 1962). However, the literature suggests that there is no consensus on the definition of knowledge (Halpern, Samet & Segev, 2009; Dicker, 2004; Kirkham, 1984; Gulley, 1962) and the debates have lasted for about two millenniums (Lemos, 2007).

Philosophers, Ayer (1956) and Chisholm (1957) defended Plato's definition of knowledge as justified true belief (see footnote below). Gettier (1963, p.123), in what is now termed the 'Gettier Problem[8]', argued against Plato's understanding of knowledge, stating that the conditions presented are not sufficient. He outlined his argument by analysing the conditions of the proposition (S knows that P if and only if) made by Plato, Chisholm and Ayer:

S is justified in believing that P. (Plato, 4th century)

S has adequate evidence for P. (Chisholm, 1957)

S has the right to be sure that P is true. (Ayer, 1956)

By taking the terms *justified*, '*adequate evidence*' and '*right to be sure*' to mean the same thing, Gettier (1963) argued that "it is possible for a person to be justified in believing a proposition that is in fact false" (p.121). Gettier came to this conclusion by examining two counter examples to the definition of propositional knowledge. One of his examples is:

> Smith and Jones have applied for a certain job. Smith has the strong evidence for the conjunctive proposition: (d) Jones is the man who will get the job and Jones has ten coins in his pocket. Smith's evidence for (d) might be that the president of the company assured him that Jones would in the end be selected, and that he, Smith, had counted the coins in Jones's pocket ten minutes ago. Proposition (d) entails: (e) the man who will get the job has ten coins in his pocket. (Gettier, 1963, p. 122)

In the analysis of the above propositions, Gettier puts a supposition that "Smith sees the entailment from (d) to (e), and accepts (e) on the grounds of (d), for which he has strong evidence. In this case, Smith is clearly justified in believing that (e) is true" (p.122).

---

[8]Gettier (1963) in his short paper, "Is justified true belief knowledge?" critiques the proof of the proposition, '**S knows that P if and only if**' by Plato (in his famous dialogues mentioned in text above), Chisholm (1957) (in his book *Perceiving: A Philosophy Study*) and Ayer (1956) (in his book, *The Problem of Knowledge*). Plato, Chisholm and Ayer prove the proposition *S knows that P if and only* if by each providing three conditions.

Plato's proposition: *S knows that P if and only*

(i) P is true; (ii) S believes that P, and; (iii) S is justified in believing that P.

Chisholm's proposition: *S knows that P if and only*

(i) S accepts P; (ii) S has adequate evidence for P, and (iii) P is true.

While **Ayer's proposition**: *S knows that P if and only*

(i) P is true; (ii) S is sure that P is true, and(iii) S has the right to be sure that P is true (Gettier, 1963)

According to Gettier, what if Smith is the one who eventually gets the job and not Jones as he had initially thought. “Also, unknown to Smith, he has ten coins in his pocket” (p.122). In this sense, proposition (e) is true and (d) is false. If that is the case, do we still consider that proposition as knowledge? As researchers, we rely on the experiential knowledge of our participants. In addition, at the time of data collection, the participant may believe their responses to interviews, questions etc. After data is collected, they might change their belief of the information given to the researcher who does not contact the participant(s) afterwards. To this end, Lemos (2007, p.14) argued that justification, unlike truth, is relative, because propositions can be justified for one person but not for the other, moreover for an individual, justification may change over time. “If knowledge requires justification,” he asks, “What degree of justification does knowledge require” (p.15)? Is the answer lying with improving our methods of data collection to ascertain validity? Alternatively, do we trust our participants as “epistemic agents” (Kirkham, 1984, p.501) that they have “epistemic justification” (Lemos, 2007, p.13)?

The difficulty of ascertaining what is believable in the understanding of knowledge has led the philosophers to be preoccupied with the question ‘what is knowledge’ and the development of epistemic logic and epistemology. For the past 50 years, philosophers have been trying to “resolve the Gettier Problem” (Kirkham, 1984, p.501). In resolving the debate around the definition of knowledge, coined by Plato and refuted by Gettier, Kirkham suggests that the evidence for the belief renders knowledge to be truthful. Evidence to claims made in research, is critical. From these claims, new knowledge is produced. Consequently, this study sought to investigate the process of knowledge production because of research claims that are found in mathematics education postgraduate studies. Postgraduate students gather data usually from participants such as teachers, learners, and managers (e.g. Principals, District and Provincial). How much of the data gathered from the participants is knowledge that is justifiable, true and believable? Are the participants justified to believe the information they provide the researchers (postgraduates) during data gathering as truthful? Lemos (2007, p.44) argued, that “a better understanding of the nature of justification will help us to understand better the nature of knowledge”.

In spite of no consensus reached on the definition of knowledge as justifiable true belief; yet philosophers agree that there is a strong link between knowledge and justification (Lemos, 2007, p.44). The literature reveals different theories of justification. Foundationalism, coherentism, and reliabilism are the three most prominent theories of epistemic justification. The less popular theories of epistemic justification are scepticism, epistemic circularity and evidentialism (Lemos, 2007). The theories of justification mentioned here are classified into either internalist or externalist (Lemos, 2007, p.108). In this chapter, I focus only on the main theories of justification.

Foundationalism proposes that there are basic beliefs, which act as the foundation from which other beliefs are derived (Lemos, 2007). According to foundationalists (e.g. Descartes[9], 17th century), these basic beliefs are non-inferentially justified. They form the basis for justification of other beliefs but they themselves need not be justified. This theory of justification came about as a way of avoiding "regress argument" (Lemos, 2007, p.48) for example, when proving mathematical propositions; one proposition is regarded as an axiom. According to Sibley (2009), axioms are used "as starting points for proving theorems" (p.353). He further recommends that, axioms to some are 'self-evident truths' for others they are assumptions used to prove other results. Criticisms levelled against foundationalism are first, "what makes justified basic beliefs justified" (Lemos, 2007, p.59). Second, is the arbitrary nature of basic belief. Who chooses basic beliefs? Are the justification of claims in postgraduate mathematics education research based on 'some' basic beliefs? Are the 'problems' researched in mathematics education based on the foundation that is known to the community? Perhaps the criticism by Pring (2004, p.220) that "research conclusions seem more like transient beliefs than well-established knowledge" is correct if one does not support foundationalist theory of justification. However, where are these basic beliefs about mathematics education that postgraduate

---

[9] Descartes is believed to be the father of modern Philosophy and a rationalist. He argued that truths, are known innately and therefore constitute basic innate knowledge, a view not always held amongst contemporary rationalists. Descartes made huge contribution to the field of mathematics and he is known as the father of analytical geometry.

students use as the basis of their justification? Alternatively, are the justifications known as theories of mathematics education?

On the other hand, the findings of previous research studies in the literature, were used as the basis of justification. Certainly, we should refer to knowledge from other research studies, in a critical manner. Pring (2004) succinctly answers the questions raised here by describing the “bodies of knowledge” (p.221) as:

> Theories, propositions and explanations which have accumulated through enquiry, criticism, argument and counter-argument. They are what have survived testing and criticism. They are, as it were, public property. And …their credential depends upon their being open to public challenge and refutation (p.221).

Coherentism is a theory of justification that is contrary to foundationalism. Coherentists (e.g. BonJour[10],1985 and Lehrer[11],1974) reject the idea that there exist basic beliefs from which other beliefs are inferred. Instead, they argue that a belief is justified if it coheres with other belief systems (Lemos, 2007, p.68). For them, a coherent belief-set is consistent and cohesive (Lemos, 2007). A belief system is consistent if there are no contradictions within it. Lemos suggests that a person cannot believe proposition *p* and *not-p* at the same time. This results in inconsistency in that person’s belief, and it is not coherent. Besides consistency, a belief system must be cohesive, meaning the beliefs it contains must support each other. Criticism levelled against coherentism is that it does not accept experience as a basis of belief to enhance justification (Lemos, 2007, p.84). The drawback with this is that mathematics education is a social science. It focuses on the study of how teaching and learning of mathematics happens in a social space. As such, human (teachers’, learners’, school management’s, or policy experts’) experiences sometimes are analysed in mathematics education postgraduate research. If experience cannot be a belief to enhance justification of knowledge, how is the nature of knowledge understood in

[10]Laurence BonJour writes about coherentism in *The Structure of Empirical Knowledge* (1985).

[11]Keith Lehrer discusses coherintism in *Knowledge* (1974) and *Theory of Knowledge* (1990),

mathematics education according to coherentists? Pring (2004) succinctly states the aforementioned:

> A criticism of educational research is that it does not create a body of knowledge upon which policy-makers and professionals can rely. First, a lot of research is small- scale and fragmented and there is no cumulative growth of such knowledge. Second, educational discourse seems to be full of people criticizing others' research such that there is nothing conclusively verified- no *knowledge*. Research conclusions seem more like transient beliefs than well-established knowledge. (p.220)

Reliabilism, unlike foundationalism and coherentism (where beliefs are related to other set of beliefs), whether a belief is epistemically justified, depends on it "being the product of a reliable cognitive process" (Lemos, 2007, p.85). According to Lemos, reliability of the belief forming process, epistemically justifies knowledge. Goldman (1979) proposes that confused reasoning, emotional attachment, hasty generalisations, wishful thinking and guesswork are faulty belief producing processes. Whereas good reasoning, remembering, and introspection produce justified belief (Goldman, 19719, p.9). In this sense, if we acknowledge the reliabilists (e.g. Goldman[12], 1967) point of view of epistemic justification, then mathematics education postgraduate students must pay attention to their data collection instruments and analysis of data. Are their participants responding to either questionnaires or interview questions in a hasty, wishful thinking, emotionally attached manner? Alternatively, are their participants' responses based on good perceptual processes such as good reasoning, remembering and introspection (Goldman, 1979)? The good perceptual processes can be, partly, determined by the reliability and validity of the research instrument postgraduate students use.

---

[12] Goldman (1967) writes about reliabilism in his article "A Causal Theory of Knowing" (*Journal of Philosophy*, *64*, pp. 357–372.

Table 2.1 Theories of justification and nature of knowledge

Main theories of justification		Nature of knowledge	
		Rationalism (reason)	Empiricism (sense/ experience)
	Externalism	Reliabilism	
	Internalism	Coherentism	Foundationalism

In spite of relying on reliable cognitive processes, reliabilism has also faced criticism. Philosophers have critiqued reliabilism for the ‘problem of unknown reliability’; ‘the generality problem’; and have called it the ‘new evil demon’ problem (Lemos, 2007, p. 90). Based on the nature of epistemic justification, the three theories foundationalism, coherentism and reliabilism can be classified into externalism or internalism. According to Lemos (2007) externalism and internalism are “general views about what is relevant to epistemic justification” (p.108). Internalism argues that epistemic justification of the participant’s belief is determined internally in their minds and accessible on reflection (ibid. p. 108). On the contrary, externalism contend that “epistemic justification of a belief depends at least in part on… reliable cognitive process[ess]” (ibid. p.110). The three theories of justification can be further categorized into two kinds of nature of knowledge namely rationalism and empiricism see table 2.1. Reliabilism is a form of externalism (based on reliable cognitive process) linked to rationalism as a nature of knowledge based on reason. Coherentism is also based on rationalism, however, it differs to reliabilism in that it takes experience into consideration.

Unlike coherentism, reliabilism does not worry whether the reliability is achieved through reflection on one’s experience, it only concerns itself whether the process is reliable (Lemos, 2007, p.110). Foundationalism is a form of internalism based on empiricism. Empiricism holds that all knowledge is derived from experience. Gulley (1962) showed a distinction between rational (*a prior*) and empirical (*a posterior*) knowledge in his metaphysical theory (p.187). However, his latest work did not go unchallenged. He himself had to abandon some explanations for the distinction between *a prior* and empirical knowledge while being challenged by Aristotle (Gulley, 1963, p.187). He could show the distinction only in mathematical knowledge.

From the beginning of this subsection, I discussed knowledge based on justification, truth, and belief, espoused by Plato and critiqued by others. I have discussed in depth the theories of justification and how they connect to the understanding of produced knowledge in mathematics education postgraduate studies. However, the theory of knowledge based on justification as a necessary condition of knowledge, has been critiqued by some scholars. Kornblith (2008) argued that "knowledge needs no justification" (p.5). She suggested "we may better understand the nature of knowledge, and we may better understand the nature of justification, if we stop viewing justification as one of the necessary conditions for knowledge" (p.6). Anderson, Hughes and Sharrock (1986) pointed out that, "the truthful and factual character of our knowledge is not guaranteed" (p.19).

If this is the case, how does one analyse a research corpus to narrate the development of knowledge in a field like mathematics education? Specifically, how should this study titled 'A critical analysis of knowledge produced through postgraduate mathematics education research in South Africa (1995 – 2004)', be focusing on the analysis of knowledge? Is it sufficient to analyse the titles, focus areas, research questions, and claims (spelt out in the first critical research question) to understand the kinds of knowledge in mathematics education postgraduate studies? Instead, should I be focusing on what the postgraduate students are saying about the belief and truth of their participants' responses? As might be expected, generally, research in education does not put under the microscope the truthfulness of the beliefs of the participants when responding to the researchers. The work of Popper (1972), on this subject in Pring (2004), indicates that "knowledge comes to be associated with the private beliefs of each individual and…the justification of a knowledge claim would lie in linking these subjective states of mind to the objective reality" (p.62).

Pallas (2001, p.6) asks critical questions about the nature of knowledge:

> Is there a single, absolute truth about educational phenomena, or are there multiple truths? (Or is the concept of truth itself so problematic as to be of no value in understanding the world?) Can we count on our senses, or on reason, to distinguish that which is true about the world from that which is false? Are there methods that can lead us close to understanding, or are there inherent indeterminacies in all methods? Is knowledge of the world discovered, or constructed? Can knowledge of

> the world, be evaluated independent of the social and historical contexts in which it exists, or is it always contingent upon, or relative to, particular circumstances (p.6)?

As a result, I chose to focus on titles, methodologies, theories, research questions, contexts, and claims in mathematics education postgraduate studies including a race and gender of the authors. I believe, by analysing the claims (which end up being knowledge in a field), it was important to link them to research questions in each study and the justification of those claims.

Further, the theory of knowledge, as explored in Chapter 2, highlights the complexities of defining and justifying knowledge, particularly in research. The emphasis on epistemic justification—whether through foundationalism, coherentism, or reliabilism—raises questions about the conditions under which knowledge claims can be considered valid. This discussion aligns with the choice of theory discussed in chapter 3. Giddens' structuration theory underscores the dynamic relationship between structure and agency in knowledge production. Giddens' notion of duality of structure suggests that knowledge is both shaped by and contributes to the social systems in which it is produced. This interplay resonates with Pallas' (2001) critical inquiry into whether knowledge is discovered or constructed, and whether it is contingent on social and historical contexts. By linking the justification of knowledge claims with the structuration process, the study acknowledges that knowledge in mathematics education research is not merely a reflection of objective reality but is continually shaped by institutional structures, methodological choices, and researcher agency.

2.7 CONCLUSION

In conclusion, this literature review has delved into various aspects surrounding postgraduate theses in the context of mathematics educational research. The journey began with an exploration of the critical role of postgraduate research in advancing our understanding of mathematics education, underscoring the importance of investigating the efficacy of various pedagogical approaches and strategies. The subsequent sections meticulously examined the existing body of research related to postgraduate theses, revealing insights into the trends, methodologies, and areas of focus that have emerged over time. One clear thread that emerged from the literature is the significance of adequately preparing postgraduate students for the unique challenges inherent in mathematics educational research. The studies highlighted the need for a multifaceted approach that encompasses not only technical and methodological skills but also a deep understanding of the pedagogical landscape and the intricacies of mathematics learning. Effective preparation equips students not only to navigate the complexities of their research projects but also to contribute meaningfully to the broader field of mathematics education.

The synthesis of knowledge from diverse sources unveiled the intricate interplay between mathematics education and research. It became evident that these two domains are mutually enriching, with research informing and shaping educational practices while the classroom context continually inspires research inquiries. This symbiotic relationship highlights the dynamic nature of mathematics education, where empirical findings and theoretical constructs merge to refine instructional strategies and improve learning outcomes. The exploration of the theory of knowledge within the context of mathematics education provided a philosophical underpinning for the research process. Acknowledging the epistemological dimensions of knowledge generation in mathematics education invites researchers to consider not only the objective truths but also the subjective constructions that learners develop. This perspective calls for a nuanced approach to research design, one that recognizes the multiple layers of understanding that influence the learning and teaching of mathematics.

As the landscape of mathematics education continues to evolve, embracing innovative teaching methodologies and technological advancements, the insights gathered from this literature review resonate with enduring relevance. Postgraduate theses stand as beacons of intellectual inquiry, illuminating the path toward enhanced mathematics education. This review serves as a foundation upon which future research endeavours can build, contributing to the ongoing dialogue that shapes the trajectory of both mathematics education and educational research holistically.

CHAPTER 3
UNDERSTANDING MATHEMATICS EDUCATION KNOWLEDGE PRODUCTION THROUGH POSTGRADUATE EDUCATION RESEARCH IN SOUTH AFRICA (1995-2004): THEORETICAL LENS

3.1 INTRODUCTION

This study analysed knowledge produced through postgraduate mathematics education research in South Africa in the first ten post-apartheid years (1995-2004). Specifically, the study intended to explore what research phenomena were researched in the postgraduate studies in the first ten years of democracy in South Africa. In addition, what kinds of research questions associated with the identified phenomena were posed in the postgraduate studies? What kinds of research design were used to research the identified phenomena? What theories were used to research the identified phenomena and how were these theories used in the studies? In short, this study sought to explore whose research phenomena, questions and claims were prioritised in South Africa (1995-2004). Moreover, which institutions contributed to the mathematics education knowledge that was produced in South Africa (1995-2004). This was important to research as South African institutions prior to 1994 were divided along the racial lines. Furthermore, as indicated in the previous chapters, there were disparities in the per capita expenditure for different racial students by the South African government prior to 1994, resulting in unequal educational opportunities. Apart from this, as indicated in the previous chapters, the South African apartheid government discouraged blacks to study mathematics at schools. Thus, the aim of this study was to investigate whether the political change in South Africa in 1994 played a vital role in changing who the producers of mathematics education knowledge were (1995- 2004)?

Knowledge was conceptualised in this study as a social construct. There are different social theories that can assist us in understanding how knowledge is (re)produced such as discourse analysis. This study utilised Giddens's structuration theory as a lens for understanding mathematics education knowledge production through postgraduate education research in South Africa (1995-2004). What knowledge was produced, by whom, where, and how, was dependent on the social interactions, systems, time, space, material resources and power differentials in the institutions (universities and mathematics education communities) (Taylor, 2003). This chapter discusses Giddens' structuration theory used in 'excavating' the relationships between the individual thesis and the systemic structures in which the theses were produced.

3.2 STRUCTURATION THEORY

Theory is a systematic endeavour aimed at constructing an understanding of the social realm. It draws upon concepts, systems, models, structures, beliefs, and ideas to elucidate various actions, events, or activities, thereby facilitating analyses of their origins, effects, and dynamics (Hitchcock & Hughes, 1995). When exploring the dynamics of knowledge production within postgraduate mathematics education research in post-apartheid South Africa, structuration theory emerges as a crucial perspective. This theory sheds light on the interplay between social structures and individual agency, revealing how these interactions shape knowledge construction processes. By emphasizing the recursive relationship between structure and agency, structuration theory provides a nuanced framework for comprehending the complexities inherent in the production of knowledge within specific socio-historical contexts. Thus, structuration theory comprises concepts such as *system*, *structure*, *time* and *space*, *power*, *agent*, and *agency* in social interactions. This study incorporated all the concepts put forth by Giddens. The following subsection delves into the tenets of Giddens' structuration theory, followed by an examination of how these concepts relate to the phenomenon under investigation.

Giddens work on structuration theory spans nearly three decades. Giddens (1971) began with the criticism of other social theorists, such as Marx, Durkheim, Foucault, Lévi-Strauss and Blau, led him to conceptualise structuration theory (Gane, 1983, Giddens, 1984; Kaspersen, 2000). He rejected positivism, arguing against timeless laws of human organisation (Giddens, 1971, pp.334-354). In addition, Giddens' structuration theory came as a criticism to functionalism and structuralism, and for functionalists (Durkheim and

Merton) the concern is downplaying the role human actors~~,~~ play on the system (Giddens, 1984, pp.1-3) in social theory. Similarly, structuralism was critiqued by Giddens to have "a problem which resembles that of functionalism: the theory recapitulates a sign system, but ignores the action respect" (Kaspersen, 2000, p.21). There are similarities between functionalism and structuralism, despite having difference (Giddens, 1984) as they "both tend to express a naturalistic standpoint, and both are inclined towards objectivism" (Giddens, 1984, p.1). Both structuralism and functionalism strongly accentuate the whole society over the individuals in that society (Giddens, 1984, pp.1-3). As a result, Giddens formulated structuration theory which has duality of structure and agency. Giddens has been accused of borrowing from Marx writing (class and historical materialism) and Foucault (power, sexuality, crime and reason) in his understanding of 'dialect of control' despite him criticizing these scholars (Gane, 1983). As a result, structuration theory is eclectic as it borrows ideas from different theoretical orientations.

It was only in 1979 that Giddens began to develop his structuration theory as an alternative to the social theories he critiqued. However, it was only five years later (1984) that the structuration theory was established, and structures are not unique to structuration theory. The concept of structure is prominent in the work of functionalists and structuralism (Giddens, 1984), however, Giddens suggests that the concept of structures is conceptualized naively in functionalism. In functionalism the structure "appears as 'external' to human action, as a source of constraint on the free initiative of the independently constituted subject" (Giddens, 1984, p.16). On the contrary, Giddens argues that the concept of structure in structuralism and post-structuralism is more appealing. In structuralism and post-structuralism, the notion of structure is conceptualized "as an intersection of the presence and absence; underlying codes have to be inferred from surface manifestations" (Giddens, 1984, p.16). Giddens proposes that the two conceptions of structure (functionalists and structuralists), though opposite, contribute to structuring of social relations in structuration theory. Giddens (1984) achieves this by "recognizing a differentiation between the concepts of 'structure' and 'system'" (p.17).

In addition to that, structuration theory focuses on the ontological questions about knowledge and society (Giddens, 1982). Kaspersen (2000) argues that Giddens "downgrades the epistemological and methodological questions in favor of the ontological questions" (p.12). Kaspersen (2000) argues against Giddens asserting that:

> Instead of focussing on how reality is to be understood, we must instead realize that we are part of reality and that understanding takes place through our language and is thereby to a great degree a question of interpretation. Hence, it is the nature of reality which ought to be the central issue for philosophy and the various sciences (p.12).

It is noteworthy that Giddens' earlier works focused on ontological issues because he was still developing his meta-theory on structures and agents. It was only seven years (1991) after establishing structuration theory that Giddens began to use his theory to analyse empirical data in society. Moreover, it took Giddens three more years (1994) to include politics in his analyses of society. Otherwise, his theory was more relevant to organisations. In summary, "Giddens [work] is divided into three levels, the structuration theory at the micro level, the modernity theory at the macro level and the political studies" (Kort and Gharbi, 2013, p.97). Though Giddens argues why he focused on ontology only, this study saw the need for epistemological and methodological questions of knowledge production. This was a result of this study focusing on knowledge that was produced by mathematics education postgraduate students who were learning at different institutions. Each institution (system) had its own rules and resources for postgraduate education. How (methodological issues) postgraduate students produced knowledge was important in this study. Whether there were trends in patterns of knowledge production in terms of methodologies, theories, research phenomena, questions and claims according to race, gender and institutions. Having discussed the tenets of structuration theory, I now focus on the constructs of the structuration theory.

Building upon the principles of structuration theory discussed earlier, Giddens proposes that social systems encompass the continual (re)production of relationships between individuals and their actions across temporal and spatial dimensions. Kaspersen (2000) uses an analogy of a bus traveling through a city to explain the social system. He suggests that every day in a year, the bus travels in a particular route. En route, passengers buy tickets and board the bus. They sit down until their destination. The aforesaid actions are "repeated and reproduced" (Kaspersen, 2000, p. 42). Giddens terms the aforementioned a social system. Drawing an analogy of the social system described by Giddens, for this study, one has to consider higher education institutions (HEIs) as social systems, postgraduate students and supervisors as individuals acting in the systems. Every year, postgraduate students register at HEIs for respective postgraduate degrees. They are assigned supervisors who work with them in producing knowledge through theses. They graduate after a certain period when the theses are completed. In South Africa prior to 1994, not all HEIs concentrated in postgraduate research. As such fewer HEIs were contributing to knowledge production hence the capabilities of supervisors were not developed in all the HEIs.

The ex-historical white universities focused on research and mostly produced knowledge in South Africa in the late 1980s and early 1990s. The ex-historical black universities were focused on teaching undergraduate students. Therefore, it was important to foreground the HEIs (systems) which produced mathematics education knowledge through postgraduate studies in the post-apartheid era. The HEIs which produced mathematics education knowledge had their own research traditions, culture, and theoretical orientations, thus influenced the kind of knowledge that was produced in the studies. In so doing, the theoretical orientations and methodological traditions employed to produce mathematics education knowledge were (re)produced over time and space. Kaspersen (2000, p.42) argues that "social systems are therefore social practice which is reproduced, and from which emerges a pattern of social relations". In addition, Heller (2007) contends that structuration theory concerns itself with the analysis of social systems, how they are "produced and reproduced". Kaspersen's and Heller's assertions might reveal whether there are patterns in the data suggesting theoretical orientations and methodological traditions in the HEIs.

In every HEI (social system) there are *rules* guiding postgraduate education. In addition, HEIs have *resources* to support postgraduate education such as supervisors, electronic resources, and funds, where available. Giddens understands structure as *rules* and *resources*. "Rules are 'generalizable procedures' and 'methodologies' that reflexive agents possess in their implicit 'stocks of knowledge' and that they employ as 'formulas' for action in social systems" (Tuner, 1986, p.972). Giddens argues that the rules of the structure "are tacitly known, widely sanctioned and frequently invoked…in interaction rituals and daily routines" (Tuner, 1986, p.972). For a thesis to be produced, there is a relationship developed between the student and the supervisor(s). In most cases, there are no explicit set rules of how these individuals communicate in the process of producing a thesis. However, some institutions have recently formalized the relationship between the student and supervisor(s) as a contract to ensure throughput rates. For example, as a PhD student at UKZN, I was required to sign a formal contract with my supervisors. This contract specified key expectations, such as the frequency of our meetings and turnaround times for feedback on submitted work. Additionally, I have the opportunity to evaluate my supervision experience, while my supervisor submits regular progress reports to the Higher Degrees Committee. This structured approach aims to promote accountability and support timely progress through the degree. Further, Giddens argues that structure "involves the use of resources that are the 'material equipment' and 'organizational capacities' to get things done" (p.972). In this case HEIs (1995-2004) which had material equipment and organizational capacities to supervise postgraduate students could "mobilize power" (Tuner, 1986) to influence the production of mathematics education knowledge.

Giddens maintains that rules and resources are "transformational" and can be "created, changed, and recombined into different forms". Further Giddens (1984) discerns that for structures to have "'virtual order' of transformative relations" (p.17) "social systems, as reproduced social practices, do not have 'structures' but rather exhibit 'structural properties' and that structure exists, as time-space presence, only in instantiations in such practices and as memory traces orienting the conduct of knowledgeable human agents" (Giddens, 1984, p.17). However, it is the system and structuration that largely perform what is expected of the structure. Giddens proposes that "we have to acknowledge both the syntagmatic dimension, the patterning of social relations in time-space involving the reproduction of situated practices, and a paradigmatic dimension, involving a virtual order of 'modes of structuring' recursively implicated in such reproduction" (p.17). This means when researching patterns of knowledge production this includes both the text (theses) produced over a time period (1995-2004) and spaces (HEIs/Faculties) where they were produced. Over and above structure being defined as rules and resources, Giddens conceptualizes structure over time and space.

Giddens defines structure as "structuring properties allowing the 'binding' of time-space in social systems, the properties which make it possible for discernibly similar social practices to exist across varying spans of time and space and which lend them 'systemic' form" (Giddens, 1984, p.17). Time and space offer another dimension for exploring the patterns of knowledge production in mathematics education postgraduate research in South Africa. Thus, time is the first decade of democratic South Africa. During this period there were a lot of changes in the HE policy landscape such as mergers, and conscious decision of the South African government post 1994 to increase the number of blacks in postgraduate education and throughput rates. Despite these changes post 1994, the period prior to 1994 heavily influenced who produced knowledge, where and how in the time (1995-2004). The space played an important role in how the HEIs (systems) were configured, consequently, influenced the knowledge production. Space in this study does not only refer to a HEI- its geographical location in terms of urban or rurality. But, how the mathematics and mathematics education departments were constituted in the HEIs (systems). In some HEIs the mathematics education was located in the Faculty of Science and not in the Faculty or School of Education. In such places, where the pure mathematics and mathematics education were located in the same space, influenced the quantity of theses produced in those institutions. This arrangement also allowed for more resources (supervisors) to supervise the students rather than only the mathematics education staff. Moreover, a different conception of space is such that through technology the students and supervisors need not be in the same geographical area. These ideas of space and time are discussed later in the chapter.

The concepts of *system* and *structure* can be associated to the analysis of knowledge produced in the mathematics education postgraduate studies (1995-2004) as follows. Social systems are the HEIs where the postgraduate studies were produced (1995-2004). In those institutions there were rules for postgraduate degrees. For example, each institution uses certain referencing styles (e.g. Harvard or referencing APA styles). There are other rules such as ethics followed in conducting research, plagiarism, formatting of the text, the time a student may take to complete the masters or doctorate, just to mention a few. The latter relates partly to the resources. The time postgraduates take to complete the degrees is linked to resources the institutions get from the South African government. If students take longer to graduate, funding from the government for the institutions is less. The relationship of time-space to social system is demonstrated in this respect. Other resources within the system can be the financial assistance and learning materials given to postgraduate students by institutions.

Another example of system within the institutions could be supervisors of the theses and examiners of the theses. Supervisors guide students in academic practices, methodological and theoretical orientations and sometimes influence what is studied, if the thesis is part of a research project. Postgraduate students write their theses knowing that their ideas are going to be evaluated by the examiners who determine whether it passes or fails. The relationship between postgraduate students, supervisors, and examiners (all three actors) is reproduced over time and space. From theses and reproduced actions, patterns may emerge when the data is analysed. I need to point out though that the examination process of the theses and how postgraduate students related to supervisors is outside of the scope for this study. Nevertheless, the aforementioned have a bearing on the knowledge production by mathematics education postgraduate students. Further, resources were pertinent in the knowledge produced by postgraduate students (1995-2004). There were disparities in the capita expenditure on students by apartheid South Africa at that time which was divided along the racial lines. Specifically, former white universities were well resourced with senior academics at professorial levels, well equipped libraries contributing to knowledge produced by postgraduate students.

Production of knowledge through postgraduate education is important in South Africa. There has been a PhD drive in the country promoted by one of its institutions National Research Council (NRF), but this push is not solely due to the NRF. The Department of Higher Education and Training (DHET) and the universities themselves have also been actively encouraging this growth, recognizing the importance of increasing the number of doctoral graduates to enhance research capacity and address national development goals. NRF provides scholarships to postgraduate students, thereby institutions are encouraged to enrol more students, thus contributing in knowledge production. Universities feel pressured to graduate more postgraduate students for their rankings. This has made universities to think creatively of how they can reproduce this social practice of the demands for masters and doctoral graduates. Some institutions started masters and doctoral "cohort model" (Govender & Dhunpath, 2011; Samuel & Vithal, 2011). As Giddens argues, social practice is influenced by time-space duality and is contextual. Therefore, more postgraduate students contributed to knowledge production in institutions (space) that thought creatively about increasing productivity in the post- apartheid era (time). Therefore, the Giddens' concepts; *system*, *structure*, *rules*, *resources*, *time* and *space* allowed the reading of the data to answer the research questions: who were the producers of knowledge, where and how was the knowledge produced.

What is structure then in the analysis of knowledge production? As Giddens suggests, structure has 'virtual order'. Giddens (1984) refines the concept of structure by differentiating between *structural principles* and *structural properties*. According to Giddens, structural principles are "most deeply embedded structural properties, implicated in the reproduction of societal totalities" (p.17). Examples of such principles are capitalism and democracy. Post 1994 the democratic principles enshrined in our (South African) constitution is evident in mathematics education. All learners in post 1994 South Africa had to take either mathematics or mathematics literacy at school level up to Grade 12. This decision counter acted the decision by apartheid government that blacks should not be doing mathematics as it was not going to assist them in their communities. The education after the demise of apartheid system was underpinned by democracy, eradication of racism, sexism, and religious bias. In consequence there should be changes in the patterns of mathematics education knowledge production according to race, gender, and geographical location of the HEIs indicative of these changes.

Even though the structural principles are "abstract" (Kaspersen, 2000, p.44), notably they exist in the mathematics education post 1994. South African children underperform in international tests such as TIMSS, more so those from disadvantaged backgrounds. Democracy has not ensured that all South African learners irrespective of race and gender perform in mathematics at the same level. Structural properties "are institutionalized features of social systems stretching across time and space" (Kaspersen, 2000, p.44). Structural properties as espoused by Giddens contain *rules* and *resources* which are "both enabling and constraining" (Kaspersen, 2000, p.43). Kaspersen argues this point with an example of English language.

> When I speak English, I utilize certain rules that enable me to formulate myself understandably. At the same time, I reproduce these rules and thereby the structure of the language. Language enables me to express my desires and intentions, but when I find that my motives/desires cannot be expressed in words, language becomes constraining. Similarly, the English language can be constraining if I meet someone who is not an English speaker (p.43).

Similarly, in mathematics education knowledge is developed and communicated via academic rules. This assists in clarity of the communicated text to the readers. In this sense, academic processes of knowledge production are reproduced. However, if the examiner of the thesis is not familiar with the theories and methodologies used in the thesis, that could be constraining. The forgoing is evident in the 'discursive' writing of a thesis. A thesis written in an academic manner is enabling for the supervisor(s) and examiners to understand clearly the discourse. However, the participants in the thesis might not be able to benefit from it because of the very nature of the language used in the thesis. This is constraining for the participants and readership (teachers at schools) that might benefit from the thesis. The foregoing reveals the 'duality of structure' (Giddens, 1984, p.25) which is central in structuration theory. Giddens suggests that the duality of structure is both *enabling* and *constraining*; structural properties are both *medium* and an *outcome*; and contains *rules* and *resources*. Giddens' next concepts discussed is agency and agents.

In relation to agency, Giddens (1984) understands an agent as knowledgeable, having knowledge about their actions. This is contrary to existing theories of system and structure which overlook agents' free will and knowledgeability (Kaspersen, 2000, p.34). In structuration theory, Giddens pays attention to two kinds of agent's knowledge. The first knowledge according to Giddens is expressed as *practical consciousness*. This knowledge is known to the agent subconsciously as routinized actions and is called tacit knowledge. Kaspersen (2000) gives an example of tacit knowledge such as waking up in the morning to an alarm, brushing our teeth, bathing, eating breakfast, etc. We do not have to consciously think about these actions but "are routinized and automatic, and they take place at a level of practical consciousness" (p.35). Giddens contends that agent's practical consciousness is neglected in sociology and social science. It is the phenomenologists and ethnomethodologists that pay attention to practical consciousness. In mathematics education knowledge production, agent's practical knowledge is implicit in how one constructs research questions, what we choose to research. Our histories, beliefs and values tacitly shape what we choose to research and how we theorise research.

The second knowledge the agent possess, is *discursive consciousness*. In this kind of knowledge, the agent can consciously explain how and why they do certain actions. By foregrounding agent's knowledgeability, Giddens argues that systems and structures "do not act behind the back of the actor" (Kaspersen, 2000, p.35). The willingness of the agent to act is informed by discursive capacity. Thereby, the agent not only can act but can also change patterns of action. Students who have mastered the academic discourse of arguing and justifying their research claims can change the patterns of knowledge production. They are able to critique existing theories depending on how they use theory in their studies, whether they support, modify, or refute (Tsatsaroni, Lerman & Xu, 2003) existing theories in their theses. Thus, some theories will grow or disappear, changing the patterns of knowledge production. Giddens not only understands agency as agents having practical and discursive consciousness but the agents' ability to act.

Agency is the capability of an individual to act, and not his/her intention of that action (Outhwaite, 1990). Giddens (1984) argues that through actions, agents reproduce structures. However, according to Giddens, agents not only reproduce but can transform structures by reflexive monitoring of their actions. Transformation of structures is further achieved by agents rationalizing their actions. The concept of agency in structuration theory is closely linked to the understanding of agent as a knowledgeable being, who is motivated to act. Through their actions, on one hand, agents produce structures. On the other hand, through reflexive monitoring and rationalization, agents transform structures. More importantly, as Giddens (1984) purports, "an agent ceases to be such if he or she loses the capability to 'make a difference', that is, to exercise some sort of power" (p.14).

In this study, agents are the mathematics education postgraduate students who wrote the theses that were produced in South Africa (1995-2004). As Giddens suggest, postgraduate students, as agents, are knowledgeable and motivated to act (produce knowledge). Through their actions (theses writing), postgraduate students produce the structure, and reproduce the academic discourse of writing a thesis. However, the postgraduate students can also transform the structures, depending on their writing skills, command of the language, and can also push the boundaries of how a thesis is written. Thus, postgraduate students have agency when they reflexively monitor and rationalize their writing of theses; when they exercise power during the supervision process of writing a thesis; when they are motivated to complete the thesis. Otherwise, as Giddens suggest, they cease to be agents. Of importance to note is that structures within which agents act, are not only constraining but also enabling. Naturally in structuration theory agents have some power.

Power is understood by Giddens (1979) as “the capability of actors to secure outcomes where the realization of these outcomes depends upon the agency of others” (p.93). The interactions between actors in social system represent power as “regularized relations of autonomy and dependence between actors or collectivities in contexts of social interactions” (Giddens, 1984, p.16). Taking mathematics education postgraduate students as agents/actors, on one hand, they exhibit power as autonomous beings that have dominion over their theses. On the other hand, they have dependency on their supervisors and mathematics education community at large (seminal theorists) to be able to produce theses. As Giddens (1984) rightfully points out, “all forms of dependence offer some resources” (p.16), i.e. postgraduate students can broaden their supervisors’ knowledge by researching topics not familiar to their supervisors. Giddens (1984) calls this “the *dialectic of control* in social systems (p.16). For Giddens it is a mistake to treat power as inherently divisive. He argues that agents have choice to act thus exercise power and contends this point with an example of a prisoner who might be viewed as powerless. Using Maze prison H-block in Northern Ireland (p.63), Giddens (1981) shows that prisoners have power resources such as dirty protest and hunger strike to effect change on the system. In comparison, postgraduate students have power over the knowledge they produce, irrespective of the choices they face as students.

The issue of power in knowledge production in South Africa has been explored by numerous scholars. Jansen (1991) addresses power dynamics concerning knowledge production by defining it as a "codified social discourse which arises to both legitimate domination and mobilize resistance." In his book, "Knowledge and Power in South Africa: Critical Perspectives across the Disciplines" (1991), Jansen employs Foucault's theory of power to elucidate how academics in positions of power, particularly those from historically white universities during apartheid, shaped knowledge production. Foucault's concept of power is dynamic and pervasive, extending beyond conventional structures like governments or institutions. He contends that power operates not only through repression but also through discourse, knowledge, and societal norms, influencing individuals' behaviour and identities (Jansen, 1991).

Consequently, the body of knowledge generated through research in South African universities before 1994 was heavily influenced by those in positions of power, shaped by the country's apartheid history. Therefore, when examining knowledge produced by mathematics education postgraduate students in the immediate aftermath of apartheid, it is pertinent to observe these power dynamics. This includes investigating potential power dynamics between postgraduate students and their supervisors in selecting topics, research questions, methodology, and theory within research programs. Furthermore, it may be insightful to explore racial dynamics in supervision, particularly between black and white student-supervisor pairs.

Moreover, the question of whether there has been any change in research productivity in historically black universities since the transition to democracy remains a topic of significant interest and necessitates further investigation. However, it's worth noting that Giddens offers a different perspective on power compared to Jansen's work. Giddens posits that power is not inherently divisive, as agents exert power through their actions, contributing to power dynamics within social systems characterized by regularized relations of autonomy and dependence between actors or collectivities in contexts of social interaction (Giddens, p.16). This discussion about agency and power sets the stage for the subsequent exploration of time and space concepts within structuration theory.

Giddens (1981) was inspired by the work of time-geographer Hägerstrand and included the concepts of time-space in the structuration theory. Giddens argue that concepts of structure, social system and agency are explicitly linked to time-space. For Giddens (1981) time and space "expresses the nature of what objects are" (pp.30-34). Accordingly, Giddens connects the concept of time to ontology. He contends, "human beings are temporal and their meaning is found in the temporal character of human existence". Giddens (1984, p.35) describes three kinds of time- *durée* of day-to-day experience (reversible time); *durée* of life span of the individual (irreversible time); *longue durée* of institution (reversible time). According to Giddens *durée* of day-to-day is insignificant as the individual goes on with daily life, it does not lead anywhere on its own. However, *durée* of day-to-day combines with *durée* of the lifespan to form *longue durée* of institutions (Giddens, 1984). This is the "*durée* of long-term existence of institutions, the reproduction of institutions and institutional time" (Kaspersen, 2000, p.47). Giddens contends that actions of the individuals constitute and reproduce social systems within time limits and spatiality. This is illustrated by an example of a school.

> When we consider the …school as a social system, this system is time-space binding on the social practice which takes place within the system. Students and teachers come to the school each day, do their homework for the next day's lectures, participate in visits to local businesses, and attend school parties. As all the social practices of the affected agents (students, lecturers, and administrative staff) are linked to the …school, this school becomes a "locale" which means that all their actions and practices take place in the same space. The school as a specific social system determines the time interval for the actions: classes are held each day at the same time of the day, and there is a two-year or three-year program of study…the continuity in all the daily routine actions undertaken by students, teachers, and administrative personnel at the business school constitutes the school as a system and thereby also space in which the social practice takes place (Kaspersen, 2000, p.47).

This example is analogous to the HEIs as social systems where the mathematics education postgraduate students were registered (1995-2004). Social practices of agents (students, supervisors, administrators) took place within time and space in the 'locale' of each institution. Each HEI, determine the duration of the masters and doctoral degree. The supervision process of the masters and doctoral studies undertaken by students, supervisors establish HEI as the system and space where social practice takes place. As a result, there might be patterns of the knowledge produced in different HEIs as social systems. For example, there might be an influence of certain theories from a HEI as agents (supervisors and students) share similar ideas. Particularly, Bernstein as a theorist is prominent in some South African HEIs. Admittedly, the social practice of knowledge production was limited within spaces (social systems) and bounded by time. Depending on the movement of the academics from one institution to another, influences of certain theories might change.

Giddens offers a second understanding of space, emphasizing the social interactions of agents within a system, such as higher education institutions (HEIs), without being constrained by geographical boundaries. In this framework, the physical proximity of the student and supervisor is not a requirement for interaction, as technological advancements, particularly the internet, have bridged distances between individuals. This was exemplified during the COVID-19 pandemic in 2020 when countries closed their borders and enforced social distancing measures. Universities swiftly transitioned to online modes of lecture delivery, utilizing platforms like Zoom and Microsoft Teams to prevent virus transmission.

However, despite the dissolution of physical barriers by technology, the temporal and spatial dimensions remain significant in the production of mathematics education knowledge in South Africa. Historically, prior to 1994, spaces within HEIs where mathematics education knowledge was generated were racially segregated. It wasn't until the late 1980s that racial integration began to take place. Following the end of apartheid in 1994, HEIs underwent integration, presenting an opportunity to examine the production of mathematics education knowledge by postgraduate students during the period of 1995- 2004 within racially integrated and some merged institutions. This study aims to uncover patterns of knowledge production within integrated spaces, including both pure mathematics and mathematics education departments.

In summary, Giddens offers diagrams to illustrate his concepts which are not easy to follow. However, Tuner (1986) proposes a diagram that shows interrelationship amongst the concepts in the structuration theory (see figure 3.1). Structure and agency are connected as Giddens argues for duality of the two concepts. Structure is associated with rules and resources which agent can use in a system (HEIs and mathematics education community) over time and space. Agents can act on the system using their practical and discursive consciousness. Agents also have unconscious dimension which results in a "sense of trust" through "ontological security". The "ontological security" is achieved through 'routinization interactions' (predictable over time) and regionalization' (space). Having discussed the Giddens' structuration concepts (system, structure, agency and agents, power, time and space) I move on to criticism of the theory.

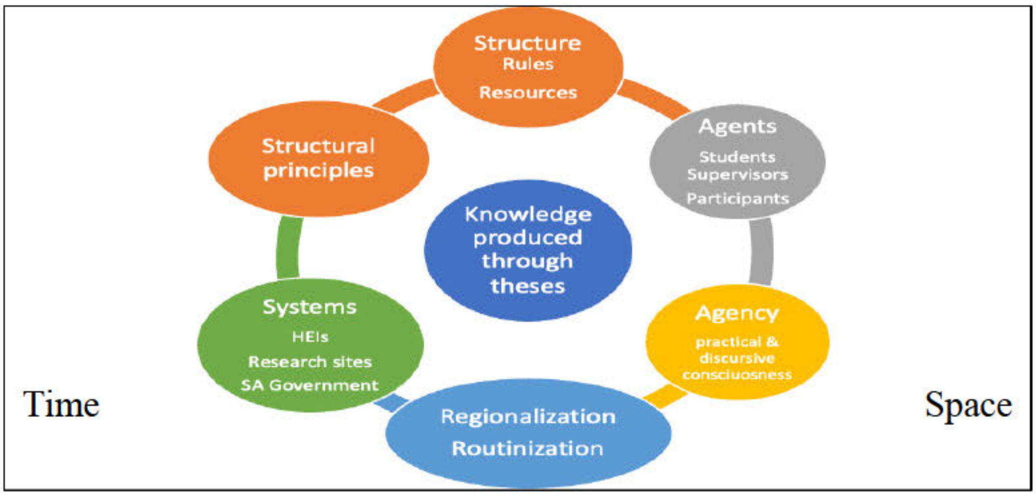


Figure 3.1 Key elements in the structuration theory (Adopted from Tuner 1986)

There are several criticisms of structuration theory, grouped into four categories: Giddens' conflation of structure and agency; omission of gender issues; philosophical orientation; and complexity. Giddens is criticized for conflating structure and agency (Thompson, 1989; Archer, 1996; Rose, 1998; Kort & Gharbi, 2013). Thompson (1989) argues that Giddens' concepts are too abstract to understand, while Archer (1996) claims this duality complicates empirical analysis, losing analytical power. Kort and Gharbi (2013) note that Giddens offers an agent-structure analysis separate from political issues. Giddens contends that structure is not external to individuals but hinges on human motivation. In this study, students acted as agents in mathematics education programs shaped by established rules. Their influence on educational boundaries depended on their discursive consciousness. Before 1994 in South Africa, macro-level rules and resources were beyond individual influence, necessitating an exploration of racial and gender dynamics in HEIs between 1995 and 2004. Two decades post-apartheid, students challenged their curricular knowledge, advocating for increased access to education, as seen in the 'fees must fall' movement.

The second criticism addresses gender issues. Murgatroyd (1989) argues that Giddens 'only tells half the story,' neglecting gender's role in social practice. Gender influences social identities and power dynamics but is overlooked in Giddens' framework, leading to a partial understanding of social systems. Traditional gender roles affect labour division and knowledge production, where women often face multiple responsibilities that hinder academic pursuits. This necessitated an investigation of racial and gender dynamics in mathematics education knowledge production.

The third criticism is the neglect of epistemology and methodology. Giddens praises the "ontological turn" (Giddens, 1982, pp.1-17), but Archer (1996) argues that focusing solely on ontology misses key questions. Rose (1998) highlights that understanding social reproduction requires examining institutional success and failure. Barley and Tolbert (2014) assert that the critique's worth lies in its epistemological issues. Understanding institutions requires acknowledging their historical context and using longitudinal data, separating institutional and localized actions. Barley and Tolbert (2014) succinctly argue this point:

> … we submit that the worth of the critique actually lies in the epistemological rather than the ontological issues that it raises. Institutions are historical accretions of past practices and understandings that set conditions on action. Unless an institution exists prior to action, it is difficult to understand how it can affect behaviour and how one can examine its implications for action or speak of action's subsequent affects on the institution. Thus, to reduce the empirical problem of conflating action and institution, one needs a diachronic model of the structuration process as well as longitudinal data. Moreover, unless researchers use separate indicators of institutions (which span settings and time) and actions (which are localized to a

> specific setting), they can neither argue convincingly that the two map the same principles nor show how actions implicate structures broader than those of setting itself.

This study aimed to address both ontological and epistemological questions, collecting data on methodologies used in mathematics education theses.

The fourth criticism concerns Giddens' writing style, which is often seen as unclear (Kort & Gharbi, 2013). Bernstein (1986) and Craig (1992) express frustration at the complexity and repetition in Giddens' prose, while Pozzebon and Pinsonneault (2005) argue that it operates at a high level of abstraction. Nonetheless, structuration theory aided in understanding postgraduate students as knowledgeable agents in their relationships with supervisors, illuminating knowledge production in postgraduate education in South Africa post-1994.

3.3 CONCLUSION

In this chapter, I set out to discuss the theoretical orientation used in this study. This study employed Giddens' structuration theory as lens for understanding mathematics education knowledge production through postgraduate education research in South Africa (1995-2004). What knowledge was produced, by whom, where, and how, was dependent on the social interactions, systems, time, space, material resources and power differentials in the institutions. Giddens' structuration theory was useful in 'excavating' the relationships between the individual thesis and the systemic structures in which the theses were produced. These social practices are produced and reproduced over time and space. There are power issues during the process of knowledge production but not necessarily divisive. The next chapter dealt with the research design for the study.

CHAPTER 4

EXAMINING KNOWLEDGE PRODUCTION IN MATHEMATICS EDUCATION POSTGRADUATE THESES (1995-2004): RESEARCH METHODOLOGY

4.1 INTRODUCTION

The previous chapter discussed the theoretical lens framing this study. Before the previous chapter, literature on knowledge, knowledge production, mathematics education research, South African higher education context in 1995-2004, amongst other things, were surveyed. The summary of the literature findings signalling the research design for this study were that mathematics education is a young discipline (Bishop, 1996). In addition, mathematics education is criticized for its lack of focus, using plethora of theories and methods when producing knowledge (English & Sriraman, 2005). Similar criticism is levelled against educational research in general that, “it does not create a body of knowledge upon which policy-makers and professionals can rely” (Pring, 2004, p.220). Furthermore, Pring (2004) argues that educational research is “small-scale and fragmented and there is no cumulative growth of such knowledge” (p.220). Such criticism led to a large research project on educational postgraduate studies (PPER) in South Africa in the post-apartheid era. PPER aimed to address the dearth of an overview of the scholarship of knowledge produced by postgraduates in South Africa, focusing on subject-content knowledge and methodological approaches (Karlsson, Balfour, Moletsane & Pillay, 2009). This study was part of the PPER focused on the scholarship that was produced in a corpus of mathematics education postgraduate studies (1995-2004). It aimed at understanding the nature of knowledge that was prioritised or neglected in the mathematics education theses in the ten-year period in post 1994 South Africa. This was achieved by posing the following research question: *What forms of knowledge emerged from postgraduate studies in mathematics education research within South Africa during the years 1995 to 2004*?

The study aimed to address the following sub-research questions:

1.1 How were the titles of postgraduate studies in mathematics education (1995-2004) formulated and structured?

1.2 Which phenomena were more frequently explored, and which were less likely to be investigated within these postgraduate studies (1995-2004)?

1.3 What were the predominant research questions, and what assertions were made concerning these phenomena?

1.4 What were the prevalent research paradigms, designs, approaches, and methodologies employed in postgraduate studies on mathematics education (1995-2004)?

1.5 Which theories were commonly utilized and which were less frequently applied in postgraduate studies on mathematics education (1995-2004)?

In addressing each of the above sub- research questions, this study examined the identities of the students who generated this knowledge, detailing their degrees and institutional affiliations.

This study took as its unit of analysis mathematics education masters dissertations and doctoral theses produced in South African universities within the period 1995-2004. Therefore, to document the scholarship in the field of mathematics education through postgraduate research, I chose a research design for reviewing and aggregating studies. Systematic, integrative, critical literature, multivocal literatures reviews, meta-family[13] (Kearney, 2001), content, and discourse analysis have been used by different scholars interested in such reviews. In this study I used Suri's (2014) Methodologically Inclusive Research Syntheses (MIRS) which extends the meta-family and is discussed later in the chapter. Content and discourse analysis as a research design were not discussed in this study. Although content and discourse analysis analyse texts, the two methods were rarely used for reviews. Content analysis was not an appropriate design for this study, as Neuman (2006) contends that content analysis "reveals the content in text but cannot interpret the content's significance" (p.324). Discourse analysis was only used as an analytical tool for the research titles in chapter 6. Secondly, I considered the appropriateness of the chosen research design

---

[13] Kearney's (2001) meta-family was understood in this study to include all the 'meta' methods of inquiry to review primary research. The 'meta' methods of inquiry included in the meta-family are meta-analysis, systematic review, integrative review, meta-synthesis, meta-ethnography, meta-interpretation, meta-study, grounded formal theory, meta-evaluation, meta-summary, critical meta-study.

(MIRS). Thirdly, I discussed research approach that was used in this study. Fourthly, I reflected on the issues of sampling the institutions, theses, supervisors, where the textual data used in this study were published. Fifthly, I examined the challenges of secondary data analysis and researching up. Sixthly, I explored the limitations of this study. Finally, I discussed the analytical framework for analysing knowledge production in postgraduate mathematics education research.

4.2 RESEARCH DESIGN USED IN REVIEWING MATHEMATICS EDUCATION THESES

Research design is about what constitutes appropriate evidence in addressing the research question(s) (Cohen, Manion & Morrison, 2018) and it should align with a specific paradigm. A research paradigm is philosophical in nature and is a set of assumptions and beliefs the researcher uses to guide their thinking during the research (Jonker & Pennink, 2010). Research approach is about how we can produce the evidence in the study (Mouton, 2008). Research approach is sometimes referred to as research methodology. Research methodology describes the research process, "theory of how researchers gain knowledge in research contexts, and why" (Scott & Morrison, 2007, p.153) and is closely related to particular research design and paradigm. Cohen, Manion and Morrison (2018) differentiate between methodology and method. Research methods are the methods of selecting participants, methods of measurement, methods of data-collection and methods of analysis (Mouton, 2008). Sometimes there is no clear distinction between research design, methodology, approaches, and methods in the literature. Consequently, researchers sometimes use these concepts interchangeably or in conflicting meanings.

As indicated earlier, there are different kinds of research designs related to textual data in general-discourse analysis, historical studies, semiotics, document analysis and content analysis. In particular, systematic reviews, integrative reviews, critical literature reviews, meta-family (Kearney, 2001), multivocal literatures review (Ogawa & Malen, 1991) are used in reviewing primary research. Document analysis and content analysis are considered as methodology and analytical tools (Neuman, 2006, p.322). In this section, I discuss *meta-family* as espoused by Kearney (2001), here referred to as meta-family, to include aggregated analysis, meta-synthesis, and meta-interpretation.

4.2.1 Meta-family

Kearney (2001) coined the concept of meta-family representing the various designs of inquiry termed 'meta' reviewing, analysing, and synthesizing primary research. In this section, I discussed different methods of inquiry used to review primary research on a meta-level to locate the research design for this study. I achieved this by organising the discussion from a paradigmatic perspective. This was important for choosing a design consistent with critical paradigm underpinning this study. Primary researches in education are predominantly conducted from either a positivistic paradigm (typically quantitative in nature) or post-positivistic paradigms (usually qualitative in nature). At first, I thought the contribution of this study was to extend the research design on reviewing primary research to include both qualitative and quantitative studies until I came across Suri's (2004) MIRS extending the meta-family.

The literature on research design for reviewing primary research, classifies on one hand, meta-analysis and systematic review under a positivist paradigm (Cooper & Lindsay, 1998; Cohen, Manion & Morrison, 2018; O'Sullivan, 2006; Graham & Perin, 2007; Neuman, 2006). On the other hand, meta-synthesis, meta-ethnography, meta-study, meta-interpretation, grounded formal theory, meta-evaluation, and meta-summary are categorised in the literature as falling within interpretive paradigm (Noblit & Hare, 1988; Kearney, 2001; Paterson, Thorne, Canam, & Jillings, 2001; Weed, 2005) (see figure 4-1). Therefore, I began this section with a discussion on quantitative research reviews (meta- analysis) followed by qualitative research reviews (meta-synthesis) which were not suitable for this study. Later, I discussed Suri's MIRS.

4.2.2 Meta-analysis

Meta-analysis, systematic reviews and integrative reviews are the main research methodologies for reviewing research using quantitative approaches. Neuman (1997) defines meta-analysis as a:

> special technique researchers use in an integrative review, or more often, in a methodological review. The researcher gathers the details about large number of research projects (e.g. sample size, date of publication, size of the effects of variables and then statistically analyzes this information) (p. 90).

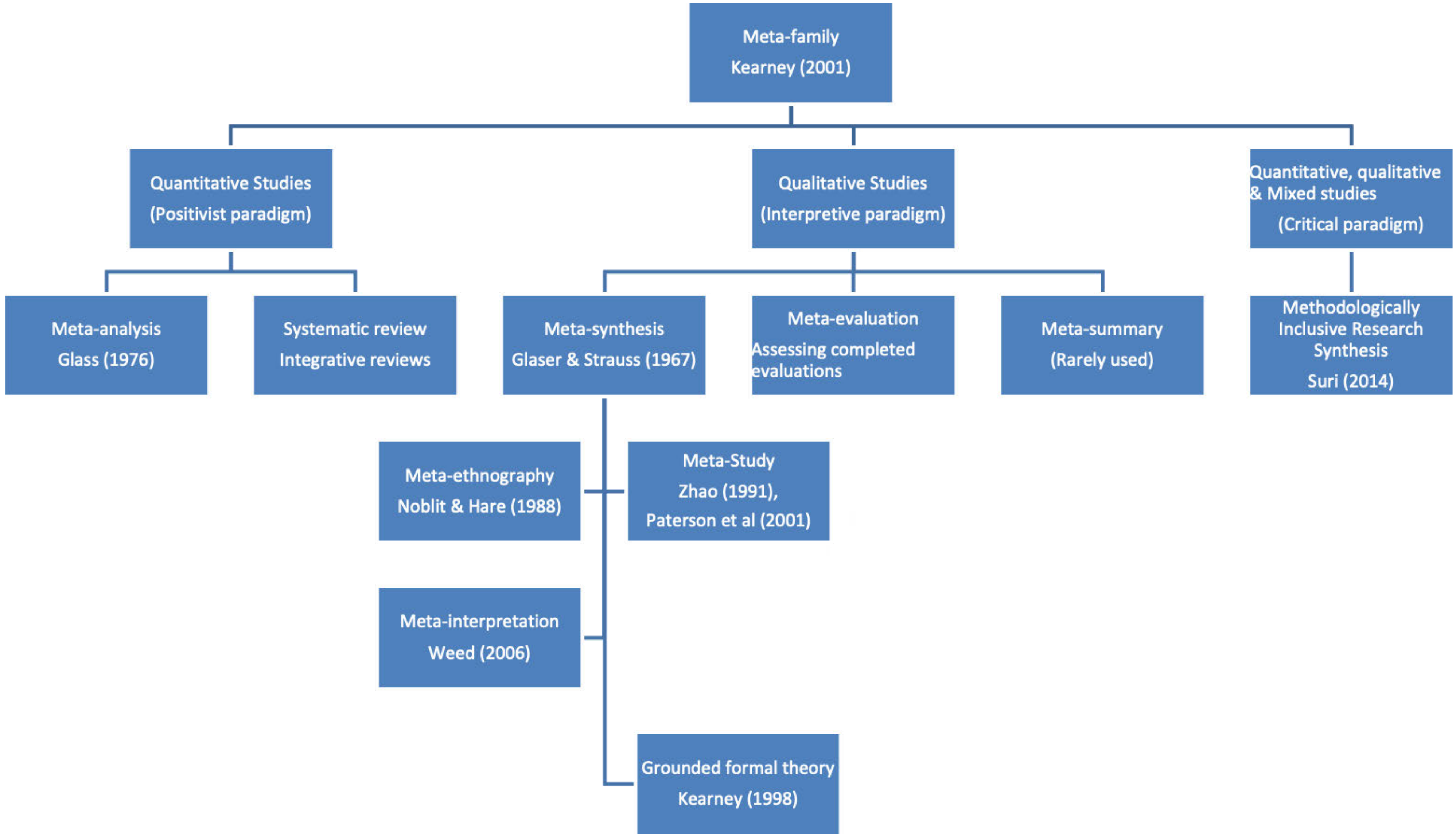


Figure 4.1 **Meta-family of research designs of inquiry for reviewing primary research**

Simply put, meta-analysis is the "analysis of other analyses". It involves aggregating and combining the results of comparable studies into a coherent account to discover main effects" (Cohen et al., 2018, p291). Cohen et al. (2018) suggest that small-scale research report conducted by individual students and lecturers, which might be gathering dust, will be "valuable since meta-analysis provides a way of coordinating results drawn from many studies without having to coordinate the studies themselves". According to Bangert- Drowns and Rudner (1991), Cooper and Lindsay (1998), and Field (2016), Glass (1976) coined the term 'meta-analysis' to describe the methodology he used to statistically analyse and aggregate results from a large number of quantitative research results. Bangert-Drowns and Rudner further suggest that Glass used the term 'meta-analysis' "to refer to a philosophy, not a statistical technique" (p.1). Meta-analysis has grown tremendously as a research methodology in medicine, psychology, and nursing. This is attested by the number of meta-analytical studies published in the journals in these disciplines. For instance, in medicine, a genome-wide association study meta-analysis of lung cancer involving 13,300 cases and 19,666 controls showcased its effectiveness in identifying genetic risk factors for specific cancer subtypes, underscoring its value in advancing medical research (Landi et al., 2009). In psychology, a meta-analysis comparing the persuasiveness of statistical versus narrative evidence across 15 studies demonstrated that statistical evidence had a stronger persuasive impact, highlighting how meta-analytic techniques can synthesize findings to uncover generalizable psychological effects (Allen & Preiss, 1997). Similarly, in education, a meta-analysis on interleaved learning provided insights into its benefits for visual materials and mathematics education, indicating how meta-analysis can inform instructional strategies (Schalk et al., 2020). In nursing and clinical practice, meta-analyses have played a pivotal role in shaping guidelines, as shown by the Australian Clinical Guidelines for Atrial Fibrillation, which integrated meta-analytic findings to make evidence-based recommendations on anticoagulation therapy and arrhythmia management (Brieger et al., 2018). These examples across disciplines illustrate the extensive application and impact of meta-analysis in advancing research and practice. However, there is paucity of such research in education. As a result, education has been criticised as a discipline for publishing small case studies without synthesising the results of these studies (Balfour, Moletsane & Rule, 2006).

A small number of research studies in mathematics education, used meta-analysis as a research methodology. These studies were conducted by for example, Horak (1981), Friedman (1989), Xin & Kishor (1997), Xin & Jitendra (1999), Ellington (2003), Kroesbergen & van Luit (2003), Haas (2005), Kunsch, Jitendra & Sood (2007), Elbaun

(2007), Browder, Spooner, Ahlgrim-Delzell, Harris and Wakeman (2008), Gersten, Chard, Jayanthi, Baker, Morphy & Flojo (2009), and Setati, Adler & Rollnick (2009). Noticeable is that almost all of these studies are associated with the psychology discipline in the last fifteen years. In these meta-analyses, mathematics is the context but the focus of these papers was on attitude levels, emotional behaviour disorders, learning problems, learning disabilities, cognitive disabilities, children with special needs, and sex difference in mathematics tasks. Horak's study focused on individualised instruction of mathematics. There are other studies in mathematics education, which conduct comprehensive literature reviews in certain topics but use a different research design. Adler, Ball, Krainer, Lin and Novotna (2005) utilized survey research methodology in their paper: Reflections on an emerging field - Researching mathematics teacher education, while Bellomo and Strapp's (2008) paper surveys advanced mathematics high school topics.

As indicated in the literature review, the special edition of AJRMSTE edited by Setati, Alder and Rollnick (2009) surveys international and local mathematics and science education journal articles published by South African academics. Some of the papers in this AJRMSTE special edition, review articles on mathematics and science education against research, policy, and practice (Venkat, Adler Rollnick, et al, 2009; Adler, Pournara, Taylor, et.al, 2009; Adler, Alshwaikh, Essack, & Gcsamba, 2017); Morrison, Graven, Venkat, and Vale's, 2023). One-paper reviewed teaching and learning of mathematics and science in the journals identified (Lelliot, Mwakapenda, Doidge et al, 2009). Venkat, Bowie and Graven's (2009) paper contextualised mathematics knowledge. In addition, other articles in the ARJMSTE reviewed research on multilingualism in mathematics education (Setati, Chitera & Essein, 2009). Only one paper from this special edition, was closely aligned to the purpose of this study researching "institutional location of research" (Rollnick, Adler & Setati, 2009). How these papers significantly differ with this study is that their unit of analysis was one mathematics content or issue, whereas, this study summarises 'all' the knowledge which was produced qualitatively and quantitatively during the period 1995-2004.

Another point illustrating how meta-analysis was not a suitable research design for this study relates to how meta-analysis is conducted. Glass (1976) suggests that the early type of meta-analysis calculated probabilities and frequencies. Nowadays, meta-analysis uses mixed model and effect of size. Glass, Mc Gaw & Smith (1981), Hunter, Schmidt & Le (2006) and Cohen et. al (2018) tabulate steps in the procedure of conducting meta- analysis:

> Specify independent and dependent variables the meta-analysis to focus on. Choose all research studies, which have the specified variables. Each study must be coded for the characteristics identified by the researcher for example age, gender, etc. Estimate the effect sizes using calculations of the variables. Calculate the variance across research studies. Work out the sampling errors, measurement errors and range. The average effect size can either be considered an accurate or inaccurate estimate depending if the large proportion of variance is attributable to the previous step.

This study did not select mathematics education theses based on their research methodologies, as the unit of analysis was not focused on mathematics content or teaching strategies. Instead, it chose to examine the entire corpus of knowledge generated by postgraduate students, following a period during which the "white intelligentsia that took the lead in creating apartheid-enforced identities in the knowledge they produced" (Mamdani, 1999).

Meta-analysis has its own limitations. One of the criticisms levelled against meta-analysis is that "it is difficult to draw logical conclusions from studies that use different interventions, measurements, definitions of variables, and participants" (Cohen et al., 2018, p 293). This criticism was also relevant in this study as it analysed research titles, phenomena, questions, claims, theories, research designs, and methods from different mathematics education postgraduate studies. It is for this reason this study did not use meta-analysis since it did not focus on variables but on categories. Moreover, some of the postgraduate studies sampled used qualitative approaches not suited to calculations of variances, mean effect size, confidence intervals and regression models.

In the next subsection, I discuss a qualitative review of research, which was more relevant to this study. Meta-synthesis, meta-ethnography, meta-study, meta-interpretation, grounded formal theory, meta-evaluation and meta-summary are the research designs for reviewing research using the interpretive paradigm falling under the meta-family. Meta-evaluation is the research design for assessing completed evaluations and meta-summary is rarely used as research synthesis. Most of the aforementioned designs were not discussed in this study, but meta-synthesis, meta-ethnography and meta-study designs are discussed briefly as they are closer to the research design used in this study.

4.2.3 Meta-synthesis and meta-ethnography

Meta-synthesis is described as the interpretation of the findings of the primary studies unlike meta-analysis which aggregates the results of the primary studies (Jensen & Allen, 1996; Paterson, Thorne, Canam & Jillings, 2001; Zimmer, 2006). In fact, Zimmer (2006) understands meta-synthesis as:

> …not an **integrative review** of qualitative literature, [and it] is not secondary data analysis of primary data from selected studies. Metasynthesis is the synthesist's interpretation of the interpretations of primary data by the original authors of the constituent studies. Metasynthesis is unlike the meta-analysis of quantitative data, which is aggregative and reduces data to a single unit. Rather it entails a comparison, translation, and analysis of original findings from which new interpretations are generated, encompassing and distilling the meanings in the constituent studies. (p.312)

Meta-synthesis is traced to Glaser and Strauss (1967) who developed a methodology for reviewing qualitative research around the 1960s. However, Stern and Harris (1985) coined the phrase qualitative meta-synthesis (Paterson et al., 2001; Jensen & Allen, 1996). Meta-synthesis is linked to grounded theory by Kearney (1998) who calls it grounded formal theory. Schreiber, Crooks, and Stern (1997) identify three purposes of meta-synthesis: theory building, theory explication and theory development. In

> theory building-the theory developed by individual studies can be combined to "push the level of theory beyond the level possible using data from only one sample". Theory explication- "lateral and deductive" analysis of concepts which might not be fully theorised in one study and can be complemented/connected through the synthesis of findings from other studies. Theory development-'thickly, descriptive, and comprehensive' synthesis of findings from different studies advances theory in a manner not possible form one study (Schreiber, Crooks, & Stern (1997).

The goals of meta-synthesis mentioned above have some similarities with this study. One of the research questions in this study synthesised the theories used in mathematics education postgraduate theses. This study interpreted how theory was used in the study in relation to the research phenomena, questions and claims in the postgraduate studies. However, the synthesis of theories used in the postgraduate studies was not sufficient, but the identity, contextual and methodological issues needed to be included. The question of who utilised the identified theories, for which phenomena and from which institution was important. Consequently, meta-synthesis did not fully describe what this study intended to achieve. In addition, meta-synthesis interprets qualitative studies only. This was a short coming as the corpus of mathematics education postgraduate theses (1995-2004) utilised both qualitative and quantitative research approaches.

Noblit and Hare (1988) describe~~s~~ meta-ethnography as “a way to synthesize interpretive research through comparing and analysing text and creating new interpretations” (p.11). For them, meta-ethnography is much more than a literature review. Similar to the argument forwarded by Zimmer (2006) for meta-synthesis, Noblit and Hare argue that instead of just aggregating data, the analysis should “take form of reciprocal translations of studies into another” (p.11). Meta-ethnography derives its name from ethnography-which means a “social scientific writing about particular” (Silverman, 2024) culture of a society by someone who has spent time in it. This implies the number of research studies reviewed should be small so that the synthesist can provide “thick rich descriptions of the phenomenon under investigation” (Noblit & Hare, 1988). Meta- ethnography is linked to interpretive paradigm, ethnographic, interactive, qualitative, naturalistic, hermeneutic, or phenomenographical studies (Planas, 2009, p.506).

Noblit and Hare (1988) describe six phases which need to be done when undertaking research synthesis using meta-ethnography:

> Getting started: Identify area of interest. Decide what is relevant to the initial interest: Perform exhaustive literature review and justify why certain studies will be included or excluded. Reading the studies: Analyze the relevant characteristics of the studies through repeated readings, paying close attention to detail and interpretive metaphors. Determine how studies are related. Translate studies into one another: Enables comparison yet maintains the central metaphors of each account. Synthesize translations: Make a whole of something-more than parts alone imply (Noblit & Hare, 1988).

The analysis process described by Noblit and Hare (1988) outlines some differences in the meta-ethnography design and the intentions of my study. My intention was not to limit the number of mathematics education studies included in the study. In fact, all mathematics education postgraduate studies published from 1995 to 2004 were the population for my study, except if the thesis could not be found in the respective institution. This study did not intend to determine how studies are related, but categorise studies into the types of research phenomena, questions, claims, designs, contextual factors, theories used, thus providing a ‘thick rich description’ of knowledge production in mathematics postgraduate education. My study certainly did not translate studies into one another as suggested by Noblit and Hare. But data was read in the studies- analysing the relevant categories through repeated reading of studies.

4.2.4 Meta-study

Meta-study is the qualitative research synthesis that is closer to this study. Paterson, Thorne, Canam and Jillings (2001) argue that what is called meta-synthesis in the literature, should be designated as meta-study of qualitative research. They define six distinctive processes in the meta-study: laying ground work, retrieval and assessment of primary studies, meta-data analysis, meta-method, meta-theory and meta-synthesis. The six processes are understood as:

> Laying groundwork-developing the research proposal, setting up research team, applications for ethical clearance. Retrieval and assessment of primary studies- deciding on the inclusion and exclusion criteria for the studies, and data management strategies. Meta- data analysis-use of multi-facets systems to capture data into categories like method, sample, theories, context, etc. Analytical tools and strategies are discussed in this stage. Meta-method-involves comparison of research designs. Meta-theory-analysis of primary studies for theoretical orientation, topics and research questions. Meta-synthesis-follows inductively from meta-data, meta-method and meta-theory "through a process of thinking, interpreting, creating, theorizing, and reflecting" (Paterson, Thorne, Canam & Jillings, 2001, p.112)

Meta-synthesis is only one step in the meta-study. The six steps in the meta-study are relevant in this study and were used. However, the only slight difference in the meta-study and the design of my study, is the question of the identity of the knowledge producers of the mathematics education theses. This understanding shifts the paradigmatic underpinning of the meta-study from interpretive paradigm (where only interpretation of the studies is done) to critical paradigm (where questions about the producers of knowledge are asked). In addition, meta-study only synthesises qualitative research whereas my study included quantitative studies as well. Therefore, the design suitable for my study needed to include, over and above the six processes in the meta-study, the critical analysis of both quantitative and qualitative approaches.

Initially I termed the research design extending meta-study as meta-critical study. Paterson's et al. (2001) meta-study was extended to include contexts where the studies were undertaken, race and gender of the authors of the studies thus pushing the methodology into the critical paradigm. I called the seventh step *meta-knowledge producer*. The seventh step in the meta-critical study was done after the retrieval and assessment of the mathematics education theses in the meta-study, before the last step of meta-study called meta-synthesis.

How was meta-knowledge producer different from meta-data analysis? Paterson et al. (2001) describes the meta-data step in meta-study as the stage where the synthesist uses software or systems to capture data such as methods, sampling, theories, and context determining tools and strategies for analysis. The meta-data was limited to the content of the theses but not the biographical details of the authors of these studies. In the meta-knowledge producer stage for meta-critical study, information on gender, race, research sites, HEIs where research was submitted for graduation purposes was gathered. Some of this information was found in the universities data bases and supervisors of the theses. The purpose for collecting this information was to critically understand- who were the producers of knowledge, where the research sites in the theses were and who the participants in the theses were. By asking these questions, the meta- study was pushed out of interpretive to critical paradigm. Hence, I added the critical dimension in the meta-study and called the design meta-critical study. However, just when I thought I had identified a new area in meta-family, I found the work of Harsh Suri theorising about meta synthesis combining primary studies from different methodological orientations.

4.2.5 Methodologically Inclusive Research Synthesis (MIRS)

Suri (2004) argues that educational research is largely qualitative as a result; systematic reviews need to consider diverse methodologies and paradigmatic positions (p.3). Suri describes her framework for systematic review of studies as Methodologically Inclusive Research Synthesis (MIRS). Suri (2004) defines MIRS as “a coherent conceptualisation of research synthesis methods expressed through the identification of critical decisions and thorough discussion of varied options associated with each decision in the process of a rigorous research synthesis” (p.4). Suri clusters her framework according to the phases: “Drawing from pertinent philosophical and theoretical discussions; identifying appropriate purposes; searching for relevant evidence; evaluating, interpreting, and distilling evidence; constructing connected understandings; and sharing with an audience (p.5). Suri’s description of the critical synthesist has similarities with the *meta-critical study*. The critical synthesist pays attention not only to what is found in the studies under review but also looks for the silences and the gaps. The critical synthesist according to Suri (2004) would address the following types of questions: What phenomena are likely and/or unlikely to be studied by primary researchers? Which populations are likely and/or unlikely to interest primary researchers? In the published literature, whose questions are prioritised? Whose questions have received little attention from primary researchers? (p.12). The aforementioned questions are similar to the ones posed in chapter 1 of this thesis.

Using Suri's MIRS I selected all mathematics education postgraduate studies from all HEIs in South Africa which offered postgraduate education degrees (1995-2005). Though meta-synthesists decide which primary studies to include or exclude in the data, I chose to include all primary studies to write about mathematics education scholarship in South Africa (1995-2004). I did not even exclude studies based on the quality of the theses. In this study I understood that the supervisors and examiners would have ensured the quality of the theses. Therefore, determining the quality of the study was not the scope for this study. The data used in this study, how it was captured and analysed was explained later in this chapter. In the next subsections I discussed the research approach, population and sample, sampling techniques, research instruments, issues of trustworthiness, analytical tools and framework, ethical issues, limitations of the study and challenges to undertaking large scale research at the universities.

4.3 RESEARCH APPROACH

This study used mixed methods as a research approach. Creswell and Creswell (2018) defines four different mixed methods: explanatory, exploratory, triangulation and embedded mixed methods. In the explanatory mixed method, the researcher begins by collecting and analysing quantitative data then uses the results to collect qualitative data. In the exploratory mixed method, the researcher begins by collecting qualitative data, analyses this data then collects quantitative data. In the triangulation mixed method, both quantitative and qualitative data sets are collected at the same time. The data are analysed at the same time to triangulate the findings.

This study utilised explanatory mixed method since quantitative data was collected first to answer the main critical research question. The preliminary analysis was done, after which qualitative data was collected. The quantitative data provided rich data that answered broadly main critical research question. It offered an overall sense of the mathematics education knowledge produced by South African universities through postgraduate education during the period 1995 to 2004. The qualitative analysis yielded rich data that provided an in-depth understanding of why South African postgraduate students produced the kinds of knowledge in mathematics education. Creswell et. al (2018) explains the purpose of sequencing the two research methods in explanatory research as that "qualitative results… assist in explaining and interpreting the findings of a primarily quantitative study. It can be especially useful when unexpected results arise from a quantitative study" (p 215). Since the research design of this study was linked to the PPER, the masters and doctoral mathematics education studies were collected while the data for the project was collected. The missing theses were collected outside of the data collection process for the PPER. However, the qualitative data (supervisors' interview) were collected after the preliminary analysis of the theses data for PPER.

4.4 POPULATION AND SAMPLE

Earlier I indicated that the study was part of a large research project (PPER) in South Africa in the first ten democratic years. Therefore, the population and sample were determined for the large research project and applicable to this study. The population from which data was collected were all South African universities which offered masters and doctoral programmes in education. However, due to funding constraints (Ford Foundation was the first sponsor for PPER) and the enormity of the project, PPER data was initially collected from 11 institutions in 2007. The eleven institutions were Nelson Mandela Metropolitan University (NMMU), Rhodes University (RU), Stellenbosch University (SU), University of Cape Town (UCT), University of Fort Hare (UFH), University of Johannesburg (UJ), University of KwaZulu-Natal (UKZN), University of the North-West (NWU), University of the Free State (UFS), University of the Western Cape (UWC) and University of the Witwatersrand (Wits). Subsequently, the National Research Foundation (NRF) offered further funding to PPER to extend the project to include the remaining HEIs. The masters and doctoral education theses were collected from the remaining HEIs in 2008. The remaining HEIs were Durban University of Technology (DUT), University of Limpopo (UL), University of Pretoria (UP), University of South Africa (UNISA), Tshwane University of Technology (TUT), University of Venda (UV), University of Zululand (UNIZULU), and Cape Peninsula University of Technology (CPUT). In total, data was collected from19 out of 23 HEIs where masters and doctoral education theses were found. There were no education masters and doctoral theses at Mangosuthu University of Technology (MUT), Vaal Triangle University of Technology (VUT) and Central University of Technology (CUT). Walter Sisulu University of Technology denied the project (PPER) access to its masters and doctoral theses in education. This is the only university, which refused the project access to its education theses. In brief, PPER intended to include all 23 universities in South Africa offering education masters and doctoral postgraduate degrees. Institutions were excluded if they did not offer education postgraduate programmes or if they denied the project access to its theses. In the next paragraphs, I discussed the location of the 19 universities sampled in the PPER.

South Africa is divided into nine provinces namely Eastern Cape (EC), Free State (FS), Gauteng (GP), KwaZulu-Natal (KZN), Limpopo (LP), Mpumalanga (MP), Northern Cape (NC), North West (NW) and Western Cape (WC). In 2007-2008, when data was collected, there were no universities in two of the nine provinces in South Africa viz. MP and NC. The location of the sampled HEIs is as shown in figure 4.2. In alphabetical order of the provinces, EC has three universities NMMU, RU and UFH. FS has one university UFS. GP has six universities namely UJ, UNISA, UP, TUT, VUT and Wits. KZN has three HEIs: DUT, UKZN and UNIZULU. LP has two universities- UL AND UV. NW has one university NWU. The seventh province, WC, has four HEIs which are CPUT, UCT, UWC and SU (see figure 4. 2 on the next page). From the large database created for PPER, I chose mathematics education theses from six of the seven provinces in South Africa. There were no mathematics education theses published at the universities located in the LP. In addition, there were no mathematics education theses in CPUT, DUT and UFH. Therefore, mathematics education theses were from 14 out of the 19 sampled institutions for PPER. What type of HEIs are the 14 sampled institutions?

Historically South African HEIs were divided racially prior to 1994. Even though the study focused on the period 1995-2004, there were no significant changes in the students' demographics, staff racial complement and funding received by HEIs from the government. Significant changes in the HEIs occurred with the mergers from 2004 onwards. There were historically black universities (HBUs) which did not produce much research, with the exception of the few. The HBUs in the data are TUT, UNIZULU and UWC (which produced considerable research). The language of instruction in these HBUs was English. TUT is located in the Capital City of South Africa called Pretoria. Three technikons (Technikon Northern Gauteng, Technikon North-West and Technikon Pretoria) merged to form TUT.

UNIZULU is located in the Umhlathuze Municipality in the Northern KwaZulu-Natal in a semi-rural area. UWC is located in the Bellville suburb of Cape Town. UWC was established in 1960 and did not merge with any institution during the transformation period of mergers. The population of students at the UNIZULU were mainly African students. TUT and UWC had mixed race student population.

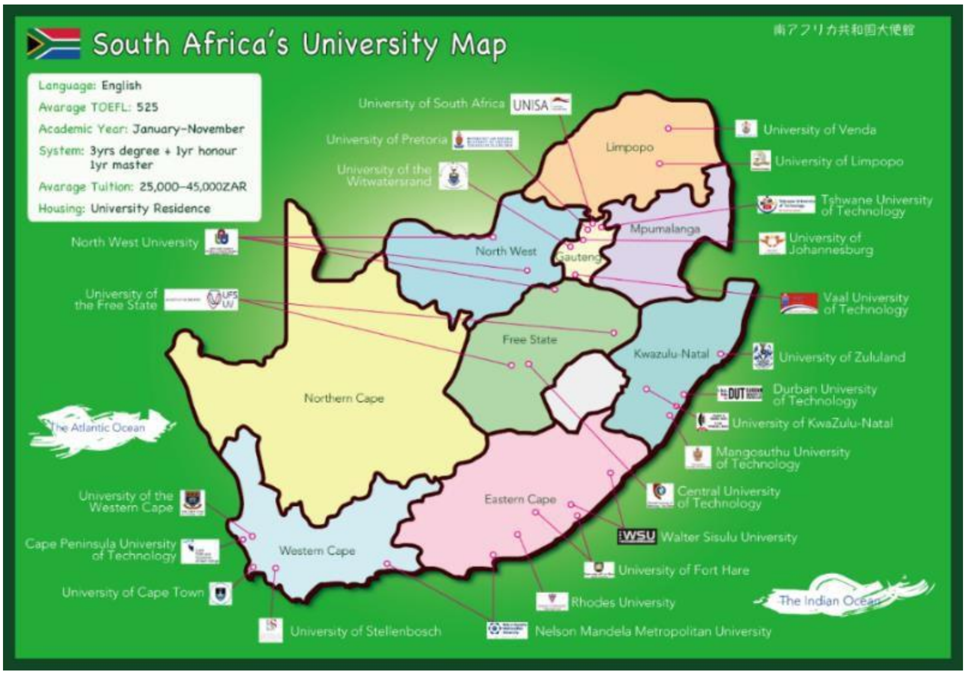


Figure 4.2 South African map showing the location of the universities prior to 2011

Source: http://www.dst.tokyo/images/MAP-SA-UNIV-big.png

Contrary to HBUs, historically white universities (HWUs) produced much research with few of these HEIs ranked internationally. The HWUs were divided according to the language of instruction i.e. English and/or Afrikaans. The English HWUs sampled were RU, UCT, UKZN and Wits. The three English HWUs (UCT, UKZN and Wits) are located in fast growing cities in South Africa with access to airports. RU is located in a small town which is slightly over 100km from the nearest airports found in Port Elizabeth and East London in the EC province. The student population of the four institutions was largely white in the 1980s to 1990s. Of the four English HWUs, only UKZN resulted from merger. Universities of Durban-Westville and Natal merged to form UKZN in 2004. The other three (UCT, RU and Wits) were established long time ago and did result from mergers. The Afrikaans HWUs sampled were NMMU, NWU, UFS, UJ, UNISA, UP and SU. These institutions are located in big cities in South Africa. The Afrikaans HWUs which did not merge are UFS, UNISA, UP and SU. NMMU was formed in 2005 through the merger of the University of Port Elizabeth and Port Elizabeth Technikon. NWU was formed as a merger of Potchefstroom University for Christian Higher Education and the University of North-West (formerly the University of Bophuthatswana). Lastly UJ is made of the former Rand Afrikaans University, the Technikon Witwatersrand and the Vista University. It is important to point out first, that students of all races could register in any of the HEIs around the late 1980s provided they applied for consent from the then minister. Second, while language policies have improved across institutions, not all Historically White Universities (HWUs) actively promote African languages within their programs. However, some HWUs are now encouraging the use of at least one of South Africa's official African languages in their institutions.

In addition to the HEIs selected in the PPER and then later in my study together with the masters and doctoral theses, the supervisors were included as part of the sample. All the masters and doctoral education theses of students who graduated from 1995 to 2004, were included as the sample in the PPER, provided they could be accessed from the library shelve during data collection phase (2007-2008). Theses which were not available when data was collected for the PPER, were loaned from the libraries of the HEIs and included in my study as part of the sample. It must be noted that not all the education theses of students who graduated between 1995 and 2004, were on the university library shelves. A process of triangulating the data gathered from the shelves with the records of the supervisors of the mathematics education postgraduate theses, was conducted. Theses were excluded from the PPER and my study after a concerted effort to locate them had failed. This was one of the limitations of the study. All the theses used in this study were listed in the reference section alphabetically with a number assigned to each one from 1 to 190. When the theses were used in the analysis chapters, the authors' names were preceded with the assigned number. For example, the mathematics education thesis number 1 was written by Adler in 1996 and is she is referred as 1-Adler (1996) in text. This separates the authors of theses used in this study and authors referenced in the literature reviewed.

The investigation into mathematics education studies from 1995 to 2004 included the identification of the authors, incorporating their demographic information. Using ENDNOTE and SPSS software, I recorded the gender and race of the authors based on their names, which often correlate with specific genders and racial backgrounds. This inclusion was particularly pertinent due to the historical context of apartheid in South Africa, where educational opportunities were delineated along racial lines. During apartheid, South Africans were classified into categories such as African, Coloured, Indian, and White, with educational resources distributed accordingly. Even in the post-apartheid era, although the government disavows these racial classifications, they are still utilized for addressing historical inequalities. The gender of the authors was discerned primarily from their names and acknowledgment sections, where spouses were occasionally mentioned. However, it's important to note that in a context of increasing acceptance of diverse sexual orientations, this data may not be entirely accurate. An essential aspect of the analysis was to investigate whether there was a dominance of male-authored research within the field of mathematics education. Consequently, the data regarding the race and gender of theses authors was shared with some theses supervisors, who provided insights into how their students were categorized within the dataset.

Supervisors of the sampled mathematics education theses were identified once the data was captured on the EndNote for the PPER. Forty-one supervisors were interviewed for the PPER and five of them were in mathematics education. The five supervisors of mathematics education theses were included as the sample in my study. These were four males and one female supervisors from four HWUs. In addition, four of these supervisors were White and one Coloured. The female supervisor had supervised 18 theses. One male supervisor supervised one thesis. The other two male supervisors supervised two and four theses each. The fourth male supervisor, did not supervise any thesis from the collected data. He was part of the focus group interview in one HEI. The supervisors' interviews included as data set for this study are tabled below in table 4.1

Table 4.1 *Mathematics Education supervisors (1995-2004).*

Supervisors	Institution	Gender	Race	Number of supervised mathematics education theses	Interviews in which I took part
Prof X	Wits	Female	White	18	Yes
Prof Y	Rhodes	Male	White	2	Yes
Prof Z	UFS	Male	White	1	Yes
Dr J	UCT	Male	Coloured	4	No
Prof W	UFS	Male	White	0	Yes

4.5 SAMPLING TECHNIQUES USED IN MY STUDY

Two different kinds of sampling strategies were used in this study. Quantitative data answering the five sub-research questions 1 to 5 were produced using convenience sampling. Convenience sampling technique often selects participants or secondary data that are available around a location. As such, the mathematics education theses published in the 19 universities were selected from the PPER data of the photocopied educational theses from the South African universities. The PPER data was collected by postgraduate students who were part of the project of postgraduate education research and housed at the School of Education at UKZN (Madikizela-Madiya, Goba & Nkambule, 2016). As mentioned earlier, if the mathematics education theses were not available in the library when data was collected in 2007-2008 and subsequently through the interlibrary loan, it was excluded in the sample. In addition, in 2007-2008, the universities in South Africa were beginning to have electronic copies of theses published in the institutions. Most of the theses published from 1995-2004 were still in print form. The qualitative data were produced using purposive sampling. Neuman (1997), Welman, kruger and Mitchell (2005) and Rossouw (2005) suggest that purposive sampling is a careful selection of cases that represent the population. Purposive sampling was used to create a small sample of supervisors of the postgraduate theses to allow for a deeper analysis of qualitative data. In this study, five supervisors of the mathematics education theses were selected purposefully and interviewed to produce rich data which shed light to the quantitative data. “Qualitative data can put flesh on the bones of quantitative data” (Shaddock, 2021), which means that qualitative data adds depth and context to quantitative data, enriching it with details and insights that bring it to life.

4.6 RESEARCH INSTRUMENTS USED TO GENERATE DATA

In this section, I first discussed the data production process of the PPER then later how I selected data for my study. There were three types of data that were produced for PPER: masters and doctoral education theses, interviews with the supervisors of these studies and questionnaires administered to supervisors. Access was sought from all institutions mentioned earlier to photocopy sections of the masters and doctoral theses. The students in the PPER went in pairs to photocopy the education postgraduate theses at the institutions where the project was granted access over a period of two years. Once the theses were photocopied, they were bound. The theses were read by the students in the PPER and the information on title of the thesis, author, gender, and race of the author of the thesis, university, postgraduate degree, keywords, paradigm, methodology, approach, data collection tools, analytical tools, sample, sampling strategy, sector, sector specifics, capturer of the thesis were entered on ENDNOTE (see Appendix A). A different student in the project checked the data entered by a colleague for accurate capturing. A meeting was held with project leaders to check the accuracy of the captured data. Once the ENDNOTE data was at a reasonably accurate stage, I then searched the ENDNOTE database using the keywords mathematics and 'wiskunde[14]' to search for postgraduate theses in mathematics education. All the mathematics education theses which were collected for the project, were used in this study.

I read again the mathematics education theses selected for my study, to check the data entered by other PPER students, and to fill in more fields on ENDNOTE that were not the original fields for PPER. The new fields were supervisor(s), abstracts, theories, theorists, research questions, research phenomena, geographical context of the postgraduate study, participants, sample size and research claims. The new fields on ENDNOTE were pertinent to my study. In order to quantify the theories, theorists, methodologies, paradigms, research approaches, methods, analytical tools, focus areas, and geographical contexts the data was captured on Statistical Package for Social Sciences (SPSS). A code book (see Appendix B) defining the variables in the study, was developed and the variables were entered on the SPSS.

How was the data of institutions, degrees, year of publication, race, gender, and language read from the primary studies? Each photocopied thesis was read from cover to cover. The name of the author, dedication and acknowledgments were used to discern the race and gender of the authors of the mathematics education theses. As I have already indicated previously, there might be discrepancy in the race and gender of authors of the studies.

---

[14] "Wiskunde" is the Afrikaans word for mathematics.

However, these constructs race and gender and the rest of the captured data were double checked by writing letters to the supervisors of the studies to confirm the race and gender of the students and some supervisors gave me feedback on these constructs.

To exemplify the process of capturing the race and gender of thesis authors, I reference the mathematics education thesis authored by Tsepo Poni (2000). Titled "*Grade 10 English second language pupils' difficulties with paradoxical jargon and technical terms commonly used in their mathematics curriculum*," this master's dissertation originates from Wits University. Within the thesis dedication, Poni expressed gratitude "To my wife …, and children" (14015-Poni, 2000, p. ii), while in the acknowledgements section, Poni further acknowledged, "I owe my greatest debt to my wife, for her continued support and encouragement" (2000, p. iii). Considering these elements alongside the author's name, the race and gender of 140-Poni were recorded as African male . The surname "Poni" is commonly associated with African individuals of Xhosa descent, derived from the English term 'pony,' denoting a horse. Additionally, the given name "Tsepo" typically identifies males. This determination was corroborated by the author's own statements in the thesis dedication and acknowledgements, despite contemporary considerations such as same-sex marriages.

The second research instrument namely, interview schedule initially centred on presenting the theses data to supervisors to verify the completeness of theses and accuracy in recording the race and gender of postgraduate students. Subsequently, the interview delved into the supervisors' experiences in guiding postgraduate students, their research philosophies, and the methodologies and theories they employ to ensure appropriate choices by their students. Furthermore, supervisors were queried about the advancements in South African educational research during the timeframe under consideration, specifically from 1995 to 2005, with a focus on Mathematics education.

4.7 TRUSTWORTHINESS AND TRANSFERABILITY OF THE RESEARCH INSTRUMENTS

According to Neuman (1997), transferability implies that the research instruments are dependable and consistent. Consistency of the instrument needs to be considered at the conceptualization stage of measurement. The instrument can also be piloted to test for its transferability and trustworthiness. Trustworthiness determines whether the instrument measures what it is supposed to measure. The instruments used in this study were interview schedule and coding of data from the mathematics education postgraduate theses from the South African HEIs. The interview schedule was designed and shared amongst the PPER team. The coding system for the designs, methodologies, paradigms, and education levels of the participants from the primary studies, including softwares for capturing data, ethical considerations were discussed with the PPER research team. The same instruments were shared with my supervisor (not part of the PPER team) who is a well-known scholar in mathematics education, and was revised accordingly before it was piloted.

The instrument was tested for its face validity, content validity and statistical validity. Face validity refers to the mathematics education community checking whether the instrument measures what is supposed to. While content validity, according to Neuman (1997), refer to the extent to which the measure covers the different meanings of the concept. Statistical validity, refers to statistical calculations whether they are appropriate. The SPSS coding sheet was constructed and piloted on ten masters and doctoral mathematics education theses from UKZN but not from the period 1995-2004. The theses were read at the UKZN library and information that answers sub-research questions 1 to 5 were recorded (see Appendix B). The same theses were read by someone who was part of the PPER research team and coded them in the same way. The coding sheets were compared with those of other researchers from PPER using the reliability agreement rate, and this was found to be 99%. The instrument developed was piloted to refine and test its validity.

[15] Each thesis in the corpus of theses was allocated a unique number from 1-190 as shown in the reference section and analysed in chapters 5-9.

4.8 ANALYTICAL TOOLS AND FRAMEWORK

"There is no data without a framework to make sense of those data" (Lester, 2005, p.458). Lester (2005) argues that one cannot analyse data in mathematics education without an analytical framework. Lester and William (2000) have argued that the statement "the data speak for themselves!", is wrong as "data have nothing to say". Therefore, there is a need for an analytical tool that can assist researchers to analyse data. There is a lot at play when choosing a framework, "the researcher's assumptions and beliefs as well as context in which the data was gathered", play a significant role in choosing which data is worth analysing.

As mentioned earlier, theses were read, and their contents summarised in the SPSS using a codebook that was created based on research questions one to five. A codebook "is a document (i.e. one or more pages) describing the coding procedure and the location of data for variables in a format that computers can use" (Neuman, 1997, p.295). The codebook assisted in the process of summarizing texts (research phenomena of the studies, theories, methodologies used in the studies and contexts of research studies) into the language (codes) that the computer can read for analysis. The computer does not read words, it reads numbers. The advantage of using a codebook was to enable other researchers to read the current work and to repeat the study elsewhere if need be. Descriptive statistics was used to analyse the data captured on SPSS. Frequency tables, cross tabulations and chi-squared were used to analyse the data captured on SPSS. Not all the information read from the theses, was coded and kept in a coded form. A summary of the text version of the research questions in the studies, abstracts, and claims made in the studies were captured on ENDNOTE (see appendix A) as annotated bibliography. ENDNOTE is the software that assists with correct referencing and writing of annotated bibliographies. The qualitative data produced through interviews was analysed by coding data into themes and categories. The analysis of this data shed light to the fifth research question.

The analytical framework for the knowledge produced in mathematics education research through postgraduate education, was based on Giddens' structuration theory. In the five analysis chapters, Gidden's concepts of time (1995-2004), space and structure (HEIs where theses are published) were infused in the analysis. The analytical framework described the linkages between time, space, structure, and agency. In order to understand the mathematics education knowledge produced by postgraduate students in South Africa, the period (1995-2004) delineates the time in which this study focused. HEIs where the postgraduate students studied and contexts where postgraduate research was conducted represent the space and structure. The HEIs, faculties, and schools of education rules for postgraduate degrees depict the structure during 1995-2004. Agency represents what and how a postgraduate student conducted his or her research within the influence of the institutional research cultures and supervisors.

Due to the nature of this study, there are five analysis chapters. Chapter 5 is descriptive in nature and focus on the institutions, author's identity and the period (1995- 2004). The analysis began with the description of data and ended with the discussion of the findings of the data linked to the literature reviewed. The following questions guided the analysis: Which South African HEIs produced mathematics education knowledge through the postgraduate studies in 1995-2004? Who (gender, race, and language) were the producers of mathematics education knowledge in South Africa in 1995-2004?

Chapter 6 focused on the analysis of titles of mathematics education postgraduate theses produced in South Africa in 1995-2004. The analysis of titles was two pronged: 'text surface' and linguistic devices. 'Text surface' analysis dealt with punctuation, metaphors, and gerunds (Hays, 2010). Linguistic devices such as colon, quotation mark, question mark, bracket, metaphors, and gerunds were analysed in titular constructions (Bengesai, Goba & Karlsson, 2011; Anthony, 2001). Chapter 7 concentrated on research phenomena, questions, and claims. The following questions were pertinent in the analysis in chapter 7: Which phenomena were more frequently explored, and which were less likely to be investigated within these postgraduate studies (1995-2004)? Which participants, contexts and education levels were frequently selected and which were less likely to be selected in the mathematics education postgraduate studies (1995-2004) researching the phenomena identified above? What was the identity of the students who researched phenomena identified in question one above? Which higher education institutions were interested in the phenomena identified above? What research questions were prioritised and what were the research claims related to these phenomena?

Chapter 8 analysed the trends of research paradigms, designs, approaches, and methods in the corpus of mathematics education postgraduate studies (1995-2004). This was achieved by identifying the identity of the students who chose those paradigms, designs and methods and the institutions in which they graduated. In addition, the analysis in chapter 8 was linked back to chapter 7, the research phenomena and what kinds of research questions were phrased in the studies with prominent paradigms, designs, approaches and methods. The last analysis chapter 9 dealt with the theories that were frequently or less employed in the mathematics education postgraduate studies (1995- 2004). The analysis was done not only by determining the identity of the students who conducted research using theories identified or the institutions where the students graduated, it integrated this chapter with the earlier chapter on research phenomena and questions. Moreover, the theories were analysed whether they were revisited or not in the studies (Tsatsaroni, Lerman & Xu, 2003). The findings of the analysis chapters (6-9) were linked to the literature reviewed in chapter 10.

4.9 APPLYING GIDDENS' STRUCTURATION THEORY IN RESEARCH DESIGN: BRIDGING STRUCTURE, AGENCY, AND KNOWLEDGE PRODUCTION

Giddens' structuration theory serves as a foundational lens in this study’s research design, particularly in its engagement with the dialectical relationship between structure and agency in shaping knowledge production. Figure 3.1 (on page 71) encapsulates key elements of structuration, such as rules, resources, and social practices, which are embedded in the methodological strategies deployed across various chapters. In Chapter 3, the theoretical framework operationalizes structuration theory by positioning mathematics education research as a socially constructed domain influenced by institutional norms, academic traditions, and historical legacies. The methodology outlined in this chapter aligns with Giddens' notion of the duality of structure—wherein postgraduate students navigate both enabling and constraining forces in their knowledge production—by employing a meta-analysis of theses to trace epistemological patterns. Analytical strategies in later chapters 5-9 leverage structuration theory to unpack how postgraduate students mobilize disciplinary conventions (rules) while negotiating intellectual autonomy (agency). The interpretive paradigm underpinning much of the analysis reflects structuration's emphasis on reflexivity, allowing the study to illuminate how postgraduate students engage with prevailing discourses in mathematics education while simultaneously shaping them.

Expanding on the connection between Giddens' structuration theory and the study's methodology, Figure 3.1 highlights key constructs that shape the analytical framework. In this study, agents are represented by postgraduate students and their supervisors. Postgraduate students, as knowledge producers, exercise agency in selecting their own theoretical frameworks and research designs, rather than having them imposed by supervisors. However, given the study's scope, direct interviews were conducted only with supervisors, as accessing students from 21 universities over a decade was not feasible. Despite this limitation, the study employed a fine-grained analysis of the theses themselves, uncovering patterns in dominant theories, research designs, and phenomena studied. The structure, conceptualized as rules and resources, is evident in the number of theses produced at each higher education institution, shaped by institutional policies on postgraduate degrees, available funding, and supervisory capacity. Meanwhile, systems, referring to higher education institutions (HEIs), provided a framework for analyzing regional trends and distinguishing between historically white universities and historically disadvantaged institutions. These structuration elements permeate the analytical chapters (5–9), offering a nuanced understanding of how institutional contexts shape postgraduate knowledge production in South African mathematics education.

4.10 ETHICAL ISSUES

This study considered the ethical issues in the PPER. The PPER requested permission to conduct the study from various gatekeepers such as Deans of Faculties of Education or Head Education Schools, Registrars of Universities, and Directors of Library Services in different universities. The identity of the institutions was not kept anonymous as the masters and doctoral studies are public documents housed in their libraries. In fact, the data collected from the HEIs was shared with each institution where data were collected for member checking. The supervisors who were interviewed were asked to fill consent form where their partial anonymity was guaranteed, and were informed that they could withdraw from the study at any stage of the research. I refer to partial anonymity as the supervisors' names are on the theses. In addition, even when the supervisors' names were not mentioned, the university names may lead people to make deductions and inferences about the identity of the supervisors.

The data was stored at the PPER offices at the University of KwaZulu-Natal and only members that were involved in the project had access to this office. Before the findings were disseminated through theses, conferences, and any publications, the participating HEI were informed of the findings of the PPER study. The faculty members at the HEIs were given an opportunity to adjust or add to the findings (member check) and to consider possible ramifications (Terre Blanche, Durrheim & painter, 2006).

4.11 CHALLENGES OF UNDERSTANDING LARGE SCALE RESEARCH AT UNIVERSITIES

The challenges of conducting large scale research include uniformity amongst the field researchers, access to the institutions, 'researching up', confidentiality, and secondary data analysis. In a large-scale research, it is important that everyone is up to speed with what is expected to be done during the data collection phase. There were slight problems in the PPER with data collection when the field researchers (postgraduate students in the PPER) did not photocopy all the necessary part of the postgraduate theses. Once the data was captured, this problem was uncovered, and this resulted in the field researchers revisiting the institutions to recollect the missing data.

The second challenge of conducting a large-scale research in HEIs is what Cohen et al. (2018) call "researching powerful people". The field researchers initially experienced problems with access to the institutions. The field researchers experienced problems at the early stages of gaining access to the institutions when, as postgraduate students, they were requesting permission to conduct research in HEIs. They had to request their own university (UKZN) to give them email addresses with their name rather than student numbers. After which, they started to receive responses from those HEIs. However, one of the institutions ultimately denied PPER access to its masters and doctoral theses, as PPER was gathering data that could reveal the institutions' capacity for research supervision and overall research productivity.

The third challenge was researching up and issues of confidentiality. When the field researchers were interviewing the academics, who supervised the postgraduate theses, sometimes they felt disempowered as postgraduate students, because they were researching up. The academics were quick to point to the flaw(s) of the PPER research design, excessing their research expertise. Cohen et al. (2018) suggest that people in powerful positions "are aware of what academic research involves, and are familiar with being interviewed" (p.128). Had this research not been large scale, the experienced academics in the project would have interviewed their counterparts. Researching powerful people does not guarantee their anonymity. "Academic educational research on the powerful may be unlike other forms of educational research in that confidentiality may not be able to be assured" (Cohen et al., 2018, p.128). Since there are not many mathematics teacher educationists per HEI, even if the identity of the academic is hidden, people might still make up who the academic is.

The last challenge of conducting large-scale research was using secondary data. Given that a group of field researchers (masters and doctoral students) collected the data, some of it used in this study is secondary data. For example, I was not part of the interview for one mathematics education supervisor, because the interview was conducted by other field researchers. I could have asked the supervisor questions related to my study, however, I had to use the data in its current form as secondary data. Nevertheless, the interview schedule was shared before the field researchers went to the HEIs to interview the supervisors.

4.12 LIMITATIONS OF THIS STUDY

The limitations of this study are primarily methodological. After careful triangulation of the masters and doctoral theses in the libraries, and supervisors' list of their postgraduate students who graduate from 1995 to 2004, there were still theses missing. This might be because of, in the first instance, the postgraduate student may not have submitted the hard copy of his or her thesis to the library if the graduation rules of the institution were not stringent. Secondly, if the postgraduate students submitted the hard copies, at the time of data collection but were being used by other students at the time of data collection. Lastly, in some institutions which merged, the theses may be lost in transit between campuses when the institutions reconfigured.

The second limitation of the study was that some theses were written in Afrikaans and I am regrettably not highly competent in the language. Thus, some valuable data might not be captured correctly. However, the PPER hired Afrikaans speaking postgraduate students and academics who read all the Afrikaans theses and captured information on ENDNOTE. This was helpful. The third limitation considered, was that the study was based on the period 1995 to 2004 immediately after democracy in South Africa, which is the period PPER is concerned about. Since this study was part of the PPER, it was also limited to this period. There could be more developments in mathematics education postgraduate research after 2004 (post the merger period of HEIs) in South Africa, which was not captured in this study.

The fourth limitation of this study was that I did not interview mathematics education postgraduate students who wrote these theses. It was impossible to track 190 mathematics education postgraduate students who studied from 1995-2004 at 21 HEIs in South Africa. Only few students (1995-2004) in the data are well known in the field of mathematics education. Nevertheless, interviewing the postgraduate students could have assisted in understanding the choices they made in terms of the research phenomena, questions, paradigms, designs, and theories. The last limitation was that sometimes the abstracts were not clearly written to discern the research phenomena. To overcome the problem with unclear abstracts, three research phenomena studied per thesis were captured and the first and methodology chapters were also used to read research phenomena. Despite these limitations, the contribution this study makes to the field of mathematics education research and research in general, is invaluable. In fact, it gives mathematics educationists and postgraduate students an overview of the field in South Africa: what was prioritised or not prioritised in research phenomena, questions, designs, and theories. The study also offers some valuable information on what progress has been made in the mathematics education field in South Africa, when compared to the rest of the world in the period immediately after apartheid.

4.13 CONCLUSION

In this chapter, I delve into various aspects essential to my research endeavour. First, I explore the research design, detailing the chosen methodology, samples, and sampling strategies employed. Then, I discuss the instruments utilized, addressing issues of reliability and validity crucial to this study's integrity. Additionally, I clarify the analytical tools and framework applied to interpret the findings effectively. Ethical considerations are also paramount, and I examine the ethical issues inherent in this research process. Furthermore, I acknowledge the limitations encountered and the challenges inherent in conducting large-scale research. This study adopts Suri's (2014) Methodologically Inclusive Research Synthesis (MIRS), chosen for its suitability in analysing mathematics education postgraduate theses (1995-2004). Moving forward, the subsequent chapter marks the beginning of the comprehensive analysis, focusing on mathematics education postgraduate theses in South Africa (1995–2004). This chapter delineates the institutions, authors, and languages of these theses, setting the stage for the detailed analysis of what forms of knowledge emerged from postgraduate studies in mathematics education research within South Africa during the years 1995 to 2004?

CHAPTER 5

DESCRIPTION OF THE MATHEMATICS EDUCATION POSTGRADUATE THESES IN SOUTH AFRICA (1995-2004)

5.1 INTRODUCTION

Before "constructing understandings by connecting the information distilled from individual research reports" (Suri, 2014, p.7), research synthesis begins with identification of issues to be considered when evaluating primary research. In this chapter, the analysis began with the description of the corpus of the education theses that were collected for the PPER. The subset of the PPER theses data related to my study were then selected for the analysis of the mathematics education studies. This chapter dealt with the understanding of where the postgraduate studies were produced. Which institutions contributed to the mathematics education knowledge generated in South Africa (1995-2004)? The second part of the chapter focused on who were the producers of mathematics education knowledge? What was the identity of the authors of the studies in terms of race, gender, language, and degree? The understanding of the contributors to the mathematics education knowledge, analysed in-depth in the subsequent chapters 6 to 9, was paramount. As mentioned in the previous chapters, South Africa had a government system which was racially divided prior to 1994. Admittedly, this study sought to understand whether the racial divisions in the apartheid era, had an influence on the knowledge produced in South Africa in the first ten years of democracy. In addition, it was important to ask the question: Is mathematics education gendered (1995-2004)? The deeper questions: What was studied (research phenomena and questions) in mathematics postgraduate education? What was known about the research claims related to the dominant phenomena? What paradigms, designs, methods were used to research the dominant phenomena and questions? What theories were used to research the prevalent research agenda? - are interrogated in chapters 7 to 9. In the next subsection, the PPER data was briefly discussed.

5.2 PPER DATA

The brief analysis of the PPER data contextualised the understanding of the mathematics education knowledge produced by postgraduate students in South Africa (1995-2004). Data for PPER was collected from 19 (CPUT, UCT, DUT, UFH, UFS, UJ, UKZN, UL, NMMU, NWU, UP, RU, UNISA, SU, TUT, UV, UWC, WITS, & UNIZULU) out of 23 HEIs in South Africa from 2007 to 2009. In three institutions (CUT, MUT & VUT) there were no education postgraduate theses. Walter Sisulu University for Technology and Sciences (WSUTS) opted not to take part in the PPER; however, they have educational postgraduate theses in their library electronic database. There are three universities that have been created in South Africa since 2014 which are Sefako Makgatho Health Sciences University, Sol Plaatjies University and University of Mpumalanga.

The PPER database has 3 776 education postgraduate studies published by 19 South African Universities in the period 1995-2004. Mathematics education theses which were missed during the PPER data collection phase in South African HEIs were requested from the respective libraries via UKZN inter-loan library. Letters were written to mathematics education postgraduate supervisors to confirm the data already collected from HEIs. Some supervisors responded pointing to more theses, which were loaned from South African HEI libraries. The focus on the analysis began with PPER data. Table 5.1 (on the next page) show the distribution of the theses according to institutions, degree, gender, and race of the postgraduate students who wrote these theses. The institutions that produced the education theses were analysed first, according to whether they were former historical white universities (HWUs) or historical black universities (HBUs). Secondly, whether the institutions which produced education theses were former technikons or universities. Thirdly, whether institutions where education studies were produced resulted from mergers.

Table 5.1 showed that (HWUs) were active in producing knowledge than their counter parts, (HBUs). HWUs (UJ, UNISA, UKZN, Wits, UP, NWU, UFS, UCT, US, RU, NMMU, DUT & CPUT) produced 3 449 (91.3%) of the education theses in 1995-2004. HBUs (UWC, UNIZULU, UL, TUT, UFH & UV) produced 327 (8.7%) of education theses in 1995-2004. This is not an anomaly as the South African government prior to 1994 prioritised financial support to HWUs. The HBUs focused mainly in teaching black students rather than conducting research. Consequently, educational knowledge was produced mainly by HWUs because of their status during the apartheid (prior 1994) South Africa. The HWUs' socio-political and economic status continued to advantage them even in the period 1995 to 2004. Education theses were predominantly produced in formal universities (3 721-98.5%) and not technikons (universities of technology). In particular, the universities of technology produced 55 education theses accounting for 1.5% of the total education theses produced in 1995-2004. This was partly due to the former status of technikons prior 1994, because they did not focus on research but developed technical skills in Engineering, Science, Commerce and related fields.

Table 5.1 ***Educational postgraduate theses (1995-2004) in the PPER database.***

HEI	Degree		Gender		Race					Total	%
	M	D	F	M	A	W	I	C	NK		
UJ	608	105	407	306	355	300	39	19	0	713	18.9
UNISA	360	196	323	233	191	291	62	7	5	556	14.7
UKZN	390	26	234	182	140	119	155	2	0	416	11.0
WITS	373	33	258	148	67	312	23	2	2	406	10.8
UP	209	93	203	99	74	215	7	0	6	302	8.0
NWU	173	48	96	125	161	56	2	2	0	221	5.8
UFS	159	43	103	99	100	91	0	3	8	202	5.3
UCT	159	13	111	61	40	105	7	15	5	172	4.6
SU	132	39	96	75	33	118	5	10	5	171	4.5
RU	119	19	73	65	65	54	11	7	1	138	3.7
UWC	118	16	63	71	43	58	3	16	14	134	3.6
NMMU	92	33	59	66	35	74	8	7	1	125	3.3
UNIZULU	97	20	67	50	81	9	27	0	0	117	3.1
UL	27	6	9	24	33	0	0	0	0	33	0.9
TUT	28	0	7	21	21	6	0	0	1	28	0.7
DUT	18	0	5	13	5	0	13	0	0	18	0.5
CPUT	9	0	5	4	1	4	2	0	2	9	0.2
UFH	8	0	4	4	8	0	0	0	0	8	0.2
UV	6	1	2	5	7	0	0	0	0	7	0.2
Total	3085	691	2125	1651	1460	1812	364	90	50	3 776	100

In particular, prior to 1994, education qualifications were offered in universities and colleges of education but not technikons. As it can be discerned from table 5.1 HBUs and former technikons are at the bottom on the table. On the PPER database eight institutions were a result of mergers between two or more institutions during the period 2004-2005 and the remaining 11 did not merge. The merged institutions (UJ, UKZN, NWU, NMMU, UL, TUT, DUT & CPUT) produced 1 563 (41.4%) of the education theses compared to institutions which did not merge. The remaining unmerged institutions produced 2 213 (58.6%) of education theses in South Africa (1995-2004). Despite that there were ~~a~~ smaller number of HEIs which resulted from mergers in the PPER database, we expected more theses from these institutions as they created bigger education faculties when data was collected in 2007-2008. As mentioned in Chapter 4, the reasons for the lower number of education theses in merged institutions could be attributed to theses being lost in transit between the newly formed campuses. This occurred before theses were digitized and made accessible online. Additionally, systems and policies needed to be consolidated to eliminate duplications and ensure coherence across the offerings. As a result, the HEIs involved in the mergers had to fine-tune their programs before finalizing their offerings.

The majority of the education theses that were produced in South African HEIs (1995-2004) were masters. Table 5.1 indicated that 3 085 (82%) masters and 691 (18%) doctoral education postgraduate studies were produced in South African HEIs in 1995- 2004. Of importance to note is that the universities of technology (CPUT, DUT & TUT) did not produce doctoral theses during the period 1995 to 2004. Further, UFH is the only university which did not produce doctoral education theses. Notably, the HBUs produced 25 (0.7%) out of 691 (18%) doctoral theses.

Who were the authors of the education theses in South Africa in the period 1995 to 2004? More female postgraduate students (2 125-56%) in South Africa (1995-2004) produced knowledge in education. The prevalence of more education postgraduate theses produced by females was a result of education being considered a 'feminine' profession. Forty-four percent (1651) of male postgraduate students produced knowledge in education in 1995-2004 (see table 5.1). However, in seven HEIs (NWU, UWC, NMMU, UL, TUT, DUT & UV) more male students produced education theses (see table 5.2). In fact, it was mainly in the four out of six HBUs (UWC, UL, TUT & UV) where more male students produced education theses. In fact, two of these HBUs (UL & UV in the Limpopo province in South Africa) (see figure 4 on page 87) produced more education theses. UL and UV are the only universities in Limpopo. Does this mean that male students were supported more in the HBUs and in the HEIs located in the Limpopo province to conduct educational research?

Table 5.2 ***Institutions where more education theses were produced by male students.***

HEI	Gender		Total	% of male students per HEI
	M	F		
NWU	125	96	221	57
UWC	71	63	134	53
NMMU	66	59	125	53
UL	24	9	33	73
TUT	21	7	28	75
DUT	13	5	18	72
UV	5	2	7	71

Further, educational knowledge was produced mainly by white postgraduate students (1 812-48%). The remaining educational theses were produced by African (1 460-39%), Indian (364-10%), Coloured (90-2%) and unknown race (50-1%) (See table 5.1). This ties with the argument made in the previous paragraphs that HWUs were predominant in knowledge production because of their support from the apartheid South African government. Hence, more white students were registered for postgraduate studies. In spite of this, it was not in all HWUs where more white students produced more educational theses. Education theses in UJ, NWU, UFS, and RU were produced more by African students. In addition, it was the Indian students who produced more education theses in HWUs (UKZN and DUT). The two institutions UKZN and DUT are found in the KZN province of South Africa where more people of Indian origin are located. Contrary, though in five out of six HBUs (UNIZULU, UL, TUT, UFH & UV) the education theses were, as expected, produced by African students. In UWC it was the white students who produced more theses, despite UWC being an HBU. In UL, UFH and UV the education theses were produced by only African students. These HBUs (UL, UFH & UV) are located in rural areas that are inaccessible to most students.

The data captured on EndNote further showed that the dominant language in which education postgraduate studies were written was English (3 076-81.46%). The other languages used to produce educational knowledge were Afrikaans (699-18.51%) and isiZulu (one-0.03%). English and Afrikaans were promoted during the apartheid South Africa as the medium of instructions. It was only in post 1994 that the new South African government had language policies promoting all 11 official languages.

When were the education postgraduate theses published in South African higher education institutions (1995- 2004)? Figure 5.1 showed that there was a steady increase in the number of education theses published in the South African HEIs from 1995 to 2004 with the exception of 1997 and 2000-2001. Further analysis of the PPER data can be read from the *South African Journal of Higher Education 25 (2) 2011*. Having looked at the PPER data, it suffices to ask how many of the 3 776 educational postgraduate theses were in mathematics education?

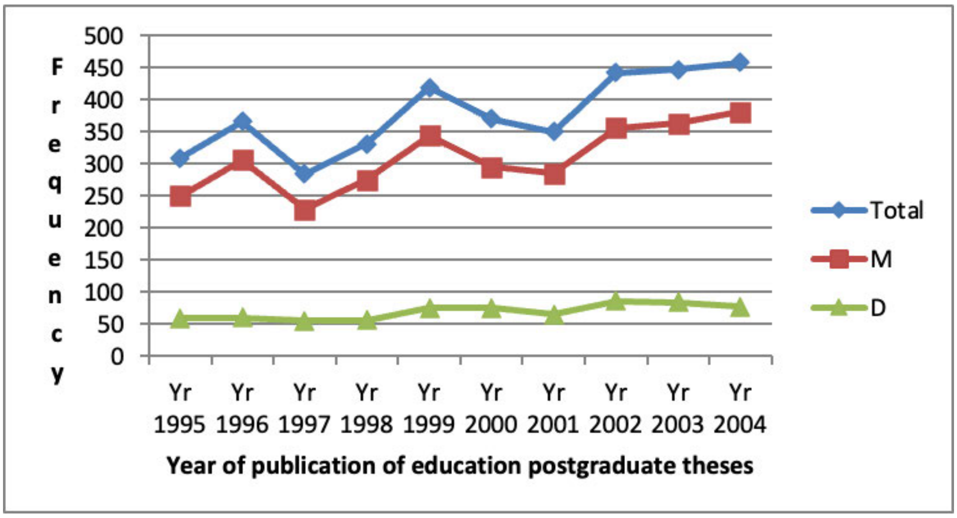


Figure 5.1 Publication of education theses in South Africa (1995-2004) per degree

5.3 MATHEMATICS EDUCATION THESES PRODUCED IN SOUTH AFRICAN UNIVERSITIES (1995-2004)

The corpus of mathematics education postgraduate studies analysed from here forth comes from the PPER data. It was interesting to see whether the generic trends in knowledge production in the broader educational theses analysed above, existed in these mathematics education theses. The deeper questions on the content of the synthesised studies were posed in chapters 6 to 9. These questions began with the titles of theses, research phenomena, questions and claims, paradigms, designs and methods and theories used to produce mathematics education knowledge in South Africa (1995-2004). There were 190 (5%) mathematics education postgraduate studies analysed for this study from 3 776 theses in the PPER database. Which South African HEIs produced mathematics education knowledge through the postgraduate studies in 1995-2004? Fourteen (14) out of 19 HEIs from PPER database, produced these theses (see table 5.3). The order of the number of the mathematics education theses per institution shown in table 5.3 was kept throughout the analyses chapters. There were no mathematics education theses in five institutions: CPUT, DUT, UFH, UL and UV. Table 5.3 showed the distribution of mathematics education postgraduate theses according to institutions, degree, gender and race.

Table 5.3 ***Mathematics education postgraduate studies produced in South African HEIs in the period 1995-2004.***

HEI	Degree M	D	Gender F	M	Race A	W	I	C	NK	Total	Total theses PPER
WITS	43	11	27	27	34	17	3	0	0	54	406
UP	17	6	13	10	3	18	2	0	0	23	302
UJ	17	4	13	8	10	10	0	1	0	21	713
UCT	20	0	13	7	5	13	1	1	0	20	172
UNISA	10	9	6	13	9	6	3	0	1	19	556
UKZN	14	1	12	3	4	4	7	0	0	15	416
SU	8	2	4	6	2	7	0	1	0	10	171
NMMU	6	2	4	4	1	6	1	0	0	8	125
NWU	5	3	4	4	2	5	0	1	0	8	221
RU	6	1	3	4	2	4	0	1	0	7	138
UWC	1	1	1	1	1	1	0	0	0	2	134
TUT	1	0	0	1	1	0	0	0	0	1	28
UFS	1	0	1	0	1	0	0	0	0	1	202
UNIZULU	1	0	1	0	1	0	0	0	0	1	117
Total	150	40	102	88	76	91	17	5	1	190	3 701

There were 190 (5%) mathematics education postgraduate studies analysed for this study from 3 776 theses in the PPER database. Which South African HEIs produced mathematics education knowledge through the postgraduate studies in 1995-2004? Fourteen (14) out of 19 HEIs from PPER database, produced these theses (see table 5.3). The order of the number of the mathematics education theses per institution shown in table 5.3 was kept throughout the analyses chapters. There were no mathematics education theses in five institutions: CPUT, DUT, UFH, UL and UV. Table 5.3 showed the distribution of mathematics education postgraduate theses according to institutions, degree, gender and race.

Wits produced most (54-28.4%) of the mathematics education postgraduate studies during the period under study. However, there were only 54 mathematics education studies out of 406 education studies produced at Wits University during the period 1995 -2004. While it is expected that mathematics education studies will resonate with education studies, at UP (23-12.1%), UJ (21-11.1%), UCT (20-10.5%), UNISA (19-10%), UKZN (15-3.6%), SU (10-5.8%), NMMU (8-6.4%), NWU (8-3.6%), RU (7-5.1%), UWC (2-1.5%), TUT (1-3.6%), UFS (1-0.5%) and UNIZULU (1-0.9%) there were far less mathematics education studies that were produced as compared to education studies. When considering the positions of the aforementioned institutions in the rankings of PPER data, Wits (54) produced more postgraduate theses surpassing UJ (21), which led the PPER ranking. Why did Wits University produce most of the mathematics education theses in 1995-2004 even though there were less number of education studies? During an interview with Professor X from Wits University, she provided insight into the surge of mathematics education postgraduate theses produced between 1995 and 2004. Professor X, who supervised 16 out of 54 masters and doctoral postgraduate studies at Wits during that period, explained that upon obtaining her doctorate in 1996, she applied for a professorship. In this role, she took on the responsibility of enhancing the institution's research output. To achieve this, she sought funding for a research project. Through this project, she mentored masters students who subsequently pursued doctoral degrees, contributing to the increased production of theses within the mentioned timeframe.

Furthermore, she established a cohort comprising 12 masters and doctoral mathematics education postgraduates, with the collaboration of a colleague from London. This initiative led to the inception of another research project named Quantum, consequently augmenting the pool of mathematics education postgraduates who then took on the supervision of masters students. This strategic approach illuminates her rationale behind the proliferation of mathematics education postgraduate theses at Wits:

> What happened was in 1996 I finished [my PhD]. In 1997 there was a chair in mathematics education at the university and I thought well I'll apply and I got it...I was professor of mathematics education and the task really was to coordinate and pull together and strengthen research in mathematics education and at the time I had graduated quite a number of masters students all of whom were interested in doing their PhDs. So, they were a group, kind of like waiting. And so, I took them all. I had six students –But four graduated in record time, in four years, four and a half years. And part of that was because we were just a group…I had a colleague who had a doctorate and he also had students so we had a cohort of about twelve. And we met regularly; they came in six times in a year and I set up a relationship with them-funded by the British Council in a way. A colleague of mine in London came and assisted me because I sort of felt I needed a little bit of help. So, when I met the students at least once or twice every year he came and worked with me with the students. And so, it was really fantastic… So, they [postgraduate students] are all academics, all doing well. They've all made a difference to the [mathematics education] field so it's fantastic". (Interview with Prof X, 4/4/2008, pp. 15-16).

From this account, it becomes evident that the organization of postgraduate supervision in higher education institutions (HEIs) and the availability of research funding for both supervisors and students played pivotal roles in facilitating the supervisor's enhanced throughput rates. Moreover, the cultivation of cultural capital through international collaborations further bolstered their efforts, given the institution's esteemed international standing. In essence, the manner in which supervisors in HEIs arranged postgraduate supervision had a direct bearing on the quantity of studies contributing to mathematics education knowledge in South Africa during the period spanning 1995-2004. The structural framework, systemic approach, and institutional setting where mathematics education studies were conducted emerged as critical determinants of which institutions and individuals contributed to the knowledge landscape in South Africa during this timeframe. At Wits University, the implementation of a cohort postgraduate supervision system significantly bolstered the production of mathematics education studies. Intriguingly, similar patterns were observed at UP, UJ, and some historically black universities (HBUs). Prof X's assertions regarding Wits' heightened production of mathematics education studies found resonance with the perspectives of Prof Y. According to Prof Y, the institutional research culture, funded research projects, and the integration of mathematics education within faculties such as Science at Wits were instrumental in driving the surge in theses production between 1995 and 2004. Prof Y succinctly encapsulated these sentiments during his interview:

> But I think it also stems or comes from the institutional culture…I mean we have never been part of the science faculty, for example Wits. Certain areas of Wits are still part of the science faculty…I still think that we have a lot of influence and a lot of impact on a lot of what the student research. If the research forms part of the funding project, that's pretty direct and focused. So, one would recruit into that stream and into that theme straight away (Interview with Prof Y, 21/4/2008, p.6).

In the subsequent paragraph, an analysis is presented regarding the institutions producing mathematics education studies based on their classification prior to 1994 and subsequent mergers.

Most mathematics education theses were produced in the HWUs. Only the HWUs which were technikons (CPUT & DUT) did not have mathematics education theses. Three of the HBUs (TUT, UWC & UNIZULU) had one mathematics education thesis each and the other three (UFH, UL & UV) had no mathematics education theses. As pointed out in the description of the PPER data, this trend was influenced by the South African government prior 1994 prioritizing funds to HWUs, and resulted to HBUs not focusing on research, rather on teaching black students. Contrary, UFS was a HWU and it managed to produce one mathematics education thesis in the period 1995 to 2004. With the support that HWU had from the government prior 1994, why did UFS fail to follow the trend set by other HWUs? UFS was the only institution in the Free State province of South Africa that could make significant contribution to postgraduate research. The focus group interview with two supervisors shed light to this issue. The supervisors suggested that only full masters dissertations and doctoral theses were put in the library shelves. In addition, a course work masters dissertation (which they called scripts) were submitted in the library if the thesis was awarded 70% mark or more when examined. Otherwise, the theses for course work masters were kept in respective departments in the university. The supervisors summarised the unavailability of theses in the library in this manner:

> W: I think what is happening with us, in the past we had to submit all copies to the library but now it is not compulsory anymore for the course work masters, the scripts...
>
> Z: for the scripts we are just sending a copy to the library for a person who has a mark higher that 70%, so a mark below 70% there is no copy in the library.
>
> W: Normally the department is keeping a copy
>
> Interviewer: So, if they sent those it would be in the library we would have collected those. I think we understand now…
>
> W & Z: Yaah
>
> Z: But a full dissertations and the doctorate PhD will be in the library.
> (Focus group interview with Profs W & Z, 11/7/2008, p.2)

The supervisors above pointed to some of the problems unique to institutions which caused the PPER research team not to be able to photocopy all education theses.

Similarly, to the trend observed in the education theses in the PPER data, the institutions which did not merge produced more mathematics education studies. The only merged institutions which produced at least 10 mathematics education theses were UJ and UKZN. This is contrary to the expectation that merged institutions should have more theses as they combined efforts of more than one institution in the ten-year period. I now turn my attention to the mathematics education degrees produced in the HEI in 1995 to 2004.

Out of 190 mathematics education postgraduate studies, 40 (21%) are doctoral and 150 (79%) are masters theses. The percentage of mathematics education doctoral theses produced in South African HEIs during the period 1995 to 2004 exceeds the norm set by the education postgraduate research in this period. Earlier, I pointed out that during this period only 18% of the total education theses produced in South Africa were doctoral theses (page 110). The analysis of the institutions with ten or more mathematics education theses reveals that not all these institutions followed the national trend discussed in the PPER data. Wits, UP, UJ and SU slightly exceeded the 18% norm. UJ produced 19% of doctorate theses, Wits and SU having 20% and UP's output of doctorate theses was 26%. UNISA[16] exceeded by far the trend of the number of doctoral theses by producing 47% of doctoral theses in 1995 to 2004. UKZN produced 7% doctorates of the total mathematics education postgraduate theses. UCT had no mathematics education doctoral theses produced in 1995 to 2004 despite that they are placed fourth in table 5.3. Three institutions TUT, UFS and UNIZULU produced one masters mathematics education thesis per institution and no doctoral theses. In short, the mathematics education doctoral theses were produced in HWUs with the exception of one from UWC. In the next paragraph I analysed the number of mathematics education theses produced per year in the ten-year period.

The number of mathematics education postgraduate studies conducted within the period 1995-2004, follow trends that show decrease in the number of studies produced for a period of five years and thereafter the number of theses produced increases (see figure 5.2). Juxtaposing figures 5.1 (on page 108) and 5.2 there was an indication that the mathematics education theses follow similar trends as the education theses with the exception that in 1999 the number of education postgraduate theses increased while there was a decline in the number of mathematics education theses. There was a steady increase in the mathematics education postgraduate theses that were produced in the last five years of the ten-year period. The number of mathematics education doctoral theses produced in 2002 increased sharply. I now turn my attention to the identity of the postgraduate students who produced the mathematics education knowledge in South Africa from 1995 to 2004.

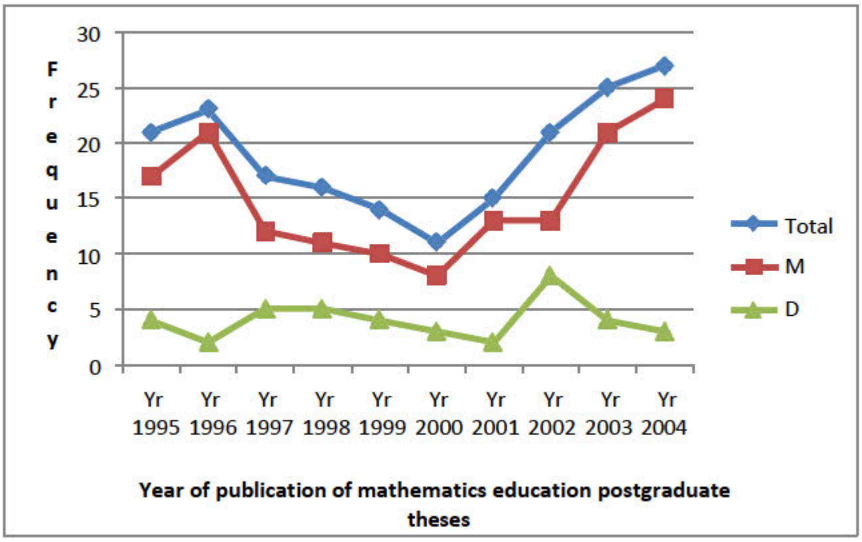


Figure 5.2 Mathematics education theses produced per year (1995-2004) per degree

---

[16] UNISA, the University of South Africa, is Africa's largest distance education institution, renowned for its flexible learning opportunities and extensive online resources. It offers a diverse range of undergraduate and postgraduate programs to students worldwide, fostering academic excellence and accessibility

What is the identity (gender, race, and language) of the students who produced mathematics education knowledge in South Africa in 1995-2004? There were more white female postgraduate students (59-31%) who conducted mathematics education postgraduate research in the period 1995-2004 than the rest of their peers. These were followed by African male postgraduate students (45-23.7%). There were almost an equal number of white male (32-16.8%) and African female (31-16.3%) postgraduate students who produced mathematics education knowledge (see table 5.4). The distribution of the gender of the mathematics education postgraduate students per institution was either equal or more females than male postgraduate students per institution (see table 5.3 on page 109). However, there is an exception in this phenomenon with the distribution of the gender of postgraduate students in UNISA, SU, RU and TUT. More males than females significantly produced mathematics education knowledge in UNISA. This was interesting as UNISA is a distance education institution. Does this mean male students could work independently with supervisors who are at a distance? The trend of more female students producing educational knowledge was observed in the PEPR data.

However, comparing the educational theses in the PPER data with mathematics education studies, it is in different HEIs that more male students produced mathematics education theses. UNISA, SU and RU had more education theses written by females in the PPER data, but the opposite is true for mathematics education theses. The trends of the race for the postgraduate students who produced mathematics education theses is different from the educational theses in the PPER data. In was shown that the HWUs (UJ, NWU, UFS and RU) had more educational theses written by African postgraduate students. However, it is not in these HWUs that more mathematics education theses were written by African students. Contrary it was in Wits and UNISA where more African students produced mathematics education studies. What is consistent is that Indian postgraduate students at UKZN produced most of both education in general and mathematics education in particular.

Table 5.4 ***Race and gender of authors of mathematics education theses (1995-2004)***

Race of the students	Gender of the students		Total
	Female	Male	
African	31	45	76
White	59	32	91
Indian	10	7	17
Coloured	2	3	5
Other	0	1	1
Total	102	88	190

Is there an association between the race, gender and the number of mathematics postgraduate theses produced from 1994 to 2005 per degree? The chi-squared analysis on SPSS on the association of gender and the number of masters and doctoral theses produced by mathematics education postgraduate students shows no significant difference. Comparing the chi-squared value in table 5-5 of 20.472, it is almost equal to $\chi^2_{10;\ 0.25} = 20.483$ showing no significant difference. However, the association between the race and the number of masters and doctoral theses was significant. The value of 42.370 (table 5.6) is lower than $\chi^2_{20;\ 0.002} = 43.986$[17]. This means the number of masters and doctoral mathematics education postgraduate students producing knowledge was significantly different according to race. In the next paragraphs, the language in which the mathematics education theses were written was analysed.

Table 5.5 ***Pearson chi-squared value for gender and the number of masters and doctoral theses in the data***

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	20.472[a]	10	0.025
Likelihood Ratio	18.609	10	0.046
N of Valid Cases	190		

a. 10 cells (55.6%) have expected count less than 5. The minimum expected count is .01.

Table 5.6 ***Pearson chi-squared value for race and the number of masters and doctoral theses in the data***

	Value	*df*	Asymp. Sig. (2-sided)
Pearson Chi-Square	42.370[a]	20	0.002
Likelihood Ratio	38.075	20	0.009
N of Valid Cases	190		

a. 21 cells (70.0%) have expected count less than 5. The minimum expected count is .01.

Many mathematics education postgraduate theses were written in English (157-82.6%) and only 33 (17.4%) of these theses were written in Afrikaans (see table 5.7). South Africa has 11 official languages. However, mathematics education postgraduate students used only two languages in the post-apartheid era to write their theses. Table 5.7 showed that theses written in Afrikaans were from the former Afrikaans HWU (UP, UJ, UNISA, SU,

[17] This value is interpolated between $\chi^2_{20;\ 0.001} = 45.315$ and $\chi^2_{20;\ 0.005} = 39.997$ values from Chi-squared distribution tables.

NMMU and NWU). Ninety-four percentage (31-94%) of the students who wrote mathematics education theses in Afrikaans were white, probably Afrikaans speaking. In contrast, UFS (former HWU) had only one thesis, which was written in English. In addition, one African and one Coloured mathematics education postgraduate students wrote their theses in Afrikaans. The former English HWU only produced mathematics education theses in English (Wits, UCT, UKZN and RU).

Table 5.7 ***Distribution of mathematics education postgraduate studies according to the language in which they are written.***

HEI	English					Afrikaans				Total
	A	W	I	C	NK	A	W	I	C	
WITS	34	17	3	0						54
UP	2	11	2	0		0	8	0	0	23
UJ	9	1	0	0		1	9	0	1	21
UCT	5	13	1	1						20
UNISA	9	4	3	0	1	0	2	0	0	19
UKZN	4	4	7	0						15
SU	2	1	0	1		0	6	0	0	10
NMMU	1	5	1	0		0	1	0	0	8
NWU	2	0	0	1		0	5	0	0	8
RU	2	4	0	1						7
UWC	1	1	0	0						2
TUT	1	0	0	0						1
UFS	1	0	0	0						1
UNIZULU	1	0	0	0						1
Sub-total	74	61	17	4	1	1	31	0	1	
Total	157					33				190

5.4 DISCUSSION OF THE FINDINGS OF META-SYNTHESES OF EDUCATION AND MATHEMATICS EDUCATION POSTGRADUATE THESES PRODUCED IN SOUTH AFRICA (1995-2004)

In summary, the PPER data revealed that 3 776 education postgraduate theses were produced from 1995 to 2004. These educational theses were produced in 19 out of 23 HEIs in South Africa. A large percentage (91.3%) of educational theses were produced in HWUs as opposed to HBUs (8.7%). A significant amount (98.5%) of the educational theses in the PPER database were produced in the former universities in South Africa rather than former technikons (1.5%). The HEIs which did not merge produced more educational theses (58.6%) than the merged institutions (41.4%). The number of education postgraduate theses produced in South Africa (1995-2004) was below the national norm spelt out in the National

Plan for Higher Education. The PPER data showed that educational theses were produced mainly by six HWUs. What the PPER data reveals about which institutions produced educational knowledge through postgraduate research is succinctly captured in the National Plan for Higher Education:

> The second area of concern relates to the inefficiencies in the utilisation of the existing resources for research. This can be illustrated by the fact that, although research funding is an integral component of the subsidy for universities (but not for technikons), comprising 15% of the subsidy, 65% of the research outputs, which are recognised for subsidy purposes are produced by only six universities. Furthermore, the six universities are also responsible for producing about 70% of all masters and doctoral graduates (DoE, 2001, p.68).

The throughput rates for educational masters and doctorate degrees in South African universities were considerably lower than what was anticipated by the National Plan for Higher Education. The data from the Ministry of Education in 2001 indicated that the number of graduates, particularly at the doctoral level, fell significantly short of the targets set by the government. This suggests a discrepancy between the intended outcomes of the educational system and the actual production of higher degree graduates, highlighting potential shortcomings or challenges within the education system.

A significant proportion of the educational theses submitted were at the masters level, comprising 82%. Notably, universities of technology, formerly known as technikons, did not contribute doctoral theses during this period. This observation aligns with the overarching focus of universities of technology, which prioritized equipping students with practical skills in science and commerce, rather than pursuing advanced degrees. This pattern is not unexpected, as universities of technology have historically emphasized training in science and commerce skills, rather than higher degrees. Consequently, the throughput rates for both masters and doctoral degrees in education were significantly below the targets outlined in the National Plan for Higher Education by the Ministry of Education in 2001. According to the analysis of graduate patterns conducted by the Ministry of Education in 2001, higher education institutions (HEIs) in South Africa were projected to produce approximately 4,600 masters graduates (or 5% of total enrollments) and 750 doctoral graduates (or 0.8%) annually (DoE, 2001, p.72). It is essential to note that these figures encompassed all postgraduate students across various disciplines, not solely those within education faculties. However, it is crucial to recognize that these figures represent annual outputs, whereas the data from the PPER spanned a ten-year period (1995-2004). Despite this temporal difference, the throughput rates for educational masters and doctoral degrees remained notably lower than anticipated by the National Plan for Higher Education. The data from the Ministry of Education in 2001 indicated a significant shortfall in the number of graduates, particularly at the doctoral level, compared to the targets set by the government. This discrepancy underscores a misalignment between the intended outcomes of the educational system and the actual production of higher degree graduates, highlighting potential shortcomings or challenges within the education system.

Educational theses were produced mainly by females (56%) and white (48%) postgraduate students. In contrast, more male educational postgraduate students produced theses in HBUs and in Afrikaans HWUs. In addition, in the KZN province, it was the Indian postgraduate students who produced more educational theses. This trend stems from the South African history, whereby African students focused on the struggle for liberation in the 1970s until 1990 when Nelson Mandela was released from jail. During the apartheid era, several blacks subscribed to the philosophy that 'freedom now and education later'. Owing to the ministry of education in 2001 wanting to consider allocating funds "targeted at addressing the race and gender imbalances in research and postgraduate training" (DoE, 2001, p.71). It would be interesting to research whether the number of education postgraduate theses produced, have reached race and gender balance in the next eighteen-year period (2005-2022).

The educational theses were mainly written in English (81.46%) and Afrikaans (18.51%) with one written in isiZulu. This trend might change as the language policy in HEIs change significantly after 2005. In fact, it was only in 2002 that the language policy for higher education institutions was published as a result HEIs started changing their own institutional language policies. It would be interesting to see whether during the period 2005-2022, the number of education postgraduate theses produced in the other nine official languages has increased instead of just one in isiZulu. In the remaining paragraphs, the discussion focused specifically on the trends in mathematics education studies that were produced in South Africa (1995-2004).

There were 190 mathematics education postgraduate theses out of 3 776 educational theses in the PPER database. These were produced in 14 out of 19 HEIs in the PPER database. Most of the mathematics education studies were produced in HWUs (98%). Similar to the trends observed in the educational studies, the HEIs which did not merge produced more studies with the exception of UJ and UKZN. The mathematics education theses were dominantly produced by HWU, and Wits produced most of the mathematics education. Wits produced more than twice the amount of mathematics education knowledge through its postgraduate students compared to other institutions in the data. What could be the explanation for Wits producing more mathematics education postgraduate theses? Space played an important role at Wits producing more mathematics education studies. On one hand, Wits had centres for mathematics and science education research, which contributed to ~~in~~ the number of produced postgraduate studies. On the other hand, at Wits, mathematics education was in the Faculty of Science and not Education. This meant mathematics educationists were working closely with pure mathematicians. As a result, Wits had opportunities of attracting potential postgraduate mathematics students to research education issues, which was a struggle in other institutions.

To elaborate on the role that Wits centre played in increasing the post graduate mathematics throughput, in 1990, Wits had a Centre for Research and Development in Mathematics, Science and Technology Education (RADMASTE). It promoted research and development of mathematics and science and was established few years before the period in this study (1995-2004). Working closely with mathematics and science teachers, RADMASTE played a significant role in attracting postgraduate students and promoting mathematics education. Interestingly, one of the directors of the centre supervised 15 (one less than the interviewed Prof X) of the Wits mathematics education postgraduate students in the database. He focused on ethnomathematics. In 2005, Marang Centre for Mathematics and Science Education was established and the mathematics education academics work collaboratively to research mathematics education issues. In the Marang Centre, Wits continued with the work that started in RADMASTE 15 years before its inaugural. Nevertheless, this trend is similar to the one observed by Rollnick, Adler and Setati (2009). Mathematics education academics who published the most (2000-2006) are from Wits, UCT, UKZN, UP, UNISA and UWC. Consequently, this might have had an influence on the throughput rate of mathematics education postgraduate theses in these institutions except for UWC.

There could be other plausible explanations why more mathematics education theses were produced at Wits than in other institutions. First, who the supervisors of the postgraduate students were, and the research culture of that particular institution during the period 1995 to 2004 played an important role in knowledge production. The Wits cohort postgraduate supervision model could have assisted in the graduation rates. A second possible explanation could be that mathematics education, as a discipline, was not established at UFS. Instead, many institutions had education studies or curriculum studies where mathematics education was the context but not a discipline area with academics focusing their energies on developing this discipline area. The third possible explanation could be funding, because some supervisors were capable of attracting funders for their research projects and included postgraduate students within their projects. This increased the number of postgraduate students graduating in a certain discipline area. Lastly, in some institutions, the practice was that only full masters and doctoral theses were submitted in the library. A number of theses might not have been photocopied because they were not in the universities' libraries.

During the period 1995-2004 in South Africa, more masters mathematics education (79%) were mainly produced than mathematics education doctoral theses (21%). UP (26%) and UNISA (47%) produced mathematics education doctoral theses far above the norm. The trend for the increased in the number of mathematics education postgraduate doctoral theses could be because of the campaign by the ministry of education to increase the number of masters and doctoral postgraduate students. The National Plan for Higher Education reported that:

> Between 1995and 1999, masters and doctoral enrolments as a proportion of total head count enrolments increased from 5% to 5.7%, i.e. from 28 700 to 32 600. There was an increase from 4.7% to 5.5%, i.e. from 27 000 to 31 300 in the universities and a marginal decrease in the technikons from 0.3% to 0.2%, i.e. from 1 700 to 1 300 (DoE, 2001, p.69).

The data indicated that white female postgraduate students were prominent producers of knowledge in mathematics education during the period 1995-2004. Contrary to the common understanding that white males are dominant in research, they were not well represented in the data. The year-by-year gender analysis of the mathematics education theses indicated that more male students were productive in the first three years. However, this trend changed in 1998 where the same number of theses were produced by both genders, and from 1999, there was an increased number of female postgraduate students that produced mathematics education knowledge. The supposition here is that with the political freedom gained in 1994 for everyone, women felt empowered to take postgraduate studies, more especially in mathematics education. The larger percentage of these women were white, signaling a recommitment to South African education (Chisholm, 2001). This trend is contrary to the idea that whites students study in South Africa then relocate to overseas countries (Bertram et al., 2007; Khan et al. 2021. Rizvi, 2005). Still, maybe there was pressure for a postgraduate qualification post 1994 with all 'races equal' in South Africa. The race of an individual could not secure one a job position but relevant qualifications were more important (Akala, 2019; Mabokela & Mawila, 2004). However, this progress has been hindered by the persistence of racial and gender-based obstacles, particularly for black women, in higher education management (Mabokela & Mawila, 2004). Despite some gains in female enrollment, there are still significant barriers to achieving gender equity in South African higher education (Akala, 2019). The need for a multifaceted approach to address these challenges, considering the diverse needs of black women, is emphasized (Akala, 2019).

Similar trends observed in the PPER data were prevalent in the mathematics education studies. The number of theses produced declined as the period 1995-2004 approached the halfway mark, thereafter, improved towards the end of the period. Also, most of the mathematics education postgraduate theses were written in English, which was the results of English language enjoying the *lingua franca* in South Africa. However, there are changes in the language policies of most HEIs in South Africa.

5.5 CONCLUSION

Chapter 5 concludes with a comprehensive analysis of the production of educational theses and, more specifically, mathematics education theses in South Africa from 1995 to 2004. The examination of the PPER data highlights several key findings regarding the distribution of research outputs across various institutions, gender and racial demographics of postgraduate students, language preferences, and factors influencing knowledge production in mathematics education.

The data underscored a disparity in the distribution of educational theses, with the majority originating from a select few higher education institutions (HEIs), particularly historically white universities (HWUs). Moreover, the throughput rates for both educational masters and doctoral degrees fell below the targets outlined in the National Plan for Higher Education, indicating a misalignment between educational outcomes and government expectations.

Within the realm of mathematics education, a similar trend emerged, with a notable concentration of theses emanating from specific institutions, prominently Wits University. Factors such as institutional resources, research culture, and supervisor influence were identified as potential contributors to this phenomenon. Furthermore, the gender and racial composition of postgraduate students revealed interesting patterns, with white female students emerging as prominent producers of knowledge in mathematics education, challenging conventional assumptions about research demographics.

The chapter concludes with a discussion on language preferences in thesis writing, noting the dominance of English and highlighting potential shifts in language policies within HEIs. Overall, the findings underscore the complex interplay of institutional dynamics, socio-political contexts, and academic priorities in shaping the landscape of educational research in South Africa during the specified period. As the narrative transitions to subsequent chapters, it sets the stage for further exploration of trends, challenges, and opportunities within the realm of mathematics education research, offering valuable insights for future scholarship and policy considerations in higher education. In the next chapter, I began with the second level analysis. I analysed the mathematics education knowledge produced in South Africa from 1995 to 2004 using the titles of the theses.

CHAPTER 6
NAMING AND FRAMING OF MATHEMATICS EDUCATION POSTGRADUATE RESEARCH TITLES (1995–2004)

6.1 INTRODUCTION

A title of a postgraduate study informs the reader of the nature of the study and also signals the nature of inquiry and the participants. Titles attract the readers, depending on how they are constructed. According to Jalilifar (2010) the "title is the proof of identity of any academic work without which the work would hardly find space in the intended discourse community" (p. 29). In addition, the title should be informative and is the first point of entry in understanding the produced knowledge in the mathematics postgraduate education studies in South Africa (1995-2004). Swales and Freak (1994) propose that the title of a research paper "should indicate the scope of the research, introduce the topic of the research, and be self-explanatory" (p. 205). Without an informative title, navigating databases such as library catalogues and SABINET to access research would prove challenging. In addition, several authors (Hays, 2010; Anthony, 2001) criticise long titles because they do not necessary guarantee clarity of what is studied. However, they acknowledge that 'novice researchers' struggle with framing titles such that they "adequately describe the content" (Anthony, 2001, p.192) with fewer words.

In this study, the titles in the data were analysed using critical discourse analysis by Jäger (2001), as a methodological tool, and not a theory. According to Jäger (2004, p.35) a discourse "can be characterized as 'an institutionalized way of talking that regulates and reinforces action and thereby exerts power'…, as illustrated by flow of knowledge through time". The analysis of titles as indicative of knowledge that was produced in the postgraduate studies, was adapted from Jäger's (2001) analytical guidelines. Jäger (2001, pp.54-56) suggests analytical guidelines for processing textual material starting with structure analysis (first level analysis), which is broad, then fine analysis (second level analysis) of discourse fragments. The structural analysis focused on the general overview of the titles. The overview centred on the length of titles (Anthony, 2001), and the words depicting mathematics content.

The fine analysis of titles was four pronged focusing on the linguistic devices (Bengesai, Goba & Karlsson, 2011; Anthony, 2001), research design, epistemological stance, and indication of results. Linguistic devices such as *colon*, *quotation mark*, *question mark*, *bracket*, *metaphors,* and *gerunds* are used in titular constructions (Bengesai, Goba & Karlsson, 2011; Anthony, 2001). Titular construction refers to the structured formulation of academic titles in research writing (Bengesai, Goba & Karlsson, 2011). It involves selecting and organizing words, phrases, and linguistic devices to create a title that effectively conveys the research focus, methodology, and key variables. A well-constructed title enhances the clarity, accessibility, and impact of an academic work, ensuring it aligns with disciplinary conventions and attracts the intended audience. In postgraduate research, titular construction is not just a technical necessity but a strategic tool influencing how research is perceived, categorized, and disseminated (Antony, 2001).

Swales and Freak (1994) suggest that the title "should indicate the scope of the research" (p.205). Hence the titular analysis further examined whether the research design, epistemological stance and indication of results were specified in the titles. The titular analysis of linguistic devices, research design and epistemological stance began with the identification of institutions where these devices, designs and epistemologies were prevalent. Thereafter, I analysed the identity of the theses authors with prevalent linguistic devices, designs and epistemological stance in titular construction. This meant certain styles of naming and framing titles may be prevalent in certain institutions thus engendering power and discourse position of knowledge produced.

6.2 GENERAL OVERVIEW OF TITULAR CONSTRUCTION IN MATHEMATICS EDUCATION STUDIES

The general overview of the titles for mathematics education studies, dealt with the length and words indicating mathematics content. The titles of the theses were read reiteratively to identify the length of words using words count in Microsoft Word 2010. In addition, the titles were read to identify the words depicting mathematics content. The titles of theses were submitted to my supervisors who checked the validity of the analysis made. The titles of mathematics education theses (1995-2004) were reasonable in length, around 15 as suggested by most journals articles (Anthony, 2001; Bisimbaeva, 2022; Hallock & Dillner, 2016; Yitzhaki, 2001). Out of 190 theses titles, only five had 25 words and over with the highest being 34. The shortest title had two words: "Uitkomsgebaseerde Wiskunde-

Onderrig" (6-Bedeker, 1999) translated as "Outcomes-Based Mathematics Education". In Afrikaans the title has two words even though in English it has three words.

The average (mean) number of words in the titles in the corpus was 14.1 (See table 6.1). The median of the number of words in the titles was 14 and the mode was 14. The range of the number of words in titles was 32. However, the range though, does not give a clear description of the variation of the number of words. The standard deviation of 5.12 was a better measure of dispersion of the number of words from the mean (14.1). The distribution of the number of words in the titles in the corpus was almost normally distributed with the mean, median, and mode almost equal (see figure 6.1).

In brief, the mathematics education postgraduate theses (1995-2004) were titled with an average number of words as suggested by most academic journals. The mathematics education theses with 15 or less number of words in titular construction were from 12 of the 14 HEIs in the database (see table 6.2). All the mathematics education theses from UJ and UNIZULU complied with the recommended number of words in titular construction of 15 words. More than 60% of theses from SU, UP, Wits, UNISA, NWU and UCT (see table 6.2) had short titles of 15 words or less. There were 20 theses with over 20 words in titular construction up to 34 words. These were from mostly HWUs (Wits (7), UCT (2), UKZN (2), NMMU (2), NWU (2), RU (2), UP (1) and SU (1)) except for one from HBU-UWC. In the next paragraph the identity of the authors of theses with short and long titles was discussed.

As shown earlier 128 out of 190 (67%) studies had short titles of 15 words or less. As expected, there were more masters (101) students who wrote short titles than doctoral (27) students, however, each was 67% of the respective theses in the database. More female (73 out of 128) students wrote short titles than their male (55 out of 128) counter parts, notwithstanding that more female students contributed to the corpus of theses. More than half of the students who wrote short titles were White (65) with a substantial number of African (50) students (see table 6.3). This might be expected as the first language for most White students was English. Contrary to the aforementioned, a small number of female (7 out of 20) students wrote titles of theses with more than 20 words (refer to table 6.1). In addition, of the 20 studies with titles which are 20 words or longer, more were written by African (10) students than their White (7), Indian (2) and Coloured (1) counterparts. Most of the students who wrote long titles were registered for masters (13) than doctoral (7) degrees. In the next paragraphs, I focused on the words indicating mathematics content in the theses titles.

Table 6.1 Length of titles in mathematics education theses (1995-2005).

No. of words	Frequency
2	1
5	5
6	6
7	7
8	5
9	8
10	11
11	18
12	13
13	19
14	20
15	15
16	9
17	9
18	8
19	9
20	7
21	2
22	4
23	4
24	5
25	1
26	2
27	1
34	1
Average 14.1	Total 190

Table 6.2 Distribution of the theses with 15 or less number of words in the titles per HEIs

HEI	No. of theses with title length of 15 words or less	Total in the database	% of the theses per HEI
WITS	35	54	65
UP	18	23	78
UJ	21	21	100
UCT	12	20	60
UNISA	12	19	63
UKZN	7	15	47
SU	8	10	80
NMMU	4	8	50
NWU	5	8	63
RU	4	7	57
UWC	1	2	50
UNIZULU	1	1	100
Total	128	190	

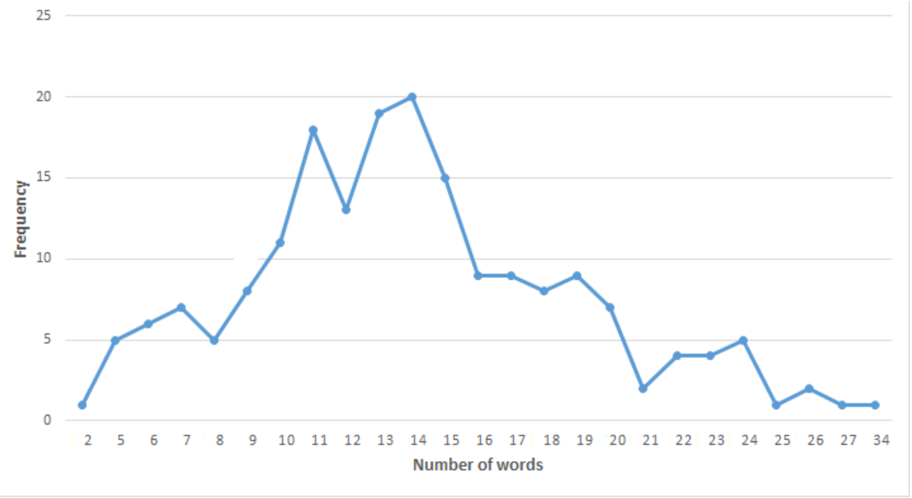


Figure 6.1 Frequency distribution of the length of titles of mathematics education theses

Table 6.3 ***Race and gender of authors of titles with 15 or less number of words.***

Race of the students	Students who wrote short titles	Total of students in the database	%
African	50	76	39
White	65	91	51
Indian	8	17	6
Coloured	4	5	3
Other	1	1	1
Total	128	190	100

Mathematics education is a young discipline, which comes from pure mathematics. As such, words indicating mathematics content should be evident in the titular construction of mathematics education theses. Notwithstanding that, mathematics education includes pedagogy as well. However, only 21.6% (41 out of 190) of mathematics education postgraduate theses indicated words reflecting mathematics content in their titles. The theses with the word 'mathematics' only, without the specific mathematical content, were not included in this category. The global overview of titles indicating mathematics content was signalled in a low number of postgraduate studies titles (Redmond, Costello, & Kay, 2014). This indicated that published research in mathematics education theses might not be accessible through search engines assisting other students registered for postgraduate studies. For example, it was difficult to ascertain, through titles only, whether the theses below were in mathematics education:

> Journeying into the space of possibility (74-Lebethe, 2004).
> Language practices in multilingual classrooms in South Africa (165-Setati, 2002).

The above titles had no word mathematics or mathematics content. 74-Lebethe's (2004) title might have been mistaken for a novel, while 165-Setati's seems to be more in the language discipline. Incidentally the limited use of mathematics content in titular construction could impact on the next chapter dealing with research phenomena, questions, and claims. The mentioning of mathematics content in titular construction early on indicates the type of knowledge produced in mathematics education postgraduate studies from 1995 to 2004. As a result, this influenced the limited research claims directly linked to the mathematics content.

Of the titles that included words with mathematics content, these were limited to algebra (21), geometry (14), calculus (5) and trigonometry (1). Studies indicating mathematics content in titular construction were limited to eight out of 14 HEIs: Wits (16), UCT (7), UNISA (7), SU (5), UJ (2), NMMU (1), UKZN (1), UP (1) and RU (1). Most of these studies were masters (35) as opposed to doctoral (5) studies. The reason why Wits had more theses indicating mathematics content in their titles could be, as indicated in the previous chapter, that mathematics education theses were linked to the Faculty of Science rather than Education. At Wits there was a close relationship between pure mathematics and mathematics education departments. The studies that signalled mathematics content in their titles were written mostly by male (23) than female (18) students. The majority of these students were Africans (21) than the other races, White (14), Coloured (3), Indian (2) and Other (1). The next section dealt with linguistic devices.

6.3 LINGUISTIC DEVICES

The analysis of linguistic devices used in titular constructions of postgraduate studies focused on the use of punctuation (*colon*, *quotation mark*, *question mark*, *bracket*), metaphors (Bengesai, Goba & Karlsson, 2011; Anthony, 2001) and gerunds (Hays, 2010). According to Bengesai et al. (2011), the linguistic devices are “devices that structure meaning relations and trigger associations of meaning” (p. 256). These linguistic devices signal the discursive limits. As indicated earlier, the titles were read in-depth for the linguistic devices and examples of titles supporting the claims that were made in this thesis were written in the text. Otherwise, a separate reference section of the theses that were used in this study is found at the end of this thesis. Thus, the general overview of the linguistic devices, reveal that the colon was the most common linguistic device used in titular construction. Out of 190 theses sampled, 48 (25%) used the colon in the titular construction. A small number of theses used gerunds, brackets, quotation marks, questions marks and metaphors (see Table 6.4). However, most postgraduate studies had simple titles, not conforming to academic practices. For the remainder of this subsection, I discussed the punctuation marks, metaphors, and gerunds in that order. As shown in table 6.4, the most common punctuation used in titular construction was the colon, I then firstly discussed the “titular colonicity” (Dillon, 1982; Hays, 2010). Since few studies used the other punctuations-brackets, quote mark and question mark, I therefore subsequently discussed on the fine analysis of these studies.

Table 6.4 ***Linguistic devices in titular construction***

Linguistic devices	Number of theses
Colon	48
Gerunds	14
Brackets	8
Quote Mark	4
Question mark	3
Metaphors	2

Colon (:) is used in a sentence "to introduce a list of things …or a phrase" (Cambridge Advanced Learner's Dictionary, 2008). The colon as an academic writing style is used to separate the title from the subtitle. Anthony (2001) calls the colonic title- "hanging title" (p.188). The colon adds complexity to the title of the thesis and the induction of the postgraduate student into academia. Dillon (1982) contends that "titular colonicity" is associated with scholarly quality as evidenced in five regards: "a predominant characteristic of scholarly publication", "a correlate of scholarly productivity", "a mark of scholarly distinction", "an indicator of scholarly complexity" and "a discriminant of scholarly character" (p.94). The aforementioned present colonic titular construction as a dominant discourse associated with knowledge and power in academe. Sometimes the colon makes the academic work interesting or is unnecessary (Bengesai et al., 2011; Hays, 2010; Anthony, 2001).

The structural analysis of "titular colonicity" showed that the postgraduate studies at Wits, more than any other institution, during the period 1995- 2004, used colons. Out of the 48 theses using colonic titular construction, 21 (45.7%) are from Wits. This indicated the powerful discourse of Wits mathematics education postgraduate students mimicking a dominant academic practice. The use of colons in titles was predominant in HWUs with only one thesis from HBU-TUT. However, not all mathematics postgraduate studies, in HWUs had colonic titles. UNISA and UFS had no postgraduate studies, with colons in their titles, despite it being an academic practice (Hartley, 2007). Similarly, UWC and UNIZULU (HBU) had no titles using colons (see table 6.5). The colonic titular construction was more prevalent in the masters (39 out of 48) than doctoral studies (9 out of 48). However, in comparison of distribution of colonic titular construction with the number of masters (39 out of 150-26%) and doctoral (9 out of 40-23%) theses in the corpus, there was not much difference between the two degrees. Both female (25) and male (22), together with one unknown, students preferred to use a colon in titular construction of their theses. In addition, White (22) and African (20) students selected to use a colon in the title of their theses more than Indian (6). In the next paragraphs, I discussed the fine analysis of how the colon was used in titular construction of the postgraduate theses.

Table 6.5 *Theses titles with a colon*

Institution	**Degree**		**Total number of theses with colons**	**%**
	Masters	**Doctoral**		
Wits	17	4	21	43.7
UP	6	2	8	16.6
UKZN	5	0	5	10.4
UCT	5	0	5	10.4
UJ	1	1	2	4.2
NWU	1	1	2	4.2
RU	1	1	2	4.2
NMMU	1	0	1	2.1
SU	1	0	1	2.1
TUT	1	0	1	2.1
Total	39	9	48	100

The fine analysis of the “titular colonicity” showed that it was used either unnecessarily or in compounding the title. In the case where the use of the colon was unnecessary, the subtitle only mention the research design. By paraphrasing the title incorporating the research design in the main title, the use of the colon could be avoided. An example of such titles are 3-Appanna (1995), 8-Berger (1996), 16-Campbell (1999), 49-Grinker (1998) and 5-Barnes (2004) shown below. The subtitle in 3-Appanna, 8- Berger, 16-Campbell and 49-Grinker was the research design. By incorporating the research design in the first part of the titles, the use of the colon can be annulled. Similarly, in 5-Barnes’ (2004) title, the research design was indicated in the main part of the title. This part alone, ‘A developmental case study’, does not inform the reader about the focus on the study. Rather the subtitle sheds light on the research design of the study.

> Pupils' perceptions of study of mathematics as a subject for the Senior Certificate Examination: Two case studies (3-Appanna, 1995)
>
> The appropriation of mathematical objects by undergraduate mathematics students: A study (8-Berger, 1996)
>
> How primary mathematics teachers learn about co-operative learning: Case investigation (16-Campbell, 1999)
>
> The usefulness of everyday mathematics in the senior secondary curriculum: a controlled experiment (49-Grinker, 1998)

> A developmental case study: implementing the theory of realistic mathematics education with low attainers (5-Barnes, 2004)

Rephrasing the above titles as shown below, signalled how the use of colon in the titles could be avoided:

> *A case study of pupils' perceptions of mathematics as a subject for the Senior Certificate Examination.*
>
> *A study of the appropriation of mathematical objects by undergraduate mathematics students*
>
> *Case investigation of how primary mathematics teachers learn about co-operative learning.*
>
> *A controlled experiment of the usefulness of everyday mathematics in the Senior Secondary curriculum.*
>
> *A developmental case study of implementing the theory of realistic mathematics education with low attainers.*

Similarly, the use of the colon in 25-Cronje's (1995) title, "Euclidean geometry: cognitive gender differences", made it unclear and also made the study seem to be ill-defined. The main title, '*Euclidean geometry'*, indicated the mathematics content area. The subtitle '*cognitive gender differences'*, indicated the phenomenon studied which is the differences in thought processes between genders. However, there was no indication of the participants. Was the study focusing on learners or teachers? The reader gets the sense of the research once she or he reads the research questions of this particular study: "Is there any gender difference with regard to achievement in Euclidean Geometry at senior secondary level in selected South African schools? If gender differences in geometry achievement exist, which gender do they favour and what is the magnitude and nature of the differences?"

The use of the colon in the titles of the studies 31-Dickson (1999), 127-Nyabanyaba (1998) and 128-Nyabanyaba (2002) (on the next page) "serve[d] as an additive function" (Bengesai, et al. 2011, p.258) compounding the title. The first part attracts, while the second part informed the reader of the study. Hartley (2007) calls this 'colonic fulcrum'. For example, the first part of 31-Dickson's 127-Nyabanyaba's and 128-Nyabanyaba's titles attracts the reader: "*Super highway or cul de sac"*, "*Whither relevance"* and "*Examining the examination"* respectively. The first part, by itself, does not inform the reader what the research study all about, especially in 31-Dickson and 127-Nyabanyaba. It was the second part of 128-Nyabanyaba title that informed the reader of the investigation of the mathematics examination. In 127-Nyabanyaba's subtitle, mathematics teachers' meaning of relevance to everyday experiences clarified the relevance of the first part. In addition, the first part of 31-Dickson's title might be confusing by itself, whether the thesis is about roads, whereas it acts as a metaphor to describe the use of internet as a tool of teaching mathematics. 31-Dickson

(1999) used the road signs as a metaphor since the internet is regarded as the super high way of information.

> Examining examination: The ordinary level (O level) mathematics examination in Lesotho and the impact of recent trends on Basotho students' epistemological access (128-Nyabanyaba, 2002)
>
> Whither relevance?: Mathematics teachers' espoused meaning(s) of 'relevance' to students' everyday experiences (127-Nyabanyaba, 1998)
>
> Super highway or cul de sac: The internet as a tool for learning school mathematics. (31-Dickson, 1999)

The above fine analysis of the colonic titular construction revealed the preoccupation of the postgraduate students with a particular discursive practice in academia showing the link between discourse, knowledge, and power. By using colonic titular construction, the postgraduate students induced behaviour of the 'powerful' (academics) making their studies to be complex and acceptable. In the process when students are initiated in the dominant discourse of "titular colonicity", the data showed that this could either be interesting or unnecessary. In addition, Hays (2010) argue that colons make the titles to be longer, doubling the word count. Furthermore, there was no consensus on whether the first word after the colon should be in lower or upper case. The fine analysis of the linguistic devices in titular construction dealt with the quotation mark in the next paragraphs.

The quotation mark (' ') emphasises, within the text, the actual words that were used by another author. It also denotes the dialogue and "titles of other people's work" (Bengesai, et.al. 2011, p.259). There were only four theses out of 190 that used quotation marks and their distribution by institutions, degree, and identity of the authors for the titles were not discussed. The analysis of the titles using quotation mark showed two results. First that the authors of the titles were uncertain of the true meaning of the word(s) used in the title, and secondly the use of quotation mark in titular construction was unnecessary. The titles in 7-Bennie (1999), 117-Nakidien (2002), 127-Nyabanyaba (1998) and 140-Poni (2000) theses were used to illustrate these points:

> Building a model of "spatial ability": An analysis of Grade 5 and 6 learners' strategies for solving "spatial activities" (7-Bennie, 1999)
>
> The recruitment of the 'everyday' in fourteen Grade 7 mathematics classrooms (117-(Nakidien, 2002)
>
> Whither relevance?: Mathematics teachers' espoused meaning(s) of 'relevance' to students' everyday experiences (127-Nyabanyaba, 1998)

The fine analysis of the titles using quotation mark revealed that 7-Bennie, 117-Nakidien and 127-Nyabanyaba used the word(s) in quotation marks-'*spatial ability'*, '*spatial* *activities'*, '*everyday*' and '*relevance*' respectively to express the author's uncertainty of the true meaning of the word. For example, 'relevance' defines the relationship between something, and/or a connection between things. In particular, 127- Nyabanyaba questioned whether the school mathematics tasks and activities relate to learners' everyday experiences. 127-Nyabanyaba did not want to reveal too early whether there was relevance of learners' everyday experiences in school mathematics. Thus, 127- Nyabanybaba invited the reader to read the research study until she or he got the sense that the school tasks and activities are relevant or not to learners' everyday experiences. None of the aforementioned terms 'spatial ability', 'spatial activities', 'relevance' and 'everyday' were used to refer to other people's work.

The second finding of the analysis of titular construction using of quotation marks showed that it was used unnecessarily. 140-Poni's (2000) title "*Grade 10 English second language pupils' difficulties with paradoxical jargon and technical terms commonly used in their mathematics curriculum*" can be read with the same meaning without the quotation marks. In comparison, the use of quotation in the postgraduate studies manifested itself in a similar manner as the colonic titles. Sometimes, the quotation mark was used unnecessarily or displayed creativity of the author of the thesis. In the next paragraphs, I discussed the use of the question mark in titular construction.

The question mark (?) is a punctuation indicating a question. In academic writing, the question mark can be used to trigger interest and engage the reader to read until the end of the text, to ascertain the answer to the question. Similarly, to the colon, the use of question mark compounds the title. Only three postgraduate theses used the question mark in the title. For this reason, only the fine analysis of the titles using question mark was performed. Similarly, to the colon, the question mark compounds the title. 17-Carr (2002) and 127-Nyabanyaba (1998) use of the question mark in the title of their theses compounded the titles. In 17-Carr's title, "Information, knowledge and learning: Is the web effective as a medium for mathematics teaching?", the constructs information, knowledge and learning are investigated. The subtitle, which was a question, engaged the reader on the effectiveness of the use of the web as a teaching resource and how information, knowledge and learning linked. 127-Nyabanyaba's title was different to 17-Carr's in that it began with a question "Whither relevance?" Whither is old English meaning 'to what place' or 'into what state'? The author here was asking a question: what is the state of relevance in everyday experiences used in the mathematics classrooms? The meaning of relevance for the everyday experiences of students was foregrounded in this title. Particularly, only one research question was 127-Nyabanyaba's thesis-*Whither relevance*?

The third thesis which used the question mark in titular construction did not compound it. 123-Ngubane (2000) titled his thesis as "*What are the links between a teacher's views of mathematics and his/her classroom practices?"* Of interest with the title was the exact similarity with the research question that was posed in the thesis text. In particular, the main research question for 123-Ngubane's study was: "*What are the links between a teachers' views of mathematics and his/her classroom practices?*" The sub- questions in 123-Ngubane's study were: "*What are the views the teachers have about mathematics?*", "*What teaching styles do teachers display in a mathematics classroom?*" and "*Do these teaching styles correspond to the views they hold about mathematics?*" 123- Ngubane's study did not follow the dominant discursive practice of titular construction in research, where the research question clarifies the title but the same phrase was used. The next paragraphs focused on the use of brackets in titular construction.

Parentheses, as sometimes the brackets ( ) are called, contain part of a sentence, and when they are excluded, the meaning of the sentence will not change. Sometimes, the use of brackets indicates the singular or plural of the word in the text. The number of postgraduate theses using brackets in their titular construction was small (eight) and only fine analysis was done. The brackets were used in four ways in the eight titles shown below. First, in 54-Heine (1997), 93-Michael (2001), 115-Naidoo (2003) and 132-Osei (1995) titles brackets were used as an abbreviation of either the concepts or the nouns (see the titles below):

> General Scholastics Aptitude Test (GSAT) as a predictor of mathematical achievement in Grade 12[**translated title**] (54-Heine, 1997)
>
> A phenomenological study of leadership in the Rhodes University Mathematics Education Project (RUMEP) (93-Michael, 2001)
>
> The in-service education and training (INSET) needs of educators of primary school mathematics (115-Naidoo, 2003)
>
> Attitudes towards mathematics and mathematics achievements: A case study of the first year students of Junior Primary Teachers Diploma (JPTD) colleges in Transkei (132-Osei, 1995)

Second, the title "*The effect of scaling in the understanding of algebraic graphs for Grade 9 (Form B) learners"* (59-Ijeh, 2003) used the bracket indicating an alternate name for Grade 9, which is Form B. In South Africa's neighbouring countries, the school classes are referred to as forms and not grades. 59-Ijeh sought to clarify for the reader, residing in their country of origin, which class he was referring to in the study. Third, the title of 143-Prins's (1995) study used the bracket to clarify the study. The main part of the title "*The* *influence of readability of examination questions on achievement in senior secondary school mathematics (A study on verbal problems with special reference to second language readers)*" (143-Prins, 1995)-was sufficient and can stand-alone. The minor part of the title reinforced and clarified the main part of the title. Lastly, the bracket was used in 127-Nyabanyaba's (1998) title, "*Whither relevance?: Mathematics teachers' espoused meaning(s) of 'relevance' to students' everyday experiences*", to indicate that there could be more than one meaning of "relevance to students' everyday experiences". This was the end of analysis of punctuation (*colon*, *quote mark*, *question mark* and *bracket*) in the titular construction. The remainder of paragraphs in this subsection analysed metaphors and gerunds.

Metaphors are rhetorical concepts through which we view and understand our world (Lakoff & Johnson, 1980). Lakoff and Johnson (1980) proposed that metaphors are thought process through which we communicate. The work on metaphors dates to the 15th century (1445) with the Greek Philosopher, Aristotle understanding metaphors as rhetorical or poetic (Kirby, 1997). The titles using metaphors were identified by using "focus word or frame" (Mungra, 2007, p.103), not having literal but metaphorical meaning. The metaphor has the tenor and vehicle (Lakoff & Johnson, 1980). In the data, only two postgraduate theses used metaphors in their titles. Because so few theses used metaphors in their titles, this resulted in a fine-grained analysis. Below are the two theses which, used metaphors in their titular construction:

> Super highway or cul de sac: The internet as a tool for learning school mathematics (31-Dickson, 1999)
>
> Journeying into space of possibility (74-Lethebe, 2004)

31-Dickson's (1999) title was compounded. It used both the colon and the metaphor. In the use of the colon, the subtitle indicated to the reader what the study entailed; the use of the internet to teach mathematics. For the author, the internet could be an endless opportunity (*super highway*) or restricting (*cul de sac*) in the learning of mathematics. In this title, the author presents the tenor (internet use) with a figurative assertion of the vehicles (*super highway* and *cul de sac)*. The vehicles super highway and cul de sac described the metaphoric visual images (Mungra, 2007) giving meaning to how mathematics can be learnt at school using internet. The tenor and vehicle of the focus words referred to something broad or highway (extensive electronic network) or dead end/ closed path. 31-Dickson accomplished this by "blending…two input domains such that the new blended space acquires the properties of both inputs" (Mungra, 2007, p.110). To be more precise, the vehicles *super highway* and *cul de sac* expressed the meaning that teaching mathematics using internet could be opening up or closing opportunities for learning. This stance revealed the ontological position of the author. It indicated the "significance of discourse" (Hyland, 2002, p.43) in written text in academia.

74-Lebethe's (2004) title, "*Journeying into space of possibility*" was first poetic. From the title, the reader cannot ascertain the discipline or the focus of the study. At best, the word 'space' related the thesis to the mathematical sub-discipline of geometry. However, this meaning was ambiguous. Particularly, this was a self-study of the author's journey in teaching of a mathematics in-service course. In the abstract, the author examined her "assumptions, prejudices and habits of practice". She "tells her story in different voices and show[d] her connectedness to the research journey by the use of linguistic play and narrative style". As it can be established, the study had nothing to do with geometry. This study did not subscribe to the dominant discursive practices of writing a thesis, especially in mathematics education. The author wrote in a poetic manner relying of her linguistic abilities rather than the scientific genre expected in mathematics education. Second, by repeating the focus word journey throughout the body of the thesis, the author created a "sub-technical language or internal jargon" (Mungra, 2007, p.99). This stance revealed what Jäger (2001) calls "entanglements of discourse strands" (p.47). The next paragraphs analysed the use of gerunds in titular construction.

Gerunds according to Hays (2010, p.101) "are verb forms that end in-*ing* but are used as nouns in sentences". Hays does not like titles beginning with gerunds. She suggests that gerunds are "superfluous and [do] no important work" (p.101) instead the actor and the action are hidden. The following 14 theses used gerunds in their titular construction: 2-Agherdien (2004), 7-Bennie (1999), 11-Bhengu (2003), 58-Howie (2004), 74-Lebethe (2004), 87-Matthee (1998), 94-Mnisi, 103-Moodley (2002), 111-Mudaheranwa (2002), 116-Nakajima (2002), 128-Nyabanyaba (2002), 135-Penlington (2004), 138-Phiri (2003) and 171-Swanepoel (1999). Of the 14 titles, ten (2-Agherdien, 11-Bhengu, 58-Howie, 74-Lebethe, 94-Mnisi, 111-Mudaheranwa, 128-Nyabanyaba, 135-Penlington, 138-Phiri and 171)-Swanepoel) used gerunds, which are verbs formed as nouns. These were *interpreting*, *journeying*, *fostering*, *developing*, *improving*, *examining*, *exploring*, *investigating,* and *creating*. How these gerunds were used, obscure the actor in the title thus losing the meaning. For example, the actor in 74-Lebethe's, 111-Mudaheranwa's, and 128- Nyabanyaba's titles was hidden. The main title in 128-Nyabanyaba (2002)-*examining examination*-does not make sense. How can the noun examination, be examined? Who is the actor? The subtitle (*the ordinary level (O level) mathematics examination in Lesotho and the impact of recent trends on Basotho students' epistemological access*) informed the reader of what was researched. It could be that the author wanted to be creative in naming the study but the result was ambiguous. Instead, the title could be reworked by removing the colon and gerund as follows: *The impact of recent trends of ordinary level (O level) mathematics examination in Lesotho on Basotho students' epistemological access*. This title is now much clearer.

The remaining four authors, 7-Bennie (1999), 87-Matthee (1998), 103-Moodley (2002) and 116-Nakajima (2002), did not nominalise the verbs into nouns. Instead, the noun *building* and adjectives *supporting*, *developing*, *intervening* were used in titular construction. The use of adjectives as nouns did not make the titles to be clear. For example, 116-Nakajima's (2002) title: *Intervening in Schools-An evaluability assessment of the secondary schools partnership project in Western Cape* - was not clear. The main title (intervening in schools) lacked both the clarity of the intervention and the person/ organisation intervening in schools. The subtitle was also not clear. It was the research questions that made sense of what the study was about:

1. What is the overall goal of the Secondary Schools Partnership Project (SSPP)?
2. Was there any programme theory applied in the course of the SSPP intervention?
3. How did each of the stakeholders groups share the policy of the project? (116- Nakajima, 2002)

However, titles not research questions are used to search database for postgraduate research. In this case, the title was not performing its function.

To this end, the linguistic devices (colon, question mark, brackets, metaphors, and gerunds) revealed that the postgraduate students use them in their titular construction in either an interesting or an unnecessary manner. The linguistic devices perform an additive function in the title. The colon was the most frequently used linguistic device showing a dominant discourse where postgraduate students mimic an academic practice of titular constructions. Contrary, Hays (2010) and Anthony (2001) argue against the use of linguistic devices such as colons, gerunds suggesting that their use make titles longer and lack clarity. Notwithstanding that linguistic devices are common in the titular construction, in the next subsection, I analysed the use of methodological stance in the titles.

6.4 RESEARCH DESIGN INDICATED IN TITULAR CONSTRUCTIONS

Oliver (2013, p.13) suggests that a title "encapsulate the nature of the thesis". With the limited number of words in titular construction, some authors chose not to indicate the research design of their study in the title. However, some authors signalled early their method of inquiry. Research design in titular construction reflects the nature of the study. In this subsection, I firstly analysed the research designs that were used in titular construction in the mathematics education theses. Subsequently, I analysed the samples and contexts of the studies mentioned in titular construction. The description of how the data was analysed for samples and contexts was discussed later in this subsection.

Using EndNote X4 to search the titles in the database for terms associated with research design, yielded only five designs. The table 6.6 below revealed the research designs as gleaned from the titles of the postgraduate theses. Thirty-one (31) theses in the database indicated the research designs in the title. *Action research*, *case study*, *ethnography, experiment,* and *evaluation* are the research designs specified in the titles of the studied corpus. The other research designs common in educational research were not mentioned in titular constructions. Consequently, the indication of the research design making the title informative was not a dominant discourse practiced for the postgraduate students. Nonetheless, it was important for the investigation as it signified the means of knowledge production by mathematics education postgraduate students (1995-2004). In addition, the use of research design in the title positioned the postgraduate thesis in the discourse community through more searchable key words.

Table 6.6 ***Research design in titular construction***

Research design	Number of theses using the research design in the titular construction	Number of theses using the same research design in text	Fraction
Case study	20	73	0.27
Evaluation	7	4	1.75
Action Research	2	5	0.4
Ethnographic	1	8	0.125
Experiment	1	46	0.02
Total	30	90	

Case study was the most indicated (20 out of 30-67%) research design in the titular construction. However, comparing each research design in titles with the same design gleaned from the research methodology chapters of the postgraduate theses indicated that the ratio of evaluation was more than that of the case study. Of the 190 theses in this study that self-reported evaluation as the design (4 in total), only two specified this design in their titles. Of the seven theses listed in Table 6.6 that mentioned evaluation in their titles, five did not actually choose evaluation as the research design for those studies. This meant evaluation was not used as a research design in titular construction. However, evaluation was used as a noun meaning analysis, assessment, or critique of the research phenomenon. In the next subsections, I focused on the structural analysis of case study, since it had substantial number of theses, and fine analysis of each research design in titular construction.

The structural analysis of the titles indicating case study in titular construction revealed that postgraduates from six institutions followed this practice (see table 6.7). These six institutions are HWU, and the postgraduate students who constructed their titles in this manner were masters students. The gender analysis of the 20 postgraduate students who constructed their titles indicating case study was evenly distributed, 10 males and 10 females. Half of these students were African (10), and the remaining were White (7) and Indian (3) respectively. The fine-grained analysis of the theses indicating case study research design in their titular construction was done in two ways: linguistic perspective and the kinds of cases.

Table 6.7 ***Theses using case study in titular construction***

Institution	Number of theses indicating case study in titular construction	Number of theses in the data base
WITS	9	54
UP	1	23
UCT	4	20
UNISA	1	19
UKZN	3	15
RU	2	7
TOTAL	20	

The fine-grained analysis of the case study research design indicated in titular construction, began with linguistic perspectives. The fine analysis of the titles indicating case study showed that 16 out of 20 are compounded. Of these 16 theses, 14 indicated the case study research design in the subtitle (or second clause). The other two theses mentioned case study in the main title. The main and sub titles of these compounded titles are either independent (subject, verb, complete thought) or dependent (subject, verb, no complete thought) clauses.

The analysis of the first set of compounded titles authored by 5-Barnes (2004) and 113-Mulcahy (1995) indicating case study in the main title, have different meanings. The title "*A developmental case study: implementing the theory of realistic mathematics education with low attainers"* (5-Barnes, 2004) is a dependent clause as it is not self-explanatory and informative. The reader understands this was "a developmental case study", of 'what' is not mentioned. The subtitle further explains the dependent clause (main title). Of interest to note was 5-Barners (2004) used non-finite academic writing prose (*implementing*) signalling confidence in the implementation strategy of "the theory of mathematics education with low attainers" that it can stand the test of time. The title "*A case study investigation of the use of a textbook in a secondary mathematics classroom: issues of regulation and control"* (113-Mulcahy, 1995) on the other hand had the independent clause in the main title. The main title had meaning and a complete thought and the reader could understand that this was a case study of the use of textbook in secondary mathematics. The subtitle was also an independent clause, which further illustrated the first independent clause (main title).

The analysis of the second set of compound titles below indicating case study in the sub title also revealed different meanings. The authors 11-Bhengu (2003), 21-Chetty (2003), 27-Davis (1995), 50-Guambe (2004), 78-Lungu (1996), 110-Msomi (1995), 131-Osei (1995) and 177-Thusi (2004) wrote more than “a case study” in the subtitle of their theses. These subtitles are dependent in that they lack a verb, subject, and a complete thought. For an example the subtitles “*A case study of three Grade 7 mathematics classes in the Durban South Region”* (11-Bhengu, 2003) and *“A case study conducted at a high school in KwaZulu-Natal”* (177-Thusi, 2004) are dependent. The subtitle informed the reader of the participants and/or the context of the study. Time, persons, or geographical area bound case studies by nature. As a result, the titles 11-Bhengu, 21-Chetty, 27-Davis, 50-Guambe, 78-Lungu, 110-Msomi, 131-Osei and 177-Thusi are more informative and expand understanding of the main title. However, the aforementioned eight titles are different, the following subtitles-40-Fakudze (1995), 103-Moodley (2002), 114-Mutemba (2001), 150-Ramsingh (1999), 159-Sebela (1997) and 162-Semeta (2004), in that only “a case study” is written in the subtitle. For an example: “*Perspectives on girls' performance in mathematics in Lesotho: A case study”* (162-Semeta, 2004). Titles 40-Fakudze, 103- Moodley, 114-Mutemba, 150-Ramsingh, 159-Sebela and 162-Semeta only indicated the research design used in the study without further explaining the main title.

Titles by 22-Ciliers (1995), 57-Horn-Botha (1996), 179-van Laren (2002) and 189-Wilson (2002) have simple clauses. These titles were supposed to have complete thought indicating the subject and verb. However, title “*A case study of mathematics teaching and learning at a rural school in KwaZulu-Natal”* 179-van Laren (2002) did not indicate the subject and for this reason, it was a dependent clause. Titles 22-Ciliers, 57-Horn-Botha, 179-van Laren and 189-Wilson have independent clauses. These are: “*Student mathematical writing, pedagogic practice and quality learning: A comparative analysis of student productions at two schools*” (22-Cilliers, 1995). “*A case study of pupils’ and teachers’ attitudes to change in the examination structure of standard 7 mathematics in a Boys only high school”* (57-Horn-Botha, 1996). Lastly, “*An action research case study of active learning through dialogue, action and structure in self-study distance education packages*” (189-Wilson, 2002). These titles follow the dominant discourse in academic writing where titles indicate the scope of research and are self-explanatory. Having discussed the indication of case study in the titular construction using linguistic perspectives, I now turn my attention to the analysis of the kinds of cases indicated in the titles.

Persons, time, and geographical location bound case studies. The fine analysis of titular construction with case study indicating persons, geographical area, schools or classes and programmes were analysed. None of the titles had time depicting the case being studied. Out of the 20 theses' titular construction indicating case study, 10 used persons as cases, seven referred to classrooms or school, two mention programmes and one on curriculum evaluation. The studies 5-Barnes (2004), 21-Chetty (2003), 22-Cilliers (1995), 40-Fakudze (1995), 50-Guambe (2004), 57-Horn-Botha (2000), 78-Lungu (1996),114-Mutemba (2001), 131-Oosthuizen (1999) and 162-Semata (2004) referred to people as the cases in titular construction. The people referred to in these titles are learners, students, teachers, girls, and INSET providers. Half of these 10 studies mentioned the geographical area where the people are located in the titles. For example, the geographical areas were: Mozambique (50-Guambe and 114-Mutemba), Katlehong (78-Lungu), Transkei (113- Oosthuizen) and Lesotho (162-Semata). The other half 5-Barnes, 21-Chetty, 40-Fakudze, 57-Horn-Botha and 22-Cilliers of the 10 theses did not mention where the people are located. Further, in title "*The influence of institutional biographies on the interpretation of inset needs and delivery on the part of primary school mathematics teachers and inset providers: a case study"* (40-Fakudze, 1995) the case was not clear. Is the case, the primary school teachers, the INSET providers or INSET?

Of the seven theses indicating classrooms, schools, or mathematics centre as the case studies in their titles, five mentioned where these are located. Titles by 113-Mulcahy (1995) and 150-Ramsingh (1999) did not however indicate the location of the classroom and mathematics centre respectively. What was exactly studied in these schools, classrooms, and mathematics centre? These titles focused on textbooks (113-Mulcahy, 1995), mathematical tasks (11-Bhengu, 2003), self-regulated learners (177-Thusi, 2004), investigative teaching and learning methods (159-Sebela, 1997), Outcomes Based Education (103-Moodley, 2002), rurality (179-van Laren, 2002) and classroom practices (150-Ramsingh, 1999). There were two titles specifying programmes, 27-Davis (1995) and 189-Wilson (2002). The programmes under investigation were the in-service mathematics education project (27-Davis, 1995) and distance education packages (189-Wilson, 2002) respectively. Under the microscope in these titles were pedagogic discourse (27-Davis, 1995) and self-study (189-Wislon, 2002). The one title (110-Msomi, 1995) focusing on the curriculum investigated its effectiveness in the pre-service mathematics teacher education. Detailed analysis of case study research design used in the corpus of theses was done in chapter 8. The next paragraphs dealt with analyses of action research methodology in titular construction.

The fine-grained analysis of titles using action research methodology in titular construction used linguistic perspectives. Titles below (13-Boshoff, 2002) and (189- Wilson, 2002) are simple clauses foregrounding the research design. For these authors, it was important that readers from the onset knew the strategy used to address the research problem effectively. This signalled the paradigmatic position of the postgraduate studies early, thus indicating how knowledge was produced.

> An action research study focused on improving the mathematical problem-solving performance of some learners in Grade 5, for a specific problem-type (13-Boshoff, 2002).
> An action research case study of active learning through dialogue, action and structure in self-study distance education packages (189-Wilson, 2002).

Action research design is committed to change, democratic and collaborative in nature (Coghlan & Brannick, 2005). So, what kind of action was conducted in the two action research studies? 13-Boshoff's (2002) title focused on "improving the mathematical problem-solving performance of some learners". By using "improving", this title was committed to changing the learner's performance in solving mathematical problem. 189-Wilson (2002) concentrated on "active learning through dialogue, action and structure". It was not stated though in the 189-Wilson's title who was engaged in the learning. In the next paragraph, I analysed the used of ethnography research design in titular construction.

Goetz and LeCompte (1984) define ethnography as an "analytic descriptions or reconstructions of intact cultural scenes and groups" (p.2). This means it was important to know what cultural scene or which groups were studied. 185-Walters' (1996) title "*An ethnographic study of a black South African High School with special reference to its mathematics classrooms*" indicated the cultural scene and group under investigation. Similar to the case study, title (185-Walters, 1996) indicated the scope and nature of research following the discourse that titles should be informative. In the next two paragraphs, I analysed the use of evaluation in titular construction.

Evaluation studies monitor the implementation and impact of a programme or an intervention (Paulsen and Dailey, 2002). According to Paulsen and Dailey, evaluation studies are either formative or summative. In addition, they suggest that evaluation studies focusing on the *implementation* ask questions about context, delivery and programme. While the evaluation studies focusing on *impact*, ask questions about performance and satisfaction. Evaluation studies were least preferred by mathematics education postgraduate students (1995-2004) with only four studies self-reporting using this research design in texts. However, in the titles, seven theses indicate evaluation in titular construction, on this basis, it may be inferred that the use of *evaluation* in the title might be a noun, meaning judging and not the research design. Nevertheless, the fine analysis of the titles of the seven theses revealed that four titles 37-Erasmus (1995), 51-Gwengo (2000), 147-Rambehari (1996) and 151-Rankwana (2003) evaluated programmes. Of these, two evaluated curriculum (51-Gwengo and 147-Rambehari). The other two focused on the computer programmes (37-Erasmus and 151-Rankwana). The titles on the evaluation of curriculum focused on the objectives and content of these curriculums. Two titles 67- Khumalo (2000) and 86-Matlou (2003) evaluated the teaching interventions. The seventh title 81-Maree (1997) evaluated the instrument for study orientation. These studies, indicating evaluation in their titles, were written by six masters and one doctoral student.

Close reading of the titles written by 51-Gwengo (2000), 67-Khumalo (2000), 81-Maree (1997), 86-Matlou (2003), and 151-Rankwana (2003) did not reveal whether the studies evaluated the *implementation* or the *impact* of the programme or intervention. Contrary, 37-Erasmus's (1995) and 147-Rambehari's (1996) titles evaluated the *impact* of the programmes. In 37-Erasmus's title the word *usefulness* and in 147-Rambehari's title, the term *efficacy* indicated the evaluation of impact of the programmes. Paulsen and Dailey (2002) alluded earlier that evaluation studies take into consideration the context, delivery, performance, and satisfaction of the stakeholders. Four titles 51-Gwengo, 67-Khumalo, 86-Matlou and 151-Rankwana indicated the context of the evaluation. 51-Gwengo's title specify Zimbabwe as the context, 67-Khumalo's and 151-Rankwana's titles indicated Grade 7 and 8 mathematics learners respectively, and 86-Matlou's title indicated Winterveldt North

Circuit high schools as the context of evaluation. When the title using evaluation research design, indicated the context, delivery, performance, and satisfaction it became informative, self-explanatory and signalled the nature of the research. This is an expected academic practice. Although the indication of the research design in titular construction was important, it was not sufficient to understand and analyse knowledge produced in the postgraduate studies. In addition, the sample and context of the study were important, and the next paragraphs analysed the samples and context of studies mentioned in titular construction beginning with samples.

The titles of the theses used in this study, captured on EndNote X4, were read individually to ascertain the samples indicated in titular construction. A search of the possible participants namely teachers/educators, learners/pupils/students, lecturers, communities, parents, principals, head of departments, subject advisors and facilitators was conducted with the 190 titles on EndNote. The participants identified in the titles were teachers/educators, lecturers, learners/pupils/students, principals, facilitators and communities. There were no titles including parents, head of departments and subject advisors in the database.

The database captured on End Note X4 was searched to determine the frequency of the participants mentioned in the titles. The structural analysis revealed that there were 59 titles indicating learners/pupils/students, 36 mentioning teachers/educators and one each denoting lecturer, principal, facilitator, and community. The fine analysis of the participants was conducted by printing the titles of each type and using different colour codes to highlight the phenomenon studied. Out of the 36 theses indicating teachers/educators in their titles, 25 focused on in-service and 11 dealt with pre-service teachers. The pre-service teachers were included in this category even though they are students because the authors did not use the word student in their titles or called them student teachers. What was under microscope in research for both types of teachers varied across the studies? For studies indicating in-service teachers in their titles, the following was studied in relation to teachers. Five theses (2-Agherdien, 2004; 40-Fakudze, 1995; 78- Lungu, 1996; 115-Naidoo, 2003 and 150-Ramsingh, 1999) studied courses and workshops provided to in-service teachers. Four theses

(21-Chetty, 2003; 22-Cilliers, 1995; 30- Deonarain, 2004 and 57-Horn-Botha, 1996) dealt with assessment practices of in-service teacher. Similarly, four theses (16-Campbell, 1999; 33-Dlamini, 1995, 66-Khechane, 1998 and 70-Kuhne, 2004) mentioned in their titles pedagogical strategies used by the teachers. These pedagogical strategies were co-operative learning strategy, learner-centred approach, instructional materials, and whole number acquisition. Two theses 1-Adler (1996) and 58- Howie (2004) each dealt with teacher knowledges. Further, two more theses 102- Monareng (2003) and 173-Temba (1998) focused on mathematical content. In particular 173-Temba (1998) focused on Grade One mathematics content while the 102-Monareng's (2003) study dealt with the quadratic function. The remaining eight theses- 154-Rowney (2002), 65-Khan (2000), 75-Long (1995), 127-Nyabanyaba (1998), 108-Mphunyane (1997), 186-Webb (2003), 89-Mdluli (2001) and 91-Mhakure (2003) indicating teachers in their titles, dealt with attraction and retention anxiety, curriculum, everyday experiences, language, nature of mathematics, teaching practices and information technology respectively.

Out of the 11 theses mentioning pre-service teachers in titular construction three focused on their mathematical content: 44-George (2001), 46-Govender (2002), and 88-McAuliffe (1999). The mathematical content studied were linear algebra, geometry, and the nature of definitions. 51-Gwengo (2000), 110-Msomi (1995) and 188-Westaway (2004) titles dealt with curriculum issues for pre-service teachers. Two theses 52-Hassan (2004) and 132-Osei (1995) studied pre-service teachers' achievement. The remaining three theses dealt with self-concepts and attitudes (106-Moyana, 1996), subject combination (4-Arigbabu, 2003) and teaching practices (80-Makara, 2004). Though there was a widespread of phenomenon studied where in-service and pre-service teachers were concerned, only three were common to both teachers' groups. These are curriculum issues, mathematical content, and teaching practices. The following paragraphs discussed the learners/pupils/students mentioned in titular construction.

Out of the 59 theses indicating learners/pupils/students in their titles, 45 focused on school going children and 14 dealt with students in higher education institutions. The mathematics education postgraduate studies indicating learners/pupils in their titles studied the following: learning strategies, teaching strategies, mathematical content, performance, assessment, language, curriculum, and anxiety among others. Ten theses indicated in their titles, learning strategies. Out of these ten, 138-Phiri (2003) and 141-Potgieter (2003) focused on cooperative learning strategy. 7-Bennie (1999) and 135-Penlington (2004) focused on solution strategies. A further two theses 13-Boshoff (2002) and 138-Phiri (2003) dealt with problem solving strategies. 72-Kwakwa (1995), 167-Sibaya (1999), 171-Swanepoel (1999), and 180-van Rooyen Barnard (2004) engaged with algebraic manipulative skills, learning difficulties, computer assisted learning and integrated learning system respectively. Six theses directed their studies in a variety teaching strategies. 23-Collins (2001), 67-Khumalo (2000), 85-Matlhaga (1995), 91-Mhakure (2003), 148-Ramnarian (1999) and 172-Tawodzera (2001) engaged in their titles with pedagogic practice, teaching volume, diagnostic and remedial programme, information technology, mathematical thinking, and mathematical misconceptions respectively.

Eight theses indicated in their titles the mathematical content the learners were doing during the investigation. Four theses (59-Ijeh, 2003; 92-Mhlanga, 2004; 114-Mutemba, 2001; and 121-Ndlovu, 2003) focused on algebra. The algebraic content covered was factorisation of quadratic functions, limit of a function and decimal fractions. Three theses (10-Bezuidenhout, 1998; 24-Cranfield, 2001 and 92-Mhlanga, 2004) dealt with geometry. Of the three only one thesis spelt out the geometry content area of quadrilaterals, in the title. The last thesis 64-Jugmohan (2004) dealt with trigonometry (sine function). Six theses (19-Cassy, 2002; 55-Hermelin, 2004; 68-Kimble, 2000; 79-Mahlomaholo, 1998, 106-Moyana, 1996; and 118-Nakin, 2003) concentrated on the performance and achievement of the learners in their titles. Performance was studied from a variety of vantage points: gender differences, influence of playing chess, culture, attitudes and creativity and divergent thinking. Five theses (50-Guambe, 2004; 140-Poni, 2000; 160- Sedibe, 1997; 164-Setati, 2002, and 166-Sibaya, 1995) dealt with language issues. The language issues varied from its use, technical terms/vocabulary, and word problems to code switching. Three theses (22-Cilliers, 1995; 57-Horn-Botha, 1996; and 128-Nyabanyaba, 2002) focused on assessment in their titles. Two theses 45-Goba (2004) and 95-Mofolo (2003) dealt with outcomes - based curriculum. 65-Khan (2000) and 176- Thijsse (2002) concentrated on the anxiety learners have when studying mathematics. One of each of the following 3-Appanna (1995), 128-Nyabanyaba (2002), 139-Pomario (1996) and 177-Thusi (2004) deliberated on mathematics subject choice, everyday experiences, extra tuition, self-regulated learners respectively. What is worth noting was that, the thesis that dealt with learners' choice of mathematics as a school subject was conducted in 1995 long before mathematics was made compulsory in South African schools in 2006.

Out of the 14 theses focusing on students in their titles, four dealt with teaching and learning strategies. 9-Berger (2002) and 63-Jordaan (2005) concentrated on appropriation of mathematics objects and misconceptions. 14-Buys (1998) and 141-Potgieter (2003) dealt with co-operative learning strategies respectively. Three theses 10-Bezuidenhout (1998), 129-Oliphant (1996) and 174-Thabane (1998) investigated how students engaged with mathematics content. The mathematics covered in these studies was differential and integral calculus, arithmetic and elementary number theory and the limit concept. A further three theses 18-Cassy (2002), 77-Louw (2003) and 83-Mashaba (1998) dealt with students' performance. The studies dealing with performance centred on gender issues, attitudes, and self-confidence. 56-Hockman (2000) and 133-Padayachee (2000) focused in their titles on the mathematics subject or course. 56-Hockman dealt with mathematics subject and pedagogy while 133-Padayachee dealt with the mathematics foundation course. The remaining two theses 8-Berger (1996) and 136-Pereira (1995) dealt with technology (graphic calculator) and assessment (mathematics competency test) respectively. The following paragraph dealt with foregrounding of principals/ lecturers/ facilitators/ communities in titular construction.

90-Mdluli (2004) investigated the principals' perception of learner performance in mathematics in OBE. 158-Scott (1996) indicated, in her thesis title, lecturers as participants. 158-Scott focused on the lecturers' belief about applicability of mathematics in technical colleges. 145-Rademeyer (1997) explored the ability of the facilitators to mediate numeracy skills. In particular, 145-Rademeyer focused on the facilitators' mathematical knowledge. Further, 145-Rademeyer's study dealt with how the facilitators' knowledge influenced their ability to facilitate numeracy level 2 skills. The last thesis 101- Molepo (1997) focused on the role of mathematics in developing rural and tribal communities in South Africa. This was an interesting study into how mathematics can assist in the development of rural communities. In the next paragraphs, the analysis of context of studies mentioned in titular construction was done.

The research contexts indicated in the titles were the levels (primary, secondary, and tertiary) and geographical location where the studies were conducted. The fine analysis of the context mentioned in the titles focused on the levels, urban/rural and geographical areas. The terms primary, secondary, tertiary, college, phase, grade, high, urban, and rural were entered on EndNote database to determine the contexts indicated in the titles of postgraduate theses. To determine the geographical area mentioned in the titles, the titles in the reference list were read individually to identify places or areas where the studies took place. The analysis began with levels, urban and rural areas, and geographical areas.

Not all authors of the theses indicated early enough in the titles where the studies were conducted. Out of the 190 theses in the database, 89 indicated the level where the studies were conducted. More than half (45-51%) of the theses where the level of study was indicated in the title were carried out at secondary schools. Of the 45 theses, 17 focused on learners, 10 concentrated on teachers and two combined teachers and learners. The remaining 16 did not indicate the participants but indicated the phenomenon studied. Out of the 89 theses indicating the level of study in their titles, 28 were conducted in primary schools. The participants signalled in the titles of studies performed in primary schools are 12 learners, 11 teachers and one principal. The remaining four theses did not indicate the participants from the primary schools in their titles. The last level where studies were conducted was tertiary. Sixteen theses indicated in their titles universities, colleges as the contextual level. Of the sixteen theses, 12 indicated students and one lecturer as the participants in the titles. The remaining three theses did not indicate the participants in their titles. The next paragraph discussed the urban and rural contexts mentioned in titular construction.

The EndNote database was searched for terms urban and rural. Out of 190 theses, only three indicated rural contexts in their titles. There were no theses indicating urban context in their titles. 101-Molepo's (1997) title focused on the role of mathematics in developing rural communities. 144-Pylman's (2001) title investigated the relationship between anxiety and cognitions of rural adolescents and its influence on mathematics achievements. 179-van Laren (2001) focused on the teaching and learning of mathematics in a rural school. The authors of the theses mentioning rural in titular construction recognised that rurality was under researched. The following paragraphs discussed the geographical areas indicated in the titles.

The geographical areas in the titles could not be searched on EndNote. As a result, the titles were individually read to ascertain the geographical area mentioned in the title. There were 40 (see table 6.8 on the next page) out of 190 titles which indicated the geographical area where the study was conducted. Of these 40 theses, 11 indicated international countries. Mozambique was the international country indicated in most titles. Five studies from Mozambique focused on cultural activities (2), difference in gender performance in mathematics (1), English second language learners (1) and understanding of the limit concept (1). Three studies were from Lesotho. These studies focused on teacher practices, examination, and girls' performance in mathematics respectively. The remaining three studies were from Nigeria, Swaziland, and Zimbabwe. These studies focused on subject combinations, teacher practices and curriculum respectively.

Table 6.8 ***Geographical areas mentioned in the titles of theses***

International areas		National areas		
Area	No. of times mentioned in the title		Area	No. of times mentioned in the title
Mozambique	5		South Africa	6
Lesotho	3	Provinces in South Africa	KwaZulu-Natal	4
Nigeria	1		North West	2
Zimbabwe	1		Limpopo	1
Swaziland	1		Gauteng	1
Total	**11**		Western Cape	1
			Northern Cape	1
		Region / Metropolitan areas	Port Elizabeth/ Nelson Mandela Metropolitan	3
			Durban	1
			Ethekwini	1
			Lebowa	1
			Transkei	1
			Mangaung	1
			Winterveldt North	1
		Townships	Katlehong	1
			Kagiso	1
			Soweto	1
			Soshanguve	1
		Total		29

Out of 40 studies, 29 indicated geographical area within the borders of South Africa. Six postgraduate theses mentioned in their titles South Africa as the country. The six studies focused on international achievement, rural and tribal communities, curriculum, teaching and learning of algebra, multilingual classrooms, and mathematics classrooms in townships. Of these studies, not all dealt with a national issue. For example, the data for the title "*Constructivism and the creative teaching and learning of algebra in South Africa*" (134-Padoa, 1995) was not the representative from South Africa. Instead, data was collected using controlled experiment from six learners at two urban schools. Ten studies conducted in South Africa mentioned the provinces in their titles. Four theses were from KwaZulu-Natal, two from North West and one from each of the provinces-Limpopo, Gauteng, Northern Cape and Western Cape. Nine theses were conducted in metropolitan areas or regions. These regions were Port Elizabeth/Nelson Mandela Metropolitan area (3), Durban/ Ethekwini region (2), Lebowa (1), Transkei (1), Mangaug (1) and Winterveldt North (1). The remaining four theses were from Kagiso, Katlehong, Soweto and Soshanguve townships. There was not much difference in the phenomenon studied at metropolitan and township level. The studies in the regions focused on assessment practices of teachers, cultural identity, teaching methods achievement, homework, integrated learning systems. The studies in the township researched teaching and learning of mathematics in township areas like Kagiso and Soshanguve. In Katlehong, the author (78-Lungu, 1996) was interested in in-service teachers' workshops. In Soweto, the author (84-Mathe, 1997) focused on attitudes and achievement. The next subsection discussed epistemological stance mentioned in titular constructions.

6.5 EPISTEMOLOGICAL STANCE

Epistemology is the relationship between the knowledge and the knower. In chapter 2, I discussed in detail how epistemology links to the understanding of the nature of knowledge. There are two major contrasting epistemic justifications: *a prior* knowledge linked to reason and *a posterior* knowledge linked to sense and experience. As a result, epistemology frames and shapes what is studied relating the ontology of the author and methodological choices made. The analysis of the epistemological stances was based on the phenomenon indicated in the titles of the postgraduate studies. There were two types of phenomenon analysed in this subsection. The first type of phenomenon was terms indicating epistemic justification-experience, perception, and attitudes. These terms experience, perception, and attitudes signalled the relationship the author has with knowledge (whether it was discovered, uncovered, or experienced) revealing the objectivity or subjectivity of knowledge. The fine analysis of epistemological stance focused on the epistemic justification through which knowledge was produced. Three terms (experience, perception, and attitude) were searched in the titles in the database representing these epistemological stances. The second type of phenomenon analysed were terms race, culture, gender and language. The South African constitution, post 1994, eradicated racial, cultural, language, and gender stereotypes from all levels of the society. Equality and equity for all citizens was promoted. As such, it was interesting to analyse whether mathematics education studies were still mentioning these terms in their titular construction. It was important to analyse the participants in titles using terms based on race, culture, language, and gender in the post-apartheid South Africa. From a discourse position, these terms "point to a meaning-creation process with ideational, relational, and identity functions" (Bengesai, Goba & Karlsson, 2011, p.263). The following paragraphs focused first on epistemic justification terms (experience, perception and attitude) and then race, culture, language, and gender respectively. Only fine analysis was done in this subsection.

Two studies 45-Goba (2004) and 127-Nyabanyaba (1998) used the term *experience* in their titles, which was associated with *a posterior* epistemic justification of knowledge. 45-Goba researched learners' experience of mathematics when OBE was introduced. Knowledge was created not from what the policies say about OBE or how teachers reasoned about it. However, the learners' experiences were investigated. 127-Nyabanyaba focused on the students' everyday experiences and how teachers use these experiences in mathematics teaching. 45-Goba's and 127-Nyabanyaba's titles signalled early in the titles the authors' paradigmatic position of the nature of knowledge as a human construction.

> Grade 8 learners' experiences of mathematics in outcome based education (45-Goba, 2004)
>
> Whither relevance? Mathematics teachers' espoused meaning(s) of 'relevance' to students' everyday experiences (127-Nyabanyaba, 1998)

Seven theses dealt with the participants' *perceptions* in titular construction. Perceptions just like experience are *a posterior*. Perception is the "quality of being aware of things through the physical senses" (Cambridge Advanced learners' dictionary, 2008, p.1054). The knowledge produced in these theses was not based on reason but belief or opinion. The participants' perceptions sought in titles 3-Appanna (1995), 65-Khan (2000), 90-Mdluli (2004), 91-Mhakure (2003), 133-Padayachee (2000), 173-Temba (1998) and 187-Wendt (1999) were learners, teachers, principals, and students. There were nine theses, which indicated in their titles the term *attitude*. Attitude is a feeling or opinion about something or someone. Knowledge produced by investigating participants' attitudes was *a posterior.* Of the nine theses, four: 18-Cassy (1997), 19-Cassy (2002), 132-Osei (1995) and 167-Sibaya (1999) focused on attitudes towards mathematics. Three theses, 68- Kimble (2000), 84-Mathe (1997) and 167-Sibaya (1999), dealt with attitudes and achievement or gender performance in mathematics. In the following paragraphs, I analysed the terms race, culture, language, and gender mentioned in titular construction respectively.

The fine-grained analysis began with participants' racial identity in titular construction. The racial categories used in South Africa prior 1994 were searched in the titles found in the EndNote database. The terms white, black/African, Indian, and coloured were searched in the titles in the database. Only two theses with the terms black (185- Walters, 1996) and African (79-Mahlomaholo, 1998) were found in the database. There were no titles indicating other racial categories. 185-Walters (1996) studied mathematics classrooms in a Black South African high school. This study was conducted by a white male using ethnographic research design. This meant he immersed himself in the field (Black high school). From the title though, one cannot discern why the author preferred the context he chose. The author explained in the abstract that he wanted to ascertain whether the conditions of teaching and learning had changed since the demise of apartheid in Black school with particular reference to mathematics education. The objectives of the study were:

1. a) To give a brief history of the school and the general community around it.
   b) To give a general description of the physical conditions at the school and of the Mathematics classrooms in particular.
   c) To give a brief overview of the inter-personal relationships between participants as these pertain to the general running of the school.
2. To describe problems faced by both learners and teachers in the school in general and in the mathematics classrooms in particular (185-Walters, 1996).

79-Mahlomaholo's (1998) title focused on the African cultural identity, individual African identity, and performance in mathematics. The author (79-Mahlomaholo, 1998) of this study was an African male and it was conducted in African schools. The use of the word *signification* in the title, foregrounds the author's preoccupation with the meaning and significance of the African identity and its influence on mathematics performance. 79-Mahlomaholo (1998) did not view the African ethnicity or race from a deficiency perspective. Instead, he set out to prove the following hypotheses:

High performing pupils, unlike low performers,

(i) were more able to see the purpose of being and recognising that they were African hence more sensitive to the challenges that faced them in South Africa,

(ii) were more aware that doing well in mathematics was one way of responding to those challenges by empowering themselves and their people,

(iii) had a relatively positive and higher self-concept,

(iv) were more in charge of themselves and their actions and thus more committed to improving their situation and that of themselves and their actions and thus more committed to improving their situation and that of their people by way of responding to the abovementioned challenges of being African in South Africa,

(v) were more focused on what they wanted to achieve to the extent that negative descriptions of their abilities (in as far as the study of mathematics in particular were concerned) generated by neo-apartheid/colonial discourse, did not distract them easily (79-Mahlomaholo, 1998).

The two titles (185-Walters, 1996) and (79-Mahlomaholo, 1998) revealed the social discourse in the post-apartheid South Africa. These titles also revealed the discursive constructions relating knowledge to socio-political discourse. 185-Walters's thesis was published in 1996, two years after the demise of apartheid in South Africa. During this time, 185-Walters wanted to ascertain whether there were changes in Black mathematics classroom. On the other hand, 79-Mahlomaholo's thesis was published four years after the apartheid era, however, he saw the need to research the identity of the African learners and how it related to mathematics performance. The following paragraphs dealt with the cultural issues related to participants mentioned in the titles.

The term culture was searched in the titles captured on EndNote database and six theses were found. The fine analysis of the studies using the discursive limits culture, revealed that there are two kinds of studies: one on monoculture and on multicultural issues. 79-Mahlomaholo's (1998) title was discussed in the previous subsection and no further analysis needed to be done. 20-Cherinda (2002) investigated the use of cultural activity (twill weaving) in the teaching and learning of mathematics. 20-Cherinda's title indicated a mathematical discourse where knowledge was not only from abstract symbols and numbers but also from our everyday surroundings. 166-Sibaya's (1995) title highlighted language problems of "culturally different pupils". Is there a dominant culture in South Africa, in which learners do not experience problems with mathematics vocabulary? In fact, the study was about black learners as the author mentioned in the abstract ("*This study examined the effects of second language in the learning of mathematics by black pupils*"). 166-Sibaya (1995) preferred not to use the term 'black' in the title but kept it in the body of the thesis. Most likely, 166-Sibaya started with the research before the new era in South Africa and had to change when the thesis was published in 1995. The term black was no longer popular in South Africa, as it had racial connotations, and culture became the substitute category for race.

The second set of titles 42-Fourie (1997), 68-Kimble (2000) and 126-Nkotoe (1996) focused on multicultural mathematics education. 126-Nkotoe (1996), who is an African, dealt with prejudice (discrimination/ narrow-mindedness/ prejudgement) reduction within a multicultural mathematics education. She specifically asked the questions: “How can racial mathematical stereotypes and multicultural education in the post-apartheid dispensation be reduced or totally eradicated”? On the contrary, 42-Fourie (1997) and 68-Kimble (2000) are white and focused on the attitudes and achievement, and accommodation of all cultures respectively. Post 1994, in South Africa the schools were no longer divided along racial lines hence there was an influx of African children in historically white schools formerly known as ‘model C’. Thus 42-Fourie (1997) in particular, addressed the inherent teaching problems of integrated learners from different cultures. In the abstract, she stressed, “the importance of a multicultural curriculum for communities with a multiracial ethnic and diverse constitution cannot be overemphasized in a modern approach to education”. Clearly, 42-Fourie (1997) wrote from a concerned position that teaching methods needs to vary and accommodate the cultural backgrounds for all learners. From 166-Sibaya’s (1995) and 42-Fourie’s (1997) titles naturally one can observe who the author was, thus determining what kind of knowledge was produced. The next paragraphs focused on the language issues related to the participants.

The terms language, speak, write and vocabulary were searched on the EndNote database. Nine theses were found on the database. Seven of these studies, 38-Erasmus (2002), 50-Guambe (2004), 108-Mphunyane (1997), 140-Poni (2000), 143-Prins (1995), 160-Sedibe (2003) and 164-Setati (1996) concentrated on English Second Language (ESL) learners. One thesis 165-Setati (2002) dealt with language practices in multilingual classrooms. The ninth thesis 166-Sibaya (1995) focused on culture and language. The phenomenon studied in the titles focusing on ESL varied from remedial strategy, language use, and teachers’ beliefs about language, jargon and technical terms, readability of examination questions, word problems to code switching. The title “*The development of a remedial strategy in Mathematics for Tswana-speaking learners*” (38-Erasmus, 2002) was proposed by a white male starting from a premise that Tswana-speaking learners (African/Black) have problems in mathematics. This study was framed as a “development of a remedial strategy” that could assist the Tswana-speaking learners to succeed in mathematics. Despite the study (38-Erasmus) published in 2002, eight years into the post-apartheid era, but it still used the political discourse that was dominant during the apartheid years, which is black learners have problems with learning mathematics. The next paragraph dealt with gender issues related to participants in titular construction.

The fine analysis of the description of participants based on gender indicated five out of six theses (18-Cassy, 1997; 19-Cassy, 2002, 25-Cronje, 1995; 57-Horn-Botha, 1996; & 162-Semata, 2004) focused on the difference in gender performance in mathematics. Gender performance was a dominant discourse in mathematics education, which had reached a saturation point. 39-Essack's (2002) title, "*Trends in participation, performance and career choice, among girls who are successful in mathematics*" on the other hand, paid attention to the promotion of girls who were successful in school mathematics. The next subsection dealt with the indication of results in titular construction of mathematics education theses (1995-2004).

6.6 INDICATION OF RESULTS IN THE TITLES OF POSTGRADUATE STUDIES

Jalilifar (2010) alludes to the terms *effect*, *impact*, *role*, and *relationship* as indicating the results of the study in titular constructions. The titles on EndNote database were searched for the terms *effect*, *impact*, *role,* and *relationship*. A limited number of theses (see table 6.9) in the database indicated the results of the study in their titles. The indication of results in the title makes it to be informative. The fine analysis of the titular constructions follows.

Table 6.9 ***Indication of results of the study in titular constructions***

Terms signalling the results of the study	**Number of theses**
Effect/Effective/Effectiveness	12
Impact	7
Role	4
Relationship	4

The fine analysis focused on the terms *effect*/*effective*/*effectiveness* indicating results in titular construction. The term *effect* denoting the results of the study in the titular construction signified efficacy and effectiveness. This term influenced the study's unit of analysis with variables measured. EndNote database search-of the term *effect* yielded three terms *effect, effective* and *effectiveness*. The fine analysis began with the term *effect* and proceeded to the other two terms *effective* and *effectiveness*. The fine analysis was two pronged: linguistic and methodological. Linguistic analysis revealed there were two prepositions that were used with the term *effect*-of and on. Six theses (19-Cassy, 2002; 55-Hermelin, 2004; 59-Ijeh, 2003; 98-Mokoena, 1998; 131-Oosthuizen, 1999 & 176-Thijsse, 2002) used *effect of* in their titles. Whereas 72-Kwakwa (1995) and 139-Pomario (1996) had *effect on* in their titles.

The fine analysis of the use of terms *effect of* and *effect on* in titular construction signalled active and passive voice respectively. A sentence is in active voice when “the subject is the person or thing which performs the stated action” (Cambridge Advanced Learners Dictionary, 2008, p.15). In other words, the subject comes before the action in active voice. A sentence is in passive voice when “the grammatical subject is the person or thing which experiences the effect of an action, rather than the person or thing which causes the effect” (Cambridge Advanced Learners Dictionary, 2008, p.1039). This means the action is before the subject. In the next paragraphs, I analysed the term *effect of* as mentioned in the titles of postgraduate studies.

The fine analysis of the term *effect of* indicated that the term was firstly written at the beginning of the title (see titles-19-Cassy, 2002; 55-Hermelin, 2004; 59-Ijeh, 2003; 98-Mokoena, 1998; 131-Oosthuizen, 1999 & 176-Thijsse, 2002). Secondly, the linguistic analysis of titular construction revealed the use of passive voice. The action came before the subject. Table 6.10 spelt out the actions and subjects of the six titles using the term *effect of*. 55-Hermelin’s (2004) title indicated ‘playing chess’ as the action done by the subjects/participants (primary school learners) on the object ‘mathematics achievement’. Similarly, 59-Ijeh’s (2003) title specified ‘scaling’ as the action performed by the subject ‘Grade 9 learners’ influencing the object ‘understanding of algebraic graphs’. The forgoing analysis applied to titles 19-Cassy (2002), 131-Oosthuizen (1999) and 176-Thijsse (2002) as well. However, though 98-Mokoena’s (1998) title was written in a passive voice, the subject was not mentioned. It was not clear who was instructing himself or herself. Was it the learners, teachers, or students? The titles are shown in table 6.10 on the next page.

Table 6.10 ***Identification of subject, action and objects in titles of postgraduate studies using effect of***

Title	Action	Subject	Object
19	Classroom interaction and gender	Secondary pupils	performance and attitudes towards Mathematics
55	Playing chess	Primary school learners	Mathematics achievement
59	Scaling	Grade 9 learners	Understanding of algebraic graphs
98	Self-instructional lesson		Mathematics
131	After school mathematics tuition	Standard 9 pupils	Mathematics ability
176	Structured teaching method	Grade 8 learners	Mathematics anxiety and achievement

> **Effect of** classroom interaction and gender on mathematics performance and attitudes toward mathematics of secondary pupils in Mozambique (19-Cassy, 2002).
>
> The **effect of** playing chess on the mathematics achievement of primary school learners in two schools in KZN (55-Hermeling, 2004).
>
> The **effect of** scaling in the understanding of algebraic graphs for grade 9 (Form B) learners (59-Ijeh, 2003).
>
> The **effect of** the self-instructional lesson in mathematics (98-Mokoena, 1998)
>
> The **effect of** after school mathematics tuition on standard 9 pupils' mathematics ability (131-Oosthuizen, 1999).
>
> The **effects of** structured teaching method on mathematics anxiety and achievement of grade eight learners (176-Thijsse, 2002).

Third, the term *effect of* signalled the research design that were used in the studies. Similarly, to the analytical tool of active and passive voice, the term *effect of* pointed to the dependent and independent variables measured in the postgraduate studies. Some relationships were determined between variables measured in the studies. In comparison to the fine analysis of 55-Hermeling's (2004) and 59-Ijeh (2003) titles done in the previous paragraph, 55-Hermeling's title indicated 'playing chess' as the independent variable and 'mathematics achievement' as the dependent variable (see table 6.11). The variable 'Playing chess' was analysed to see whether it has influence on the variable 'mathematics achievement'. All the other variables such as study time, learner background, parental involvement, extra tuition, which could influence achievement, were controlled. Similarly, in 59-Ijeh's title the independent variable (scaling) caused change in the dependent variable (understanding of algebraic graphs). The identification of variables measured signalled early in the title how the results of the postgraduate studies were achieved. Without reading the theses, the reader can discern that quantitative methodologies were used in these postgraduate studies. Further reading of the EndNote database, checking the methodologies that were employed in these six studies, indicated that quasi-experimental or experimental methodologies were used. This confirmed what the reader can perceive from the titles, that results were reached using quantitative research approaches. In the next paragraph, I focused on the analysis of the use of the term *effect on* in the titular construction.

Table 6.11 ***Identification of independent and dependent variable in titles of postgraduate studies***

Title	Independent variable	Dependent variable
19	Classroom interaction and gender	Performance and attitudes towards Mathematics
55	Playing chess	Mathematics achievement
59	Scaling	Understanding of algebraic graphs
98	Self-instructional lesson	Mathematics
131	After school mathematics tuition	Mathematics ability
176	Structured teaching method	Mathematics anxiety and achievement

The fine analysis of the second term *effect on* indicated first; the term was used in the middle of the title for example 72-Kwakwa's (1995) and 139-Pomario's (1996) titles. Second, these titles were written in both active and passive voice. To be precise, the subject comes before the action. 72-Kwakwa's (1995) title began with the subject (pupil) whose action, (algebraic manipulative skill) influenced the object (performance in mathematics), which was active. Contrary, in 139-Pomario's (1996) title, subject (Grade 8 learners) comes after the action (mathematical thinking). Rendering the subject in 139- Pomario's title to receive the action and hence passive. 139-Pomario's title can be reconstructed as *Grade 8 learners' mathematical thinking and its effects on problem solving performance.* Notwithstanding that, the passive voice is not grammatically incorrect, however; it makes the sentence wordy. The use of active voice makes the title to be concise and clearer. The title becomes lexical dense and follows the academic writing style.

> Pupil algebraic manipulative skill and its **effects on** performance in calculus (72-Kwakwa, 1995).
>
> An investigation of the processes of mathematical thinking of Grade 8 learners and its **effects on** problem-solving performance (139-Ramnarain, 1999).

Third, the term *effect on* communicates the research design utilized in the studies. In comparison to the analytical tool used in the previous paragraph, the term *effect on* pointed to the dependent and independent variables measured in the postgraduate studies. 72-Kwakwa's (1995) title indicated the independent variable (manipulative skill) causing a change in the dependent variable (performance). In the same way, 139-Pomario's (1996) title had the independent variable (mathematical thinking) influencing the dependent variable (problem solving performance). Naturally, when reading 72-Kwakwa's and 139-Pomario's titles, the reader anticipates the results were derived using quantitative research approaches. Closer reading of the data captured on EndNote revealed that 72-Kwakwa's and 139-Pomario's studies used pre and post-test designs to measure the relationship between the variables. The fine-grained analysis proceeded to examine both "effective" and "effectiveness," starting with "effective.".

17-Carr's (2002) and 89-Oosthuizen's (1999) titles used the adjective effective to describe the noun. Effective is described as "successful or achieving the results that you want" (Cambridge Advanced Learners Dictionary, 2008, p.449). 17-Carr's title was compounded using colon and the question mark. Effective, was written in the subtitle. In this subtitle, *effective* described the action of the subject (web) on the object (mathematics teaching). Thus, 17-Carr's title was written in active voice. As one might expect, *effective* in 17-Carr's title, signalled the thesis as an evaluation study. This was confirmed by the research design gleaned from the body of the thesis, captured on EndNote. 17-Carr's study used pre and post-tests. The fine analysis of 89-Oosthuizen (1999) title showed it was constructed using the passive voice. The action (use) was stated before the subject (spreadsheets) that was acted upon the object (learning of mathematics). Likewise, the reader can get a hint from the title that 89-Oosthuizen's thesis was an evaluation study. This was confirmed by the statistical analytical tools used in 89-Oosthuizen's study.

> Information, knowledge and learning: Is the web **effective** as a medium for mathematics teaching? (17-Carr, 2002).
>
> **Die gebruik van sigblaaie om die effektiewe leer van wiskunde te bevorder**. (89-Oosthuizen, 1999)/The use of spreadsheets to promote **effective** learning of mathematics (translated title).

The fine analysis proceeded to effectiveness.

110-Msomi's (1995) and 148-Ramnarain's (1999) titles used the noun *effectiveness* in titular construction. Both titles (110-Msomi, 1995 & 148-Ramnarain, 1999) were compounded. In 110-Msomi's title the term effectiveness was stated at the end of the subtitle. Here is 110-Msomi's title: "*The pre-service preparation of secondary school mathematics teachers - A case study of curriculum* ***effectiveness***". This title was constructed in the passive voice. The action (preparation) came before the subject (school mathematics teachers). In comparison, the term effectiveness in 148-Ramnarian's (1996) title was written in passive voice , as noted on the title: "*The* ***effectiveness*** *of NGO- Sponsored INSET on the classroom practices of primary school mathematics educators: A case study of MCPT*". Similar to 110-Msomi's, 148-Ramnarain's title was written in the passive voice. The action (classroom practice) came before the subject (school mathematics educators). A contrary observation from the analysis of the terms *effect of/on* and *effective* was made, when titular construction using *effectiveness* employed case studies. These case studies are qualitative in nature. In particular, the research design used in 110-Msomi's and 148-Ramnarain's studies, captured on EndNote database was qualitative in nature and used thematic analysis. I now turn my attention to the term *impact.*

The term *impact* signifies something having an influence on another thing. *Impact* denotes the results of the study in the titular construction. The search on EndNote database resulted in seven mathematics education postgraduate theses, which used *impact* in construction of their titles. The fine analysis of the theses with *impact* in their titular construction followed linguistics and methodological consideration. Linguistic analysis revealed two prepositions used with the term *impact*-of and on. Six theses (77-Louw, 2003; 78-Lungu, 1996; 88-McAuliffe, 1999; 128-Nyabanyaba, 2002; 145-Rademeyer, 1997 & 180-van Rooyen Barnard, 2004) used *impact of* in their titles. Whereas, 154-Rowney's (2002) title had *impact on* in the titular construction. Similarly, to the linguistic analysis on *effect* of and on, the terms *impact of* and *impact on* were constructed using active and passive voice. The linguistic analysis of titular construction using *impact of* indicated the use of passive voice. Whatever the impact of measured (action), came before the subject and the object. Table 6.12 (on the next page) listed the actions and subjects of the six titles using the term *impact of*. 77-Louw's (2003) title signified tutorials as influencing the object (mathematics performance) of the subjects/participants (first year students). Similarly, the forgoing analysis applied to-88-McAuliffe's (1999), 145-Rademeyer's (1997) and 180-van Rooyen's (2004) titles, where the action came before the subject and object. On the contrary, even though 128-Nyabanyaba's (2002) title was written in a passive voice, it was compounded. The action, subject and object are found in the subtitle. 128-Nyabanyaba's main title "examining examination" had no meaning and the subject was not mentioned. It was only when I read the subtitle, I got the idea about the focus of the study, the O level mathematics in Lesotho. Further reading of the title, I got the idea that the 'recent trends' (action) influenced the 'epistemological access' (object) of the Basotho students (subject). 78-Lungu's (1996) title could not be classified whether it was written in the passive voice, because the title was compounded. However, it did not have the action, and was not stated what the in-service workshops impacted on. Was it the teaching or teacher knowledges? The following paragraph discussed the analysis of the research design in titles with *impact of*.

Table 6.12 ***Identification of subject, action and object in titles of postgraduate studies using impact of***

Title	Action	Subject	Object
77	Tutorials	First year students	Mathematics performance
78	In-service workshops	School teachers	
88	Geometry course	Pre-service teachers	Understanding of geometry
128	Recent trends	Basotho students	Epistemological access
145	Mathematics expertise	Facilitators	Mediate level 2 numeracy skills
180	Use of an integrated learning system	Grade 12 learners	Mathematics SG paper 2 marks

The term *impact of* written in the postgraduate studies titles signalled the research design. Similarly, to the analytical tool of active and passive voice, the term *impact of* pointed to the dependent and independent variables measured in the postgraduate studies. Table 6.13 outlined the dependent and independent variables gleaned from the titles. Comparing the fine analysis of 77-Louw's (2003) title written in the previous paragraph, tutorials (independent variable) are said to influence the mathematics performance (dependent variable). All the other variables such as attitude, study time, parental involvement, diet, which could influence achievement, were controlled. In the same way, 77-Louw's (2003) 88-McAuliffe's (1999), 128-Nyabanyaba's (2002), 145-Rademeyer's (1997) and 180-van Rooyen Barnard's (2004) titles identified variables measured early in the title, thus signalling how the results of the studies were achieved. In fact, without reading the theses, the reader can discern that quantitative methodologies were used in these studies. This was corroborated by the methodology (quantitative methodologies) that was captured on EndNote database for the aforementioned theses, with the exception of one thesis. This verifies what the reader can observe from the titles, that the results were reached using quantitative research approaches. However, 145-Rademeyer's thesis used grounded theory, and using grounded theory in a study seeking to measure impact is not a common discourse in academia. In the next paragraph, I focused on the analysis of the use of the term *impact on* in the titular construction.

Table 6.13 ***Identification of dependent and independent variables in titular construction with impact of***

Title	Independent variable	Dependent variable
77	Tutorials	Mathematics performance
78	In-service workshops	
88	Geometry course	Understanding of geometry
128	Recent trends (O level mathematics examination	Epistemological access (Basotho students)
145	Mathematics expertise	Mediate level 2 numeracy skills
180	Use of an integrated learning system	Mathematics SG paper 2 marks

The fine analysis of the second term *impact on* was based on linguistic and methodological analysis. One thesis, 154-Rowney (2002), indicated the term *impact on* in its titular construction. 154-Rowney's title was "*Factors that impact on the attraction and retention of Science and Mathematics teachers in public secondary schools in Gauteng"*. In the title, the subject (Science and Mathematics teachers) whose action (attraction and retention) was influenced by the object (factors) was active. The use of impact in the title signalled the reader that quantitative research approaches were used in the study. Reading the EndNote database for the actual research approach used in the 154-Rowney's thesis confirmed the discernment of the approach. The next paragraph focused on the titles using the term *relationship*.

The fine analysis of the titles using the term *relationship* signifying the results of the study, indicated that one of the four studies used qualitative research approach. Relationships were determined in causality research designs where association between independent and dependent variables was established. These relationships were established using statistical analysis. 171-Swanepoel's (1999) title used the term relationship differently than the titles in 68-Kimble (2000), 109-Mpofana (1996) and 144-Pylman (2001) studies. In 68-Kimble's, 109-Mpofana's and 144-Pylman's titles, the variables measured were indicated as: attitudes and achievement, teaching methods and achievement, and anxiety and cognitions respectively. However, in 171-Swanepoel's title the term relationship referred to the linkages of computer programme with subjects like mathematics and English, rather than the causal relationship between variables. The following paragraphs dealt with the *role* indicated in titular construction.

The term *role* means "the position or purpose that someone or something has in a situation, organization, society or relationship" (Cambridge Advanced Learners' Dictionary, 2008). Searching EndNote database yielded four titles- 8-Berger (1996), 101- Molepo (1997), 108-Mphunyane (1997) and 112-Mudaly (2004) using the term *role* in their titular construction. What indication of results can be discerned from the title using the term *role*? A fine analysis of the four titles considered whose or what *role* was played in a situation. Titles of three studies, 8-Berger, 101-Molepo and 112-Mudaly, determined the roles of graphical calculator (tool), mathematics (subject area) and sketchpad (program) respectively. 8-Beger's title determined the purpose of the graphical calculator on mediating zones of proximal development. 101-Molepo's title identified the purpose of mathematics in developing rural and tribal communities. 112-Mudaly's title examined the function of sketchpad as a modelling tool. Whereas, 108-Mphunyane's title was different to the other three titles, the role that is determined in 108-Mphunyane's title was not of an object but of participants (teachers).

Titles using the term *role* signalled for a reader that qualitative research approach was used in the study. It was expected that the "purpose that someone or something has in a situation" (Cambridge Advanced Learners' Dictionary, 2008) could be determined from in-depth research through interviews and observation. Notwithstanding this, the searching of EndNote database for the research approach revealed three titles, 8-Berger, 101-Molepo and 112-Mudaly using quantitative research approach to arrive at the results of their study. To this end, the titles were informative indicating the results of the study, however, they were not pursuing the common discourse in educational research. 108-Mphunyane's (1997) title used qualitative research approaches gathering data with opinionnaires, observation and in-depth interviews.

> The **role** of the graphical calculator as a mediating sign in the zones of proximal development of students studying a first-year university mathematical course (8-Berger, 1996)
>
> The **role** of mathematics in developing rural and tribal communities in South Africa (101-Molepo, 1997)
>
> Teaching mathematics in ESL classrooms: A study of mathematics teachers' beliefs about language and mathematics teachers' **roles**. (108-Mphunyane, 1997)
>
> The **role** and use of sketchpad as a modelling tool in secondary schools. (Mudaly, 2004)

6.7 SUMMARY OF EMERGING THEMES FROM THE ANALYSIS OF TITULAR CONSTRUCTION

In this chapter, I set out to answer the first sub question of critical research question 1: How were the titles named and framed in mathematics education postgraduate studies (1995-2004)? Overall, the mathematics postgraduate students named and framed their research titles using linguistic devices, research design, epistemological stance, and indication of the results. Colon, question mark, quote mark, brackets, metaphors, and gerunds were the linguistic devices that were used to name the research titles. The colon was the most preferred linguistic device. These linguistic devices attracted the reader to read the thesis. Sometimes they were used interestingly or unnecessarily in titular construction. Linguistic devices also play an additive function, compounding the title.

The analysis of the use of research design in titular construction revealed that case study was commonly mentioned in the titles with evaluation being the least preferred design. Action research, ethnography, and exploration were also used in titular construction. The indication of the research design made the title to be informative, signalling the scope and nature of research of the theses. The analysis of the research design in titular construction focused on linguistics perspectives, participants, and context indicated in the postgraduate studies. This discursive practice of indicating the research design was common amongst the masters mathematics education postgraduate students. In addition, the mentioning of participants and context of studies in titular construction was analysed, and the findings suggest that the inclusion of these elements enhances the clarity and comprehensibility of the research topic, facilitating better understanding and interpretation of the study's objectives and outcomes.

The study analysed two epistemological stances: epistemic justification of knowledge and the consideration of racial, cultural, language, and gender issues. Regarding the epistemic justification, only a few theses favoured it in titular construction, with just one thesis indicating *a prior* justification of knowledge. Those employing epistemic justification tended to prioritize the subjective experiences, perceptions, and attitudes of participants, suggesting *a posterior* nature of knowledge. Meanwhile, the exploration of racial, cultural, language, and gender issues varied in perspective, focusing on understanding, promotion, or identification of deficiencies. While epistemic justification was less common in titular construction, it favoured subjective experiences and attitudes. Conversely, the treatment of racial, cultural, language, and gender issues encompassed diverse perspectives. The authors' identities influenced how race or culture was addressed, whether emphasizing understanding, promotion, or identifying deficiencies. Notably, in one instance, "culture" replaced "black," reflecting the evolving socio-political discourse in South Africa towards inclusivity, often obscuring specific racial references under broader cultural and linguistic terms.

The last determinant of the discourse position indicated in titular constructions was the analysis of the terms signalling the results of the study. A limited number of postgraduate theses indicated the results of their study in titular constructions. These postgraduate theses preferred terms like *effect*, *impact*, *role,* and *relationship*. The results were arrived at using linguistics and research methodological analytical tools. The linguistic analysis of titles indicating results, revealed that most titles using effect and impact were written in passive voice. The methodological analysis of titles indicating results showed more titles using quantitative research approaches. When the terms effect, impact, role, and relationship were used in the titular construction, they signalled early influence of the independent variable on the dependent variable. Nevertheless, the titles introduced the postgraduate theses in the discourse communities. However, the titles alone cannot reveal the nature of mathematics education knowledge produced in the postgraduate studies. An analysis of the research phenomena, questions and claims was imperative discussed in Chapter 7.

CHAPTER 7

RESEARCH PHENOMENA, QUESTIONS AND CLAIMS SIGNALING KNOWLEDGE GENERATED FROM MATHEMATICS EDUCATION THESES (1995-2004)

7.1 INTRODUCTION

The previous chapter dealt with titles of the mathematics education postgraduate theses published in South African Universities from 1995 to 2004 as the entry point to the thesis. The next step in analysing the knowledge produced by mathematics education postgraduate students (1995-2004) concentrated on research phenomena, questions, and claims. In some postgraduate studies, there were no research questions but rather hypotheses or aims and objectives. Therefore, for the sake of analysis, research questions included research aims, objectives and hypotheses. Not much research has been conducted on the nature of mathematics education knowledge using research phenomena, questions, and claims. The indicated knowledge deemed important by students and their supervisors in mathematics education postgraduate research in the period 1995-2004. Research claims sum up what we know about phenomena studied by mathematics education postgraduate students (1995-2004) in the South African context. Therefore, analysis of the research phenomena, questions, aims, objectives, hypotheses and claims in a corpus of theses, pointed to knowledge prioritized during the period 1995-2004 in South Africa. The previously mentioned were analysed together in this chapter as it provided data on what was studied and what was found in the corpus of theses (1995-2004).

Fawcett and Downs (1986) argue that theory related to the phenomenon being researched is central in the type of research questions that are posed in studies. That is, depending on the level of theory development for a phenomenon, studies will pose either descriptive, relational, or explanatory research questions, which also represented research questions and the nature of research (Fawcett & Downs, 1986). These types of research questions lead to descriptive, relational and explanatory research respectively. It is important to point out that these three types of research questions were not mutually exclusive i.e. there might be some blurred boundaries between them. Descriptive research questions are exploratory in nature and are phrased as; what is…? These types of questions are meant to describe and classify the parts of a research phenomenon. Relational research questions seek to explain the relationship between parts of the phenomenon. Relational questions are phrased as, "to what extent is…". Explanatory research questions are linked to experimental research, explaining why there are changes in a phenomenon studied (Fawcett & Downs, 1986). The three types of research questions (descriptive, relational, and explanatory) are associated with descriptive, correlational, and experimental research designs (Fawcett & Downs, 1986), and the relationship between questions and designs were analysed in chapter 8. Further, the type of research questions central in generating theory in the corpus of mathematics education postgraduate theses (1995-2004) were analysed in chapter 9. Therefore, this chapter addressed the second and third sub research questions of the main research question:

> 1.2 Which phenomena were more frequently explored, and which were less likely to be investigated within these postgraduate studies (1995-2004)?
>
> 1.3 What were the predominant research questions, and what assertions were made concerning these phenomena?

Once the research phenomena were determined, a meta-critical synthesis MIRS of corresponding research questions/ aims/ objectives/ hypotheses and claims was done. In addition, the participants, contexts, and education levels that were selected in the mathematics education postgraduate studies (1995-2004) researching the identified phenomena above were recognised. The identity of the students who researched the phenomena identified in questions 1.2 and 1.3 above were discussed. Lastly the higher education institutions, where theses researching the phenomena identified above, were noted.

7.2 RESEARCH PHENOMENA AND QUESTIONS

The section discusses the categorisation of the phenomena from the corpus of theses data. How were the research phenomena categorized from the corpus of theses data? First, if the information about the author's intentions or focus of the study was unclear in the abstracts, I then searched for the information in chapters one and the methodology of the studies. Research phenomena were captured on a table according to the thesis number, degree, institution, and the entire abstract or research questions/aims/objectives/hypotheses. Thereafter keywords indicating the phenomenon/phenomena studied in a thesis was identified from the abstract. Subsequently a shorter version of the table showing the direct quotation from the corpus of theses indicating what was studied was created. Initially one keyword signalling the phenomenon studied per thesis was captured. This proved problematic since theses sometimes focused on more than one phenomenon. Hence, up to three phenomena studied in a thesis were included as data. To illustrate this point, in a thesis numbered 18 (Cassy, 1997) a master's research at Wits University: "the purpose of this study was to explore possible gender differences in performance and attitudes towards mathematics among 1996 BUSCEP students" (18-Cassy, 1997). The three keywords gender, performance and attitudes were taken as the research phenomena studied in this thesis (see table 7.1 for example of the coded data and appendix D for the entire data).

In addition, the mathematics content researched per thesis, participants, and contexts of research sites were captured together with the research phenomena (see appendix D). The purpose of including the aforementioned was to draw links between what was studied in a thesis and other aspects such as contexts and participants. Thus, further clarifying what knowledge was produced in the mathematics education postgraduate studies in South Africa (1995-2004). The resultant keywords of research phenomena were captured on EndNote and SPSS databases. Keywords signalling similar research phenomena as indicated in the studies were grouped into categories (see table 7.2). Seminal authors in the literature guided the grouping of the keywords into categories. The actual keywords associated with each category (see appendix E) are discussed later in this chapter. Furthermore, all the research questions posed in the studies were put on a table in a word document and the type of the questions was identified. In the next paragraphs I analyzed the research phenomena.

Thirteen categories were summarized from the keywords (see table 7.2). These categories in table 7.2 were related to one another as they were associated with teaching

Table 7.1 ***Example of coded research phenomena from corpus of postgraduate mathematics education theses (see appendix D for the entire coded data)***

No/ Degree/ HEI	Research phenomena quoted verbatim from studies	Key words (KW) of phenomenon studied			Mathematics Content	Cat	Participants	Edu level	Location
		KW 1	KW2	KW 3					
1 D Wits	"This is a study of secondary mathematics teachers' knowledge of the dynamics of learning and teaching mathematics classrooms in South Africa. It probes teachers' articulated and tacit knowledge …[of] teachers drawn from three different multilingual school contexts".	Knowledge	Language			2 7	Teachers	Secondary Grs 8-12	Urban/ township
2 M UCT	"This study focused on Foundation Phase teachers' pedagogical and content knowledge. It investigated the impact that a geometry course (Shape and Space), had on the teachers levels of understanding of shape and space".	Knowledge	PCK	Geometry course	Shape and space	2 10	Teachers	FP Grs 1-3	Urban
3 M UNISA	"The aim of this study was to gain insights into pupil's perceptions of mathematics".	Perception				2	Learners	Secondary Gr 12	Urban
4 D UNISA	"This study examined pre-service mathematics teachers' examination performance over a period of three years".	Performance				3	Students	Tertiary 3rd year	Internation al
5 M UP	"The research document in this report had a twofold purpose. Firstly, it was to design and implement an intervention based on the theory of Realistic Mathematics Education (RME) aimed at improving the mathematical understanding of learners …a second purpose was to investigate the viability and emerging characteristics of an intervention based on the theory of RME in such a setting (i.e. with low attainers to revisit key number concepts)".	Realistic Mathematics Education	Understandin g		Place value, fractions & decimals	2	Learners	Secondary Gr 8	Urban
6 M UJ	"The research conducted for the purpose of this study clearly showed that outcomes-based education (OBE) potentially offers a remedy for this country's ineffective education system"	Outcomes Based Education				9	Documents/ Literature	Combined Grs 1-12	Urban & rural
7 M UCT	"This study explores the notion of 'spatial ability" from the perspective of mathematics education".	'Spatial ability'			Space and shape	2	Teachers Learners	I F Grs 5-6	Urban

and learning mathematics. For example, pedagogy is understood in the literature as "any conscious activity by one person designed to enhance learning in another" (Watkins & Mortimore, 1999, p.3). Pedagogy is the relationship "between its elements: the teacher, the classroom or other context, content, the view of learning and learning about learning" (Watkins & Mortimore, 1999, p.8). However, pedagogy categorized as a research phenomenon in this study, does not include 'syllabus', 'curriculum', technology, content, and context. For the purpose of this study, all keywords related to learning activities, mathematics skills, learning perspectives and teaching perspectives were categorized as pedagogy. All keywords related to knowledge, reasoning, understanding and theory of knowledge were grouped into cognition, epistemologies & knowledge research phenomenon. The third category, assessment combined all keywords that linked to attainment or success of learners in some mathematical activity, test, or examination. Keywords related to educational technology and resources such as computers, computer software, worksheets and materials facilitating learning were grouped together. Keywords associated with feelings towards mathematics as a subject were grouped into affective domain research phenomenon. These are words like attitudes, anxiety, emotions, beliefs, and perception. In addition, keywords associated with gender, cultural games, ethnicity, rural tribes, and race were clustered into socio-cultural and political research phenomena. Moreover, keywords connected to language, in-service and pre-service teacher education, curriculum policy development and implementation, leadership, adult basic education and attrition rate were clustered into respective categories of research phenomena (see appendix E).

Table 7.2 Categories of research phenomena and the number of theses which dealt with mathematics content

Category number	Category coding	Number of theses	Number of theses with math content
1	Pedagogy	77	24
2	Cognition, epistemologies & knowledge	63	37
3	Assessment	53	9
4	Technology & resources	38	14
5	Affective domain	35	4
6	Socio-cultural political perspective	17	
7	Language	15	
8	In-service Education & Training (INSET)	12	
9	Curriculum policy & development	12	
10	Pre-service Education & Training (PRESET)	6	
11	Leadership	2	
12	ABET	1	
13	Attrition rate	1	

The phenomena that were studied in mathematics education postgraduate studies (1995-2004) are as follows: Which phenomena were more frequently explored, and which were less likely to be investigated within these postgraduate studies (1995-2004)? Knowledge related to pedagogy (77), cognition, epistemologies & knowledge (63), assessment (53), technology & resources (38) and affective domain (35) were researched the most in the postgraduate studies. There were paucities in knowledge about socio- cultural political perspective (17), languages (15), INSET (12) in mathematics education, curriculum policy, development, and implementation (12), and PRESET (6). Research on attrition rates (1) of learners taking up mathematics, leadership (2) and ABET (1) was low in the data. There was a dearth of research that focused on types of mathematics students (e.g. gifted students), history of mathematics education and rurality in postgraduate mathematics education. Worth noting was that only the first five categories with more theses involved mathematics content in producing knowledge. Before an in-depth analysis (MIRS) of the research phenomena, questions, and claims, I present the global analysis of the research questions posed in the corpus of studies.

The research questions/hypotheses/objectives were captured from 187 out of 190 studies. The photocopied parts of the three studies were missing the research questions/hypotheses, as a result the questions from these studies could not be included as part of the data. The attempts to find these three theses failed despite searching online for the electronic versions from their respective institutions. Also, the universities were reluctant to release hard copies of theses through inter-loan library. The majority of the studies (64) posed a single research question, while most studies phrased from two to five research questions (see table 7.3). Twenty studies posed either six or more up to 10 research questions.

Most studies posed descriptive (117), followed by relational (66) and then explanatory (35) research questions. In some studies, more than one type of research questions were presented, as twenty-two (22) studies posed descriptive and relational research questions. Five studies set descriptive and explanatory research questions, and four studies phrased a combination of relational and explanatory research questions. Half (32 out of 64) of the single research questions posed in the studies were descriptive. The other single questions in the studies were relational (22) and explanatory (10).

Table 7.3 ***Number of research questions posed per study***

Number of research questions posed per study	Number of studies
1	64
2	25
3	28
4	37
5	13
6	8
7	3
8	6
9	2
10	1

The descriptive research questions posed in the studies were naming and classifying the characteristics of the research phenomenon investigated. Typical descriptive research questions posed in the studies were: “How do mathematics teachers in a primary school learn about co-operative learning in their classrooms” (16-Campbell, 1999)? “What do teachers understand by the term ‘learner-centred’” (66-Khechane, 1998)? The descriptive research questions were posed mainly by female (75) than male (45) students. Equal number of African (49) and White (49) students posed descriptive research questions, followed by Indian (15), and then Coloured (4). Most of the students who posed descriptive research questions were registered for masters (95) than doctoral (22) degrees. The majority of students who posed descriptive research questions were from Wits (35) and the others from UCT (14), UJ (13), UKZN (12), UP (12), UNISA (9), RU (6), NMMU (5), NWU (5), SU (4), UF (1) and UWC (1).

Relational (66) research questions investigated the relationship between the parts of the phenomenon. Example of relational research questions in the database were: “Is there any relationship between the students' attitudes toward and achievement in mathematics in the Soweto senior secondary schools” (84-Mathe, 1997)? “To what extent does the teaching/learning environment contribute to mathematics anxiety” (65-Khan, 2000)? There were mostly masters (47) than doctoral (19) students who used this kind of question in their studies. Relational research questions were posed by almost the same number of male

(33) and female (32) students, and one unknown gendered student. More White students (35) posed relational research questions than African (21), Indian (9) and Coloured (1). These were mainly masters (47) than doctoral (19) students. Most of these students were from Wits and dominantly used this question, followed by UJ and UP, and NWU students used least of this question. (15) than from UKZN (7), UP (7), UNISA (5), UJ (4), SU (4), NMMU (3), UCT (1) and NWU (1).

Explanatory (35) research questions attempted to predict the cause of the relationship between the dimensions of the phenomenon. Explanatory research questions are framed after the relationship between dimensions of a phenomenon has been established. The example of such questions from the data base were: “Is there any significant difference between the average mathematics self-concepts of prospective mathematics teachers before and after the intervention programme” (107-Moyana, 2000)? “Why do students, after having successfully completed matric mathematics, find it difficult to adapt to first year post matric level mathematics (N4) at a technical college” (136-Pereira, 1995)? Slightly more male (19) than female (16) students posed explanatory research questions. While the same number of African (16) and White (16) students posed explanatory research questions, the remaining students were Indian (1), Coloured (1) and other (1). These students were mainly registered for masters (24) than doctoral (11) degrees. These students were from UNISA (6), Wits (6), UCT (5), SU (5), UP (4), UJ (2), NMMU (2), UKZN (1), RU (1), TUT (1), UWC (1) and UNIZULU (1). Generally, more descriptive research questions were posed in the studies researching the 13 phenomena that were identified in the database. The number of descriptive research questions posed per research phenomenon were followed by relational and explanatory research questions (see table 7.4). In the next subsection I analyzed the five most researched phenomena- pedagogy; cognition, epistemologies & knowledge; assessment; technology & resources and affective domain.

Table 7.4 ***Research phenomena and the three types of research questions***

Research phenomenon	Total	Descriptive questions	Relational questions	Explanatory questions
Pedagogy	77	44	29	16
Cognition, epistemologies & knowledges	63	43	22	11
Assessment	53	43	22	11
Technology & resources	38	26	15	7
Affective domain	35	14	15	9
Socio-cultural political perspective	17	11	6	5
Language	15	11	3	3
INSET	12	11	1	0
Curriculum policy & development	12	10	1	1
PRESET	6	4	1	2
Leadership	2	2	0	0
ABET	1	0	1	0
Attrition rate	1	1	0	0

7.3 MIRS OF RESEARCH PHENOMENA AND QUESTIONS IN MATHEMATICS EDUCATION THESES (1995-2004)

The MIRS of five research phenomena including the related research questions and claims was done. The analysis first dealt with keywords from the postgraduate studies categorised into the five research phenomena. Secondly, how the categorized research phenomena related to the mathematics content, participants, education level and context was analysed. Thirdly, who researched the five research phenomena and from which institutions, was further analysed to understand knowledge produced in mathematics education postgraduate studies (1995-2004). Lastly, a methodologically inclusive research syntheses for each research phenomenon together with related research questions and claims was done.

7.3.1 Pedagogy

Generally, pedagogical issues were mostly researched in the mathematics education postgraduate studies (1995-2004) in South Africa. From the analysis, 77theses focused on mathematics pedagogical issues. The keywords that specified mathematics pedagogical research phenomena were divided into four subcategories: teaching approaches, learning approaches, activities during the lessons and mathematics skills (see table 7.5). Several postgraduate studies focused on teaching (48) and learning approaches (22), and then activities (11), and least mathematics skills (4). The activities that were researched in the postgraduate studies included application tasks, appropriation of mathematical objects, cooperative task, extra tuition, mediation, tutorials, and homework. Mathematics skills researched in the postgraduate studies were algebraic manipulative skills, logic, modelling, solution strategies and whole number acquisition. The latter two subcategories (activities and skills) had few theses to warranty a MIR synthesis. The remaining paragraphs of pedagogy research phenomenon were a MIR synthesis of teaching and learning perspectives.

Table 7.5 *Subcategories of pedagogy research phenomenon*

Subcategory	**Keywords depicting pedagogy research phenomenon**
Teaching approaches	Absolutist & Constructivists Pedagogies; Algo-heuristic; Classroom practices; Cognitive mapping ; Constructivist methods; Grounded teaching; Guided programme; Strategic teaching and learning; Hour-glass model; Teaching strategy; Contextual teaching; van Hiele levels; Facilitation & mediation; Teaching styles; Regulation & control; Problem solving; Process-based instruction; Reflection technique; Pedagogic Content Knowledge; Pedagogic discourse ; Teacher practices; Teaching problems; Regulating principles; Diagnostic & remedial approach; Inclusive classroom; Self-instructional lesson; Methods; Mathematical investigations
Learning approaches	Cooperative learning; Early learning; Learner-centred approach; Lesson strategy; learning problems; Learning difficulties; Teacher learning; Small groups; Study orientation questionnaire; Combined subjects; Participation; Child care; Reflective technique
Activities	Application tasks; Appropriation of mathematical objects; Cooperative task; Extra tuition; Mediation; Tutorials; Homework
Skills	Algebraic manipulative skills; Logic; Modelling; Whole number acquisition; Solution strategies

A wide range of teaching approaches from the broader education field, such as constructivism, inclusive classroom, grounded teaching, problem solving, and cognitive mapping were investigated in the postgraduate studies. Some teaching approaches that dominated were researched in the studies located within mathematics education field e.g. van Hiele’s levels of geometric thinking levels. Additionally, the teaching perspective- hour-glass model, was investigated in one thesis (161-Sekao, 2004). Moreover, pedagogic discourse linked to Bernstein, was researched in two studies (27-Davids, 1995; 142-Press,

1999) from UCT. Out of the 48 theses researching teaching approaches, 14 focused on problem solving as a teaching approach. Problem based learning theory was discussed later in chapter 9. Problem based learning theory included problem solving and problem centred teaching approaches. Further, eight theses researched teaching styles. The remaining teaching approaches researched in the postgraduate theses were sporadic and did not warranty meta-synthesis. Later in this section a MIR synthesis of problem-solving keyword, research questions and claims were done. The next section presents the analysis of the participants in the studies that focused on teaching approaches, and the locations where these studied were conducted.

Learners (35[18]) and teachers (26) were sampled in the postgraduate studies researching teaching approaches than the students (4), lecturers (1) and documents (3). In accordance with the aforementioned, more participants were from secondary schools (29), followed by primary (12), and tertiary institutions (4). Most of these schools were in the urban[19] areas (23) than from townships,[20] rural, national, and international contexts (see table 7.6). This signalled that postgraduate students were interested in learners and teachers in secondary schools that were situated in urban areas when researching teaching approaches.

The identity of mathematics education postgraduate students researching teaching approaches, along with the institutions involved, is detailed. An almost equal number of female and male mathematics postgraduate students displayed interest in teaching approaches. Among the 48 theses focusing on teaching approaches, 25 were authored by females and 23 by males. Moreover, empirical data in Chapter 5 (referencing Table 5.4 on page 120) revealed the demographics of mathematics education theses, with contributions from White (91), African (76), Indian (17), and Coloured (5) postgraduate students. This

---

[18] Thirty-five represents the number of theses using learners as participants. But not the number of learners per individual study.
[19] Urban areas in South Africa encompass densely populated regions with diverse economic opportunities, better infrastructure, and access to services.
[20] Townships, historically designated for non-white residents during apartheid, are characterized by informal housing, limited economic prospects, and inadequate infrastructure, often facing socioeconomic challenges

Table 7.6 Distribution of pedagogy research phenomenon according to degree, participants, education level and location

	Degree			Participants					Education-level						Location						
Subcategories	Masters	Doctorate	Children out of school	Learners	Students	Teachers	Lecturer	Documents	Primary	Secondary	Combined	Tertiary	Service Provider	Children out of school	Township	Urban	National	Rural	International	Combined urban & rural	Total per subcategory
Activities	8	3		6	3	5				5		3			3	5			2	1	**11**
Learning perspectives	15	7	1	14	2	11	1	2	4	13	1	3	1	1	5	12			2	2	**22**
Skills	2	2		1		2		1	1	2		1			1	1		1		1	**4**
Teaching perspectives	41	7		35	4	26	1	3	12	29	2	4	1		9	23	1	6	4	5	**48**
Total	**70**	**19**	**1**	**61**	**9**	**44**	**2**	**6**	**18**	**47**	**3**	**11**	**2**		**19**	**41**	**1**	**7**	**8**	**9**	

demographic distribution was mirrored in studies focusing on teaching approaches, with 24 theses authored by White students, 21 by African students, 2 by Indian students, and 1 by a Coloured student among the 48 analyzed. These postgraduate students hailed from 13 out of the 14 higher education institutions included in the study's dataset. Notably, Wits (12), UJ (8), UCT (6), and UNISA (5) showcased more postgraduate studies on teaching approaches compared to the remaining institutions, which had between one and three each. Notably, no theses from UNIZULU investigated teaching approaches. At this juncture, I conducted an analysis of the research questions, problem-solving claims, and keywords related to teaching approaches, as previously discussed.

There were fourteen postgraduate theses that dealt with problem solving as a teaching strategy. In one thesis (189-Wilson, 2002) problem solving was a subsidiary phenomenon studied. “This study investigate[d] the terms, dialogue, structure, and active learning in open distance learning texts in a constructivist and problem solving approach” (189- Wilson, 2002, own addition). However, it was not clear from the four research questions how problem solving was linked with the open distance learning texts:

> *How should we change the manner in which students learn so that they become active participants in their learning experiences? How should this change in learning design change the self-study materials to enable learners to become active learners? How should these changes in learning design change the course design process? How would these changes in learning design affect the distance education institute to accommodate new course development?* (189- Wilson, 2002).

Further, the research claim from this study- “course design and development should be based on the Post Fordist notion in the constructivist paradigm” (189-Wilson, 2002)-did not include problem solving.

In the analysis of the 13 studies, the synthesis of research questions in the realm of problem solving emerged as predominantly descriptive. Specifically, nine of these studies framed their inquiries with descriptive questions. Among these, one study initiated with a descriptive research question, which then transitioned to explanatory inquiries. Conversely, three studies investigating problem-solving phenomena within pedagogical contexts formulated relational research questions. Notably, within this subset, one study introduced a relational question before delving into explanatory aspects. Moreover, three additional studies concentrated on problem-solving phenomena through the lens of explanatory research questions. Consequently, the collective knowledge generated on problem solving primarily revolved around the identification and categorization of its defining characteristics.

In the preceding paragraph, the 13 studies under review addressed various facets of problem solving across different domains, including pedagogy (4), mathematical processes (4), understanding/thinking (3), curriculum (1), and technology (1). Among these, four theses were particularly noteworthy for their exploration of problem solving within pedagogical contexts. These theses encompassed topics such as group work, mediation, 'problem-centered mathematics teaching,' and the 'cooperative learning teaching method.' Drawing from the insights gleaned from postgraduate studies on pedagogical matters and their intersection with problem solving, I contend that mediation and cooperative learning methodologies significantly enhance learners' proficiency in solving mathematical problems as shown in the two studies below:

> Teachers should use the interactive method to teach problem solving as well as mathematical content. Problem solving is the overall umbrella under which meaningful mathematical knowledge construction occurs (13- Boshoff, 2002).
>
> The results shows that with mediation there is an improvement in the pupils' problem solving abilities (32-Dirks, 1996).

In contrast to the positive impact observed with mediation and cooperative learning, postgraduate studies have yielded mixed results regarding the efficacy of group work and 'problem-centered mathematics teaching' in enhancing learners' problem-solving abilities. Despite group work falling under the umbrella of cooperative learning, divergent conclusions were drawn by two studies regarding its effectiveness (13-Boshoff, 2002; 183-Viljoen, 1995). 183-Viljoen (1995) noted that while a group approach heightened pupils' meta-cognitive awareness, further meta-cognitive training was necessary for them to excel as problem solvers. Additionally, 183-Viljoen's (1995) study on problem-centered teaching underscored the importance of a constructivist approach in equipping teachers to effectively implement problem-centered methodologies. The findings suggest that junior primary teachers harbored negative perceptions of problem-centered mathematics teaching primary due to inadequate preparation for the constructivist approach (183-Viljoen, 1995).

Four theses delved into the intersection of problem solving and mathematical processes, with three of them framing their inquiries around descriptive research questions aimed at understanding learners' strategies in mathematical problem-solving scenarios. For instance, 120-Ndhambi (2002) explored how Grade 2 learners tackled addition word problems with known basic facts, while 135-Penlington (2004) sought to identify and analyze solution strategies employed by Grade 7 learners in various mathematical tasks. Similarly, 138-Phiri (2003) investigated the approaches utilized by learners to solve problems involving algebraic expressions and equations within contextual settings. These studies collectively revealed a predominant reliance on procedural understanding rather than conceptual comprehension among learners when tackling mathematical challenges. They underscored the necessity for deeper conceptual understanding to effectively navigate mathematical problem-solving tasks. This assertion finds support in the observations of 135-Penlington (2004), who noted that learners predominantly leaned on procedural understanding, often neglecting conceptual grasp and failing to integrate standard algorithms with underlying concepts. Likewise, 138-Phiri (2003) highlighted that learners' struggles stemmed from misconceptions distorting the task demands, suggesting a need for enhanced conceptual clarity to overcome such challenges.

The other study focused on student learning process in a problem solving-based approach. 111-Mudaheranwa (2002) stated explanatory research question was; “Is it possible to design an innovative mathematics teaching and an active learning environment, which will promote students’ learning process through a problem solving-based approach in algebra?” (111-Mudaheranwa, 2002). However, the empirical evidence from 111-Mudaheranwa suggested that students’ results of pre and post tests were low. Nonetheless “students’ way of thinking…observed through the variety and originality of their strategies, their systematic work and their perseverance in solving algebra problems” (111-Mudaheranwa, 2002) was improved.

Three studies within the pedagogy research domain examined the efficacy of a problem-centered approach in fostering understanding and critical thinking among students. These studies framed their research questions with a relational and explanatory focus. For instance, 44-George (2001) queried whether an emphasis on the problem- centered approach could enhance students' comprehension of systems of linear equations. Similarly, 24-Cranfield (2001) sought to unravel the underlying reasons behind learners' struggles with learning geometry. Of the three studies, only one indicated a positive impact of the problem-centered approach on students' mathematical understanding. 24-Cranfield (2001), on the other hand, asserted that a significant proportion of students lacked the proficiency in problem solving. In contrast, 118-Nakin (2003) observed evidence of divergent thinking in geometrical problem solving, where learners employed cognitive processes such as conjecturing, experimenting, comparing, applying, and critical thinking. This suggests that learners relying solely on traditional methods may encounter difficulties in problem solving. In the subsequent paragraphs, we delve into the second subcategory of pedagogy research, focusing on learning perspectives.

The postgraduate studies examined various learning perspectives, encompassing areas such as cooperative learning, early learning, learner-centered approaches, lesson strategies, learning problems and difficulties, teacher learning, study orientation questionnaires, participation, and reflective techniques. Notably, these investigations extended beyond student learning to encompass the professional development of teachers as well. Two theses (15-Cameron, 2003; 47-Graven, 2002) delved into the realm of teacher learning, while five studies centered on learners' mathematical development. These inquiries explored diverse dimensions of mathematics learning, ranging from the cultivation of creative and strategic learning methods to the integration of technology, such as computers, to enhance learning outcomes. Additionally, four studies concentrated on the implementation of cooperative learning strategies, while three studies delved into learners' challenges and difficulties in mathematics. Further, other learning strategies, including reflection techniques, study orientation questionnaires, learner-centered approaches, participation, and early learning, were each investigated in individual thesis. The subsequent section provides an analysis of the study participants and the geographic locations where these investigations were conducted.

Similar to teaching approaches, studies on learning approaches sampled mostly learners (14) and teachers (11). These participants were mainly from secondary schools (13) situated in urban (12) and township (6) areas (see table 7.6 on page 187). Mostly it was masters (15) than doctoral (7) students who were interested in the learning of mathematics. Although the number of postgraduate students that were interested in the learning of mathematics was 12 for female and 10 for males, most were White (16) postgraduate students that focused on this phenomenon. The remaining were one Indian and five African postgraduate students. Postgraduate students focusing on learning approaches were only from eight HWUs: Wits (5), NWU (4), UJ (4), NMMU (3), UP (3), RU (1), UCT (1) and UKZN (1). I now turn my attention to the MIR synthesis of research questions and claims for cooperative learning and learning problems.

The above paragraph focused on the identity of the mathematics education postgraduate students who researched the five research phenomena and the corresponding findings and the MIR synthesis of research questions and claims for cooperative learning and learning problems are discussed. MIR synthesis of research questions posed in the postgraduate studies researching cooperative learning showed that more relational research questions were posed in the studies than descriptive and explanatory. That is, these studies produced knowledge on how cooperative learning related to other characteristics of the phenomenon. The MIR synthesis of the research questions on cooperative learning was two pronged in the studies. On one hand, postgraduate studies focused on teachers' understanding of cooperative learning, and the other hand, postgraduate studies concentrated on the influence cooperative learning has on learners' performance. For example, for the former, "How do mathematics teachers in a primary school learn about cooperative learning in their classrooms" (16-Campbell, 1999)? "What level of understanding do the respondents have to OBE and cooperative learning (184-Volschenk, 2004)? These studies claim that a conducive learning environment will assist teachers with cooperative learning. Further, teacher training was important to assist teachers with cooperative learning implementation. For the latter, 141-Potgieter (2003) enquired, "Does the implementation of a cooperative learning strategy influence the mathematics test results of pre-Technician students"? "How can the application of Hour-glass model of cooperative learning be used to enhance the mathematics academic achievement of grade 8 learners, especially in the context of crowded classes" (161-Sekao, 2004)? Evidence from the postgraduate studies suggested that the cooperative learning strategy improved learners' performance in mathematics. This was substantiated by results from these studies, "Students can optimally perform in a cooperative learning environment" (141-Potgieter, 2003). Further results stated, "The groups that received the treatment… achieved higher scores of practical significance in mathematics academic achievement test than the groups that did not receive the treatment" (161-Sekao, 2004). For 161-Sekao, cooperative learning assisted teachers cope with teaching large class sizes. "The teachers who applied the Hour- glass model revealed that they coped easier with crowded mathematics classes when using cooperative small groups" (161-Sekao, 2004).

> *Ingrained teacher beliefs and concomitant practices seem immutable. However, enabling learning and teaching environment may catalyse and sustain meaningful change in teacher pedagogy* (16-Campbell, 1999).
>
> *The implementation of…co-operative learning is seen as complex and cannot be applied haphazardly in the math class. Staff should be well trained in facilitating learning in order to ensure that learners will progress satisfactorily and to ensure the success of implementing the teaching approaches* (184-Volschenk, 2004).

In the next section I analyse the second research phenomena: knowledge, cognition and epistemologies.

7.3.2 Cognition, epistemologies and knowledge

The research phenomena cognition, epistemologies and knowledge dealt with the types of knowledge, the nature of mathematics knowledge and understanding of knowledge (episteme). The two sub-categories (cognition and knowledge and epistemologies) were grouped together as they relate to knowledge. Cognition is associated with mental abilities, thinking, reasoning, intuition, understanding and conceptualization of mathematical knowledge. Epistemology is the study of how knowledge is acquired. Thus, studies researching construction of school mathematics, everyday knowledge, the nature of mathematics and definitions, pedagogical content knowledge, proof, realistic mathematics education, relevance, solution to problems and views of mathematics were grouped under knowledge and epistemology. Most postgraduate studies researched cognition (43), followed by knowledge and epistemologies (20) (see table 7.7.)

Male students (28) researched cognition more than their counter parts, females (15) , and almost the same number of White (18) and African (17) students researched cognition. The remaining students who researched cognition were seven Indians and one Coloured. The majority of the students who researched cognition as a phenomenon were masters (40). These students were from nine HWUs, and Wits had more students and UNIZULU only had one, as represented here: Wits (12), UNISA (6), SU (6), UCT (5), UKZN (4), UJ (3), UP (3), NMMU (2) and RU (1) including one from UNIZULU. The participants who were selected in the studies on cognition were mostly learners (30) and teachers (11) from secondary (22) schools in urban areas (22)(see Table 7.8.).

Table 7.7 Knowledge, cognition and epistemologies research phenomena

Subcategories	**Keywords coded as knowledge, cognition and epistemologies**	**Number of theses**
Cognition	Ability; Acquiring; Cognitive; Cognition; Competencies; Conceptualization; Conceptual understanding; Concept development; Construction; Errors; Intelligence; Intuitive; Misconceptions; Special abilities; Thinking; Understanding; Visualization, Visual disability; Spatial ability; Metacognitive strategies;	43
Knowledge & Epistemologies	Construction of school mathematics; Everyday; Everyday knowledge; Mathematics Knowledge; Mathematics meaning; Nature of mathematics; Nature of definitions; Pedagogical Content Knowledge; Proof; Realistic; Realistic Mathematics Education; Relevance; Solution to problems; Views of mathematics	20

The research questions posed in the postgraduate studies focusing on cognition phenomenon (understanding, thinking, mathematical abilities, meta-cognition and misconceptions) were more descriptive in nature than relational and explanatory. The postgraduate students were more interested in naming and classifying what is involved in understanding and thinking mathematically. Thus, less knowledge was produced on predicting what impact there was on mathematical understanding and thinking. The research questions posed in the studies on cognition were two pronged. First, most research questions dealt with learners'/ students' cognition of mathematics concepts. Largely these studies researched understanding of geometry concepts with a few focusing on algebra and trigonometry concepts. Mainly the research questions posed in these studies enquired

Table 7.8 Distribution of knowledge, cognition & epistemologies research phenomenon according to degree, participants, education level and location

Knowledge, cognition & epistemologies																					
	Degree		**Participants**						**Education level**					**Location**							
Keywords	**Masters**	**Doctorate**	**Learners**	**Students**	**Teachers**	**Lecturers**	**Documents**	**Out-of-school youths**	**Primary**	**Secondary**	**Combined**	**Tertiary**	**Post sec**	**Township**	**Urban**	**Suburban**	**Rural**	**National**	**International**	**Combined urban & rural**	**Total No of degree per keyword**
Cognition	40	3	30	9	11	2		1	11	22	1	9		6	22	2	3		7	3	**43**
Epistemologies	16	4	9	3	12	1	1		4	9	2	3	1	5	8	2	1		2	2	**20**
Total	**56**	**7**	**39**	**12**	**23**	**3**	**1**	**1**	**15**	**31**	**3**	**12**	**1**	**11**	**30**	**4**	**4**		**9**	**5**	

whether learners’ mathematical understanding was improved by using certain strategies or technologies. For example, below are questions presented in these studies:

> Do students in general achieve the desired level of understanding? (12-Bezuidenhout, 1998)
> How do students understand the idea of a limit? (63-Jordaan, 2005)
> To what extent does the students' understanding of the nature of definitions change while involved in a process of formulating definitions within a Sketchpad context? (46-Govender, 2002)
> What conceptions do learners have about area? (92-Mhlanga, 2004)
> How do some Form C students in Lesotho conceptualize fractions? (97-Mokapi, 2001)
> The culturally different pupils understand the meaning of words found in their textbooks. (166-Sibaya, 1995)
> What possible misconceptions for Grade 7 learners from a sample of 14 formerly DET primary classrooms in predominantly black townships near Cape Town display in a test on decimals, percentages and measurement? (172-Tawodzera, 2001).

Empirical evidence from the studies above was either favourable or unfavourable towards development of learners’ understanding of mathematics concepts. Positive results towards the development of learners’ understanding were evident if, in the studies, strategies like modelling, scaling, and curve-fitting and technology (Sketchpad, logo and spreadsheets) were used. This was demonstrated in the claims that were made in the studies, for example, below are results on understanding :

> The results indicate that the curve-fitting tasks may indeed be useful in promoting construction of the gradient concept (28-de Witt, 1998).
> After engaging the prospective mathematics teachers in a process of defining within a dynamic geometry context, it was found that the students' understanding of the nature of definitions had been enhanced considerably and that they had become more competent in evaluating definitions (46-Govender, 2002).
> The results proved that scaling has influence on the understanding of algebraic linear graphs at grade 9 (Form B). Learners will find it easy to construct, interpret and make prediction from a graph drawn by scaling (59-Ijeh, 2003).
> Logo and a spreadsheet facilitate learning in an interactive computer environment, enabling pupils to use variables in different ways, systematically leading up to generalisations (119-Nairainsamy, 1998).

However, negative results towards development of learner understanding were evident in other studies. The authors of the studies argue that language, conceptual understanding, cultural meaning, and extra tuition amongst other things impeded learner understanding of mathematics concepts. 41-Feza (2004) argued that “The use of everyday language and learners' limited experience in geometry is depicted in the learners' difficulty in using and understanding technical definitions of shapes". In addition, 63-Jordaan (2005) contends:

> The outstanding observation was that students see a limit as unreachable. This could be due to the language used in many textbooks to describe limits for example 'tends to' and 'approaches'. These words are verbs or action words and as Monaghan (1991:23) describes, the action in this mathematical setting is 'getting to a limit' sets up a dynamic interpretation of a limit (pp. 67-68).

Moreover, 166-Sibaya (1995) asserted, it is not only the language but their cultural meaning that inhibited learner understanding of mathematics concepts. 166-Sibaya (1995) captures the claims of learner understanding in her thesis as follows:

> The present study revealed that standard nine and ten pupils have problems in defining concepts that are found in their mathematics text books. They also fail to associate a concept with a description. The causes for these problems are varied. It may be due to language that it is restricted to the classroom situation or the methods used in teaching new concepts are to culturally different pupils (166-Sibaya, 1995).

24-Cranfield (2001), 73-Lampen (2001), 97-Mokapi (2001), 129-Oliphant (1996) and 138-Phiri (2003) in their studies argued that learners had low understanding of mathematics concepts. "The overall findings of the study revealed that at least 75% of the students had low levels of understanding geometry" (24-Cranfield, 2001). This trend is still reported in the Department of Basic Education National mathematics assessment of South African learners (DBE, 2022).

Second, four studies posed research questions dealing with teachers' understanding of how children learn mathematics or their conception of a teaching strategy. "How do teachers understand the ways in which children learn number?" (70-Kühne, 2004). "Can a geometry course shift pre-service teacher's levels of understanding?" (88-Mc Auliffe, 1999). "What is junior primary teachers' conception of problem centred mathematics teaching?" (152-Roos, 1996). These studies reached similar conclusions that teachers have low levels of understanding mathematics and how children learn mathematics. "The study… revealed that there are serious gaps in the mathematics content knowledge of primary school teachers" (94-Mnisi, 1996). 152-Roos' (1996) study showed "that junior primary teachers in this group have negative conception of problem-centred mathematics teaching". 88-McAuliffe's (1999) "overall findings of… [her] study revealed that the majority of students/ [pre-service teachers] had low levels of understanding of geometry before and after the course". The subsequent paragraphs discussed the studies that researched knowledge and theory of knowledge.

Twenty studies researched mathematics knowledge and epistemology, and four were from the doctoral research and 16 were from the masters students that researched knowledge and epistemology. Eight of these students were males and twelve were females. More White students (10) undertook research on knowledge and epistemology than African (8), Indian (1) and Coloured (1) students. Students from fewer HEIs researched this phenomenon- Wits (11), UCT (4), UKZN (1), NMMU (1), UP (1), UNISA (1) and SU (1). Similar to cognition phenomenon, these studies sampled learners and teachers more than other participants. Most participants were from secondary schools in urban areas (see Table 7.8 on page 186).

The research questions that were prioritized in the knowledge and epistemology research phenomena were descriptive research questions more than relational and explanatory questions. In addition, research questions about teachers' knowledge of their practice, types of knowledge for practice, their mathematics content and children's mathematics knowledge were prioritized. Examples of such research questions are: "What is teachers' knowledge of their practices in this complex multidimensional dynamic?" (1-Adler, 1996). "What aspects of subject matter knowledge, pedagogical content knowledge and curricular knowledge are drawn on by mathematics classes in South Africa?" (58-Howie, 2004). "How do teachers understand the ways in which children learn number?" (70-Kühne, 2004). Additionally, questions about the knowledge learners brought to school were posed in the studies. For instance, "What background mathematical knowledge and beliefs do learners bring to school?" (156-Sambo, 2003). Research questions related to epistemology were focusing on philosophy, views, and nature of mathematics knowledge. Such questions were: "Is it viable to apply the theory of Realistic Mathematics Education in such a setting? (i.e. with low attainers to revisit concepts they had previously learnt)" (5-Barnes, 2004). "What is the impact of the trends on Basotho students' epistemological access to the O level mathematics examination? (128-Nyabanyaba, 2002). "Are the various philosophical schools of thought have an impact on the formalization of proof?" (181-Van Staden, 1999).

Research claims on teachers' knowledge about their mathematics content showed low levels of understanding even after being exposed in a mathematics course, as noted in the following findings "Majority of the teachers had low levels of understanding of geometry…before the course. These levels were still low after the course even though there has been an improvement in some of the items" (2-Agherdien, 2004). Teachers understand that teaching needs to be sequenced from abstract to concrete to improve teaching (70-Kühne, 2004). Further, teachers' knowledge about learners' misconceptions assist teachers prepare lessons suited to counter act the errors (96-Mohlala, 1996). Research findings on the use of 'everyday' knowledge in mathematics activities had varying implications, positive and negative results. From the positive results, "Emerging are understandings that relating the learning of mathematics to students' everyday experiences… induce positive associations for students" (127-Nyabanyaba, 1998). In addition, 5-Barnes (2004) argues "it is viable to apply the theory of Realistic Mathematics Education with low attaining Grade 8 learners in order to visit the key number concepts of place value, fractions and decimals." The negative results from 49-Grinker (1998), 128- Nyabanyaba (2002), 156-Sambo (2003) and 181-Van Staden (1999) show learners' socio- economic background, cultural practices, their understanding of logic and sound instrumental mathematics hinder positive results of epistemological access to mathematics.

> …unless [learners] had a sound instrumental understanding of related concepts, ethno-mathematical methods did not improve their mathematical performance (49-Grinker, 1998, own addition).
>
> Evidence presented in this study reveals that schools reflect different socio-economic backgrounds of students. The backgrounds explain why some students do better in the context of widespread poor performance and the prevalent avoidance or selecting out of some 'realistic' questions. Some students select out 'realistic' questions in such a way that the 'realistic' questions do not frustrate 'confuse' them as they do other students (128-Nyabanyaba, 2002).
>
> …there were some learners who did not see any mathematics in cultural practices initially, but the situation changed as the learners were exposed to teaching based on cultural practices (156-Sambo, 2003).
>
> The conclusion which is reached, gives evidence that pupils' and students' background in logic is completely lacking and inadequate. As a result, they cannot cope adequately with argumentation and this causes poor perception of what Mathematics exactly entails (181- Van Staden, 1999).

7.3.3 Assessment

"Assessment is a continuous planned process of identifying, gathering, and interpreting information regarding the performance of learners using various forms of assessment"

(DBE, 2010, p.223). In this thesis, assessment is used in broad terms to include processes and outcomes. From the data, four subcategories of assessment were developed: types, methods, outcomes, and practices (see Table 7.9). Most of the postgraduate studies (44) dealt with assessment outcomes i.e. what were the achievements, attainment, or performance of the participants in their studies. Seven studies researched methods of assessment which were mainly examinations and tests. Five studies investigated the types of assessment, for example, diagnostic, continuous assessment and Trends in International Mathematics and Science study (TIMSS). Four studies dealt with teacher assessment practices (see table 7.10). Only nine studies dealing with assessment phenomenon included mathematics content (algebra, geometry and calculus), and were on the assessment outcomes. The next paragraphs in this subsection present the contextual issues, researchers' identities, and from which institutions and the meta-synthesis of the research questions and claims of assessment outcomes (achievement, attainment, and performance).

Table 7.9 ***Keywords for assessment research phenomenon***

Subcategories	Keywords coded as assessment focus area
Types	Diagnostic approach, Continuous assessment, Competency test, TIMSS
Methods	Examination structure, Examination items, Examination questions, Test instruments
Outcomes	Achievement, Attainment, Performance
Practices	Assessment practices

There were 44 postgraduate studies that researched performance, achievement, or attainment. Of these studies, 13 were doctoral and 31 masters, and were from eleven institutions which were Wits (13), UNISA (8), SU (5), UJ (4), UP (4), UKZN (3), NMMU (2), NWU (2), UCT (1), UWC (1), and UZUL (1). The studies on performance, achievement and attainment were written by 23 male and 20 female postgraduate students with one student whose gender could not be determined. More African males (15) and white female (12) students were interested in researching performance of learners and students (see Table 7.11). The studies on performance/ achievement/ attainment sampled mainly learners (29), students (12), teachers (9), lecturers (1), documents (1), principal (1) and out of school

Table 7.10 Distribution of the keywords for assessment phenomenon according to degree, participants, education level and geographical context of the studies

Assessment																						
	Degree		**Participants**							**Education-level**					**Location**							
Keywords	**Masters**	**Doctorate**	**Learners**	**Students**	**Teachers**	**Lecturer**	**Documents**	**Principals**	**Out-of-school youths**	**Primary**	**Secondary**	**Combined**	**Tertiary**	**Post sec**	**Township**	**Urban**	**Suburban**	**Rural**	**National**	**International**	**Combined urban & rural**	**Total per keyword**
Types of assessment	4	1	2		3						4	1			2			1	1		1	5
Assessment methods	4	3	4	3	1	1				1	3		2	1	1	4	1			1		7
Assessment outcomes	31	13	29	12	9	6	1	1	1	4	25	4	11		7	20	2	5	1	5	4	44
Assessment practices	4		2		4					1	3					2	1				1	4

youth (1). These were largely from secondary schools (25), then tertiary (11), primary (4), and combined (4) schools. These were located mostly in urban areas (20) than township (7), international (5), rural (5), combined rural and urban (4), suburban (2) and nationally (1).

Table 7.11 Gender and race of postgraduate students who researched assessment outcomes: performance/attainment/achievement

Race/ Gender	Male	Female	Unknown	Total
African	15	4	1	20
White	6	12	0	18
Indian	2	2	0	4
Coloured	0	2	0	2
Total	23	20	1	44

In this paragraph, a meta-synthesis of research questions and claims of performance/achievement/attainment phenomena is done. The MIR synthesis of the research questions on assessment phenomenon showed a different trend. More relational (29) research questions were posed in the studies than descriptive (18) questions. There were substantially more studies which posed explanatory research questions. This means knowledge on how assessment relates to other characteristics of the phenomenon was produced and also research questions that predicted what affects assessment thus impacting on the type of knowledge produced by postgraduate students. The MIR synthesis of the research questions on assessment outcomes further showed three major trends: gender and socio-political backgrounds (11), teaching strategies (11) and attitudes (9). Other research questions were posed in the postgraduate studies that linked assessment outcomes with subject combination; classroom interactions; learners' aptitudes, teachers' gender, qualification, experience and in-service; learners' aptitude and readability factors of test items. The research questions on gender and assessment outcomes were posed mainly to find out whether and what were gender differences in mathematics performance.

> Does gender, in any way, influence pre-service mathematics teachers' performance in the subject? (4-Arigbabu, 2003).
> Do females perform mathematically at a lower level than males at Universidade Eduardo Mondlane? (18-Cassy, 1997).
> Is there any gender difference with regard to achievement in Euclidean Geometry at senior secondary level in selected South African schools? (25-Cronje, 1995)

> Is there a significant difference between the mathematics achievement of boys and girls? (105-Mosala, 1997)
> Do boys and girls in Lesotho perform differently in mathematics? If so, to what extent? What social factors are perceived by the girls to influence their performance in mathematics? (162-Semata, 2004)

Research claims indicated no gender difference in mathematics performance, as noted in 4-Arigbabu's (2003) "findings revealed that (in Nigeria) the gender gap in mathematics achievement is disappearing". "The results suggested that gender performance and attitudes towards mathematics tend to be similar, and the inequalities found were more evident in the participation in mathematics related careers" (18-Cassy, 1997). Similar results were found in 25-Cranfield's (2001) study indicating "the performance of males and females in secondary Euclidean geometry, displayed more resemblances than differences".

The second type of research questions posed in the studies linked assessment outcomes with teaching strategies: problem solving, 'everyday' experiences, use of chess and tutorials. Some of the questions posed were as follows: "Everyday mathematics enhances matric pupils' performance and motivation" (49-Grinker, 1998). "Does playing chess have a positive impact on a learner's mathematics achievement?" (55-Hermelin, 2004). "What is the impact of tutorials on mathematics achievement?" (77-Louw, 2003). 49-Grinker (1998) posed a research hypothesis: "Everyday mathematics enhances matric pupils' performance and motivation" (p.2). The research results were positive for assessment outcomes that linked to problem solving, Students and Youth into Science, Technology, Engineering and Mathematics (SYSTEM) and use of chess during teaching. "The results also highlighted the enhancement of pupils' abilities to cope successfully with mathematics through the problem-centred approach" (43-Gee, 1997). 55-Hermelin's (2004) study showed that "incorporation of chess into school activity and further encouragement for all learners to play the game should be seriously considered by the education authorities since it is likely to result in the overall improvement of the mathematical achievement, especially in the higher grade of the Senior Primary School". However, the use of 'everyday' experiences and tutorials in teaching mathematics did not improve learner performance. "Results showed that although everyday based activities improved pupils' attitudes, unless they had a sound instrumental understanding of related concepts, ethno-mathematical methods did not improve their mathematical performance" (49-Grinker, 1998). 77-Louw's (2003) study on tutorials suggests "students in the experimental group did not perform significantly better than those in the control group, yet that does not diminish the value of the study in any way".

The third type of research questions stated in the studies that researched assessment outcomes dealt with attitudes. Some examples below:

> Is there a relationship between attitudes towards mathematics and achievement in mathematics of South African learners in Grade 7, 9 and 11? (68-Kimble, 2000)
> Is there any relationship between the students' attitudes toward and achievement in mathematics in the Soweto senior secondary schools? (84-Mathe, 1997)
> Were the individuals whose achievement improved, the ones whose attitudes to mathematics also improved? (85-Matlhaga, 1995)
> Are the first year JPTD students' attitudes related to their achievement in mathematics? (132-Osei, 1995)
> What is the relationship between anxiety and cognitions in adolescents' rural group, with particular reference to their mathematics achievements? (144-Pylman, 2001)
> What is the influence of attitude on the mathematical achievement of the standard 8 pupil? (157-Scholtz, 1996)
> The hypothesis that a structured, sequenced, approach to mathematics learning based on the application of learnt facts will decrease mathematics anxiety and increase achievement is tested in this study (176-Thijsse, 2002).

The results of the above studies mostly argued that attitude and anxiety influence learner achievement. "The results…indicated that there is significantly positive relationship between students' attitudes towards mathematics and mathematics achievement, and that there is positive attitude among first year students in Transkei" (132-Osei, 1995). Similarly, 144-Pylman (2001) found "that there is a significant relationship in respect of achievements in mathematics, anxiety and home language". Likewise, 176-Thijsse' (2002) "results support the hypothesis that a structured teaching method results in a decrease in mathematics anxiety and an increase in mathematics achievement". The next subsection is technology and resources research phenomena.

7.3.4 Technology & resources

"The term 'technology' refers to material construction uses as well as the intellectual and social contexts. It refers to the organization of knowledge for the achievement of practical purposes as well as any tool or technique of doing or making, by which capability is extended" (Luppicini, 2005, p.104). It is for this reason that technology and resources were put together as a research phenomenon in this thesis. The analysis in this subsection began with the identity of the authors of the studies researching technology and resources in mathematics education. Second, the higher education institutions where the authors of the studies were registered are identified. Third, the participants, contexts, and educational levels which were selected in the studies are discussed. What technologies were researched in the postgraduate studies? What research questions were prioritized in technology and resources phenomenon and what claims were made?

Out of the 38 studies researching technology and resources, more were female (22) rather than male (16) students, and more were White (21) postgraduate students that researched technology and resources than African (11), Indian (4), Coloured (1) and Saudi Arabian (1) counterparts. Ten of these students were registered for doctoral studies and 28 for masters. These students were registered in eight universities. UP (13) had more students who researched technology and resources phenomenon than Wits (6), UKZN (5), UNISA (5), UJ (4), UCT (2), NWU (2) and NMMU (1). The studies sampled more learners (22) and teachers (18) as participants and they were mostly from secondary (16) schools. The schools were typically from urban (22) areas (see table 7.12). The use of computer in the teaching and learning of mathematics was researched the most in the studies (26 out of 38) researching technology and resources. Of the 26 studies, four dealt with the world wide web, three focused on Sketch Pad and three concentrated on the use of spreadsheet softwares, and the remaining 16 out of 26 studies did not specify what computer software was used. Further five of 38 studies researched materials used in courses and textbooks in the schools. Two studies researched the use of chess, Tchadji, donkey card, muravarava, cowry shell and coin. An additional two studies researched the use of graphic calculators in the teaching and learning of graphs. The remaining three studies investigated models (1), video class system (1) and media (1).

Table 7.12 Distribution of the keywords for technology and resources phenomenon according to degree, participants, education level and geographical context of the studies

Technology and resources																					
Participants										Education-level					Location						
Learners	Students	Teachers	Lecturer	Documents/ Textbooks	Principals	HOD	Subject Advisors	Vendors	Computer Software	Primary	Secondary	Combined	Tertiary	Post sec	Township	Urban	Suburban	Rural	National	International	Combined urban & rural
22	9	18	4	3	2	1	3	1	1	11	16	2	9	1	6	22	1	1	1	2	5

For the research questions that were prioritized in technology and resources phenomenon, contrary to the previous assessment phenomenon, more descriptive (26) research questions were posed in the studies researching technology and resources than relational (15) and explanatory (7) questions. Consequently, descriptive knowledge of the technology and resources used in the teaching and learning of mathematics were produced more in the studies. Additionally, the studies posed questions that associated technology use and learners from disadvantaged background, understanding of mathematical concepts, performance, and improving visualisation of geometric shapes. Some research questions that were posed in the studies relating technology use and learners from disadvantaged were: "To what extent can Web-delivery of lesson material be used to address the education shortfall in disadvantaged communities? How will students from disadvantaged communities cope with this method of lesson delivery?" (17-Carr, 2002). "What is the feasibility of computer-aided education in mathematics for milieu-deprived learners in the senior primary phase in order to obtain a positive learning environment?" (62-Janse van Rensburg, 1999). "What is the effect of lessons using a spreadsheet offered to students in millieu-deprived communities?" (104-Moolman, 1996). "What are the implications of using AniFarm on milieu deprived standard 4 learners' performance in word sums?" (130- Oosthuizen, 1996). "What gaps are there in milieu-deprived standard 4 pupils in terms of mathematics? What are the experiences of milieu-deprived standard 4 pupils learning with the Computer-Assisted Education [CAE] approach?" (153-Rootman, 1996, own addition).

The research claims suggested that generally the use of computers in teaching improved understanding of learners from disadvantaged backgrounds. "The qualitative results showed that a CAE-approach could provide specific benefits to milieu-deprived learners not obtainable from conventional teaching" (62-Janse van Rensburg, 1999). "When compared to a group of children from more advantaged communities, they [learners from disadvantaged background] showed that they really benefited from these lessons and closed the performance gap significantly" (104-Moolman, 1996, own addition). 17-Carr (2002)'s study yielded slightly different results. His study showed that "the results obtained by students using this method were slightly better than that of students on the equivalent paper-based course. However, students from disadvantaged backgrounds fared marginally worse than those on the paper-based course" (17-Carr, 2002).

Studies also posed research questions about the use of computers and understanding of the mathematics concepts. Such research questions were: "To what extent does the students' understanding of the nature of definitions change while involved in a process of formulating definitions within a Sketchpad context?" (46-Govender, 2002). "What is the influence of Logo programming on the pupils' understanding of a variable concept at the pre-algebra stage?" (119-Narainsamy, 1998). The results of these studies generally reported improved learners' understanding of the mathematics concepts when computers were used for teaching. 46-Govender (2002) found that student teachers' understanding of the nature of definitions in geometry improved when Sketchpad was used. However, 61- Jakovljevic (1995) results were contrary. "Computer supported instructional progamme [did] not enhance pupils' lower, middle and higher order thinking skills and achievement in the mathematics classroom" (61-Jakovljevic, 1995).

Additionally, postgraduate studies posed research question on how technology and resources impact on learner performance. Such research questions were: "Does playing chess have a positive impact on a learner's mathematics achievement? Does the length of exposure to chess impact on mathematics achievement?" (55-Hermelin, 2004). "Does the use of the graphics calculator result in better performance on the effects that a, p, and q have on the behaviour of quadratic functions defined by $y = a(x-p)^2 + q$ amongst SPTD 111 student teachers when compared with performance of SPTD111 students who do not use the graphics calculator?" (102- Monareng, 2002). "What are the implications of using AniFarm on milieu deprived standard 4 learners' performance in word sums?" (130-Oosthuizen). "Does the performance in Mathematics and Science of standard 8 students in the pilot study receive tuition in Technology Education improve or not?" (169-Sitole, 1997). "What is the impact of Integrated Learning System (ILS) usage on the raw marks of mathematics standard grade paper 2 learners in Grade 12?" (180-van Rooyen Barnard, 2004). 190-Yushau (2004) posed a hypothesis- "There is a significant positive relationship between mathematics aptitudes and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program". Some studies reported that the use of technology and resources improved learner performance in mathematics. 169-Sitole's (1997) study found that technology education plays a role "in enhancing performance in Science and Mathematics including English". 102-Monareng (2002) study "showed that the difference in means for the test scores [was] statistically significant". 55-Hermelin's (2004) study showed that playing chess "is likely to result in the overall improvement of the mathematical achievement especially in the higher grade of the Senior Primary School". 180-van Rooyen Barnard (2004) and 190-Yushau (2004) studies could not confirm that the use of technology and resources only improved learner performance. For 190-Yushau "Mathematics aptitudes and English language proficiency are the most significant contributors to students' mathematics achievement".

The last type of research questions on technology and resources used in teaching and learning dealt with visualization of geometric shapes. "What are the requirements for graphing technology to ensure meaningful visualisation of two-dimensional functions to promote better understanding of the mathematical concepts involved?" (170-Steyn, 1998). "What part of using models in the teaching of standard eight geometry later assisted student to recall and be able to do geometry problems?" (26-Davids, 1995). The results of these studies suggested that the use of technology and resources focusing on visualization in teaching and learning mathematics promoted conceptualization of mathematics. "It is argued that the meaningful combination of graphical exploration and graphical analysis according to a judicious didactical approach is necessary in order to successfully incorporate technology into instruction aimed at the understanding of fundamental mathematical concepts" (170-Steyn, 1998). "The empirical research has shown that models can serve as a medium to unlock the learning content of Geometry to the pupil. This can be done by concretizing and presenting Geometry on a level which enables the pupils to experience its simplicity with optimal learning" (26-Davids, 1995).

7.3.5 Affective domain

Thirty-five postgraduate students (1995-2004) had an interest in researching the affective domain of mathematics education. Of the 35 theses dealing with affective domain in mathematics education, very few (4) included the mathematics content investigated. The aforementioned further signals the separation of the affective issues from cognition in understanding teaching and learning of mathematics. The gender and racial division of postgraduate students, who were interested in affective domain, were split evenly between females (18) and males (17), and African (15) and White (15). The remaining five students were of Indian and Coloured descent. In addition, these postgraduate students were from nine HEIs with Wits University (43%) having more students interested in affective issues in teaching and learning of mathematics. There were no studies focusing on affective domain in mathematics education from the five HEIs (TUT, UCT, UFS, UNIZULU, & UWC). Twenty- six masters and 9 doctoral students dealt with affective domain. This was expected because there were more (150) masters than doctoral (40) students.

The keywords categorized under the affective domain research phenomenon encompass a range of concepts, including affective, anxiety, attitudes, beliefs, emotions, hypnotherapy, opinions, perceptions, self-concept, and self-regulation. Anxiety signifies feelings of nervousness or apprehension related to mathematics, while attitude denotes the overall positive or negative orientation towards mathematics teaching and learning. The term affective describes emotional responses associated with mathematics teaching and learning experiences. Moreover, hypnotherapy involves inducing a trance-like state in individuals to uncover their true or repressed feelings concerning mathematics teaching and learning.

The postgraduate studies focused more on attitudes (17) towards mathematics than the remaining keywords which were six or less (see table 7-13). Students' (5) and learners' (9) attitudes towards teaching and learning of mathematics were considered more in postgraduate studies, and then teachers' (4) attitudes were considerably focused on by postgraduate students as opposed to academics (2) at tertiary level. Attitudes of participants from secondary (9) and combined (1) schools, tertiary (4) and postsecondary (1) institutions were considered. This signals that younger learners in primary schools were not mature enough to communicate their attitudes towards mathematics teaching and learning. Although more studies researched schools, postgraduate students were researching down and across. Attitudes towards mathematics of participants from urban areas (7) were considered more than their counter parts in townships (3), rural (3) and international (3). Having discussed the attitudes towards mathematics according to participants, education level and geographical location, below I analyse the research questions related to this keyword of affective domain phenomenon.

Further understanding of postgraduate studies focusing on attitudes, demands an analysis of research questions and claims that dealt with this keyword. More relational and explanatory research questions were posed in studies on attitudes than descriptive questions. Consequently, knowledge on the relationship between characteristics of attitude and the prediction of what causes attitudes towards mathematics was produced more in the studies. The attitudes of learners/students towards mathematics were linked to achievement, pedagogy, gender and intervention programmes. Improvement in mathematical achievement had a bearing on the learners' attitudes towards mathematics. For example, the research questions below were posed in the postgraduate studies: "Is there a relationship between attitudes towards mathematics and achievement in mathematics of South African learners in Grade 7, 9 and 11?" (68-Kimble, 2000). "Is

Table 7.13 Distribution of the affective domain keywords according to degree, participants, education level and geographical context of the studies

	Affective domain																		
	Degree		Participants					Education-level					Location						
Keywords	**Masters**	**Doctorate**	**Learners**	**Students**	**Teachers**	**Lecturer**	**Documents**	**Primary**	**Secondary**	**Combined**	**Tertiary**	**Post sec**	**Township**	**Urban**	**Suburban**	**Rural**	**International**	**Combined urban & rural**	**Total per keyword**
Affective	2		2		1			1	1				1	1					2
Anxiety	5	2	6	2	3				5	1	1		1	3	2			1	7
Attitudes	9	8	9	5	4	2			9	1	4	1	3	5	2	3	3		17
Beliefs	4	2	1	2	3	2			2	1	2	1	1	2		1	1	1	6
Hypnotherapy	1		1						1					1					1
Opinion	1			1							1		1						1
Perceptions	4	1	3	1	3		1	1	2	2			2	2				1	5
Self-concept		1	1						1							1			1
Self-regulated	1															1			1
Total	27	13	21	11	15	4	1	2	20	5	8	2	9	14	3	6	4	3	

there any relationship between the students' attitudes toward and achievement in mathematics in the Soweto senior secondary schools?" (84-Mathe, 1997). "Are the first year JPTD students' attitudes related to their achievement in mathematics?" (132-Osei, 1995). "What is the influence of attitude on the mathematical achievement of the standard 8 pupil? Which factors contribute mainly to the attitude of the standard 8 pupil towards mathematics?" (157-Scholtz, 1996).

The results show that the relationship between attitude and the first construct achievement is positive. Attitudes influences achievement in mathematics (68-Kimble, 2000; 84-Mathe, 1997; 132-Osei, 1995; 157-Scholtz, 1996). If learners had positive attitude towards mathematics they were motivated to study hard and their performance improved. The postgraduate studies indicated factors contributing to positive attitudes towards mathematics. Teachers' role and supportive parents were some of the factors that influenced positive attitude towards mathematics, thus improving learner achievement. However, in one postgraduate study, 190-Yushau (2004), argued that "Mathematics aptitude and English language proficiency contribute more to learners' achievement as opposed to attitudes, instruction and learning styles". Nevertheless, it can be accepted that positive attitudes towards mathematics lead to improved learner achievement. The results from postgraduate studies below support the claim that attitudes related to achievement.

> The results of a reliable and valid questionnaire indicate that a significant positive correlation exists between attitude towards mathematics and achievement in mathematics for Grade 7, 9 and 11 learners (68-Kimble, 2000).
> Learners are not highly motivated to do well in mathematics (84-Mathe, 1997).
> There is significantly positive relationship between students' attitudes towards mathematics and mathematics achievement (132-Osei, 1995).
> These findings underline the important role of the teacher, as well as the supportive role of the parents in creating a positive attitude towards mathematics. The achievement of the learner can be improved by motivation and support. This will result in a more positive attitude towards mathematics (157-Scholtz, 1996).
> The results show that mathematics aptitudes and English language proficiency are the most significant contributors to students' mathematics achievement. No other variables show statistically significant effects on students' achievement (190-Yushau, 2004).

Secondly, the postgraduate studies wanted to find out whether attitude towards mathematics can be improved pedagogically. Different teaching strategies e.g. cooperative tasks, classroom interaction and Functional Model were investigated whether they improve learners' attitude towards mathematics. "To what extent does the perspective of instruction, using the Functional Model, contribute to a change in attitudes and beliefs of the students with respect to the learning and teaching of mathematics?" (56-Hockman, 2000).

Contradictory claims were reached in the studies investigating whether pedagogical activities improve learners' attitude towards mathematics. Studies researching cooperative tasks, Functional Model and methods of teaching and learning difficulties concluded that pedagogies mentioned above improved learners' attitude towards mathematics. "The findings of the study suggest that the cooperative and learning task does assist in promoting favourable attitudes towards mathematics among the students" (83-Mashaba, 1998). However, studies researching diagnostic-remedial programme and classroom interactions could not clearly state whether the aforementioned resulted in positive attitude toward mathematics. "The study does not show any clear picture in connection with the effect of achievement on attitude. It is not clear whether attitude influenced achievement or achievement influenced attitude" (Matlhaga, 1995). The implication was that changing teaching and learning styles do not necessarily yield positive attitudes in learners towards mathematics.

Thirdly, postgraduate studies investigated whether intervention programmes improved learners' and teachers' attitudes towards mathematics. "How do the workshops affect the teachers' attitudes to their respective subjects (i.e. biology, mathematics or physical science)?" (78-Lungu, 1996). "Will exposure to a diagnostic-remedial programme yield a greater number of individuals with improved attitudes toward mathematics?" (85- Mathlaga, 1995). "Is there any significant difference between the average attitudes of prospective mathematics teachers before and after the intervention programme?" (106- Moyana, 1996). The question was, do teachers intervention programmes assist in improving learners' and teachers' attitudes towards mathematics? Positive teachers' attitudes towards mathematics, was promoted after an intervention programme such as workshops (78-Lungu, 1996; 107-Moyana, 1996). However, 78-Lungu and 107-Moyana warn that both quantitative and qualitative research methods are needed to triangulate the results reached rather than using one of the two methods. "The findings … advocate the need to combine both quantitative and qualitative research in studies: the results of the quantitative research did not conclusively indicate a positive impact of the intervention programme. However, the qualitative research saw respondents expressing improved confidence and attitudes" (107-Moyana, 1996). "Th[e] study provide[d] evidence that in- service courses can affect secondary teachers' content knowledge and attitudes. However, effects on teaching skills can better be established by a further classroom study of the teachers" (78-Lungu, 1996, own addition).

Fourthly, gender differences were investigated as a factor for negative attitude towards mathematics, and the following question was asked "Do attitudes towards mathematics differ across gender BUSCEP students at Universidade Eduardo Mondlane?" (18-Cassy, 1997). The findings suggest that gender does not influence attitudes towards mathematics and achievement. Research claims in 18-Cassy's (1997) "study suggested that gender performance and attitudes towards mathematics tend to be similar, and the inequalities found were more evident in the participation in mathematics related careers". In summary, learners' attitude influenced their achievement in mathematics, and the intervention programmes for teachers promoted positive attitude towards mathematics and achievement. Teaching methods and gender difference does not influence learners' attitudes towards mathematics.

The remaining keywords anxiety (7), beliefs (6), perceptions (5), affective (2), hypnotherapy (1), opinion (1), self-concept (1) and self-regulated do not warranty a MIR synthesis. However, I will briefly analyze anxiety and beliefs. Seven postgraduate studies (5-masters & 2-doctoral) focused on anxiety. The studies sampled learners, students, and teachers to research their anxiety towards mathematics. The participants were mainly from secondary schools in urban areas (see table 7-13 on page 210). The seven studies posed relational (4), descriptive (2) and explanatory (2) research questions. Through these questions, the studies investigated the relationship between anxiety and achievement, gender, study methods and language. The findings of the postgraduate studies investigating anxiety showed that there was a relationship between anxiety, achievement, home language and age. The studies suggested that supportive learning environment, constructivism, structured teaching method and hypnotherapy, decrease anxiety towards mathematics thus improving learner performance. The next paragraph analysed beliefs.

There were four masters and two doctoral students that focused on beliefs. The beliefs of teachers and lecturers, less than that of learners (see table 7-13) were investigated in the studies. The participants were from secondary schools and tertiary institutions. The participants were spread evenly in the geographical areas: township, urban, rural, and international. The studies posed more descriptive (5) than relational (2) research questions. What kind of beliefs were the postgraduate studies researching? The studies researched teachers and learners' beliefs in the nature of mathematics (158-Scott, 1996; 173-Temba, 1998; 186-Webb, 2003). For example, 186-Webb (2003) investigated whether there is "any correlation between teachers' beliefs about the nature of mathematics, teaching and learning?" 108-Mphunyane (1997) conducted research about teachers' beliefs about language in mathematics teaching. He was interested in finding out "mathematics teachers' beliefs about language in teaching mathematics to ESL pupils and the roles [they] assume". What were the research results of beliefs in the nature of mathematics, teaching mathematics and language? "The data reveal that there is a positive correlation between the beliefs expressed about the nature of mathematics, teaching and learning" (186-Webb, 2003). Teacher's beliefs about mathematics affect how and what they teach.

7.4 SUMMARY OF THE TRENDS AND EMERGING ISSUES ON RESEARCH PHENOMENA, QUESTIONS AND CLAIMS IN THE THESES (1995-2004)

This chapter analysed the research phenomena that were studied in the corpus of mathematics education postgraduate studies (1995-2004). Which participants, contexts and education levels were selected in the studies? In addition, this chapter analysed the identity of the postgraduate students who researched the identified phenomena. Moreover, the chapter analysed the institutions from which the studies were published. Furthermore, a MIR synthesis of the research questions and claims related to the researched phenomena was done. What research phenomena were researched in mathematics education postgraduate studies? The findings show that affective domain, assessment, cognition, epistemologies and knowledge, pedagogy, technology, and resources were dominantly researched in the mathematics education postgraduate studies in South Africa (1995-2004). There were paucities in studies researching socio-cultural political perspectives, languages, in-service education, curriculum policy, development and implementation, attrition rates of learners taking up mathematics, and adult basic education and mathematics. There were no studies researching gifted students/learners, history of mathematics education amongst other research areas.

Generally, the gender of the postgraduate students who researched affective domain, assessment, cognition, epistemologies and knowledge, pedagogy, technology, and resources were divided equally between males and females. However, more male postgraduate students researched cognition while more females researched technology and resources. Similarly, the race of the postgraduate students who researched the aforesaid phenomena was largely equal for White and African students. Nonetheless, more White postgraduate students researched knowledge and epistemologies and technology and resources. The number of Indian, Coloured and other postgraduate students who researched the five research phenomena were minimal. Wits had more postgraduate students researching pedagogy, cognition, knowledge and epistemologies, assessment, and affective domain except for more studies on technology and resources that were published from UP.

Pedagogical issues were researched the most in mathematics education postgraduate studies in South Africa (1995-2004). Pedagogical issues had four subcategories: teaching approaches, learning approaches, activities during the lesson and mathematical skills. The teaching approaches that was researched the most was problem solving strategy. The research claims that mediation and co-operative learning improves problem solving skills in mathematics. Contrarily, research also claimed that group work did not improve the problem solving skills of learners. Learning approaches researched in mathematics education postgraduate studies were co-operative learning, early learning, teacher learning, study orientation, participation, reflective techniques. Co-operative learning was researched the most in postgraduate studies. Research questions posed in the studies researching co-operative learning linked it to teacher understanding and learner performance. Research claimed that co-operative learning improved learner performance. In addition, co-operative learning assisted teachers to cope with large class sizes when teaching mathematics at schools.

The second most researched phenomena in mathematics education studies (1995-2004) were cognition, epistemology, and knowledge. These phenomena had two sub-categories cognition and knowledge including epistemology. The research questions posed in cognition phenomenon were directed at learners' understanding of geometry, algebra and trigonometry concepts and were descriptive in nature. Research claimed that strategies like modelling, scaling, curve-fitting and technologies like sketchpad and spreadsheets improved learner understanding of mathematics concepts. However, to the contrary, some studies reported negative research results on cognition and learner understanding of mathematics concepts. In particular, the authors of the studies cited language, conceptual understanding, cultural meaning, and extra tuition as impeding learners' understanding of mathematics concepts. In addition, some studies claimed that teachers had low levels of mathematics understanding and how children learn mathematics.

The studies on the second subcategory knowledge and epistemologies posed research questions teachers' knowledge of their own practice, types of knowledges practice, mathematics content and children's mathematical knowledge which were mainly descriptive. Further, research questions of the philosophy and nature of mathematics were presented in the postgraduate studies. The research studies claimed that teachers had low levels of mathematics knowledge and knowledge of their practice. Moreover, the research claimed that the use of everyday knowledge in mathematics teaching was conflicting, while some studies claimed that the use of everyday knowledge assisted learners to understand the taught mathematics concepts. In some studies, it was claimed that the use of everyday knowledge in the teaching of mathematics impeded learners from understanding the concepts taught.

The third most researched phenomenon in mathematics education postgraduate studies (1995-2004) was assessment. The keywords related to assessment were types and methods of assessment, assessment outcomes and practices. Assessment outcomes were the most researched phenomenon related to assessment in mathematics education studies (1995-2004). The research questions on assessment outcomes focused on the gender difference in mathematics performance, teaching strategies, and attitudes towards mathematics. Mostly, the research questions were relational. The aggregated research claims from the mathematics education theses (1995-2004) suggest that there was no gender difference in learner performance in mathematics. The teaching strategies researched that were linked to assessment outcomes were problem solving, everyday experiences, use of chess in teaching and tutorials. The mathematics education postgraduate research (1995-2004) claimed that problem solving improved learner achievement in mathematics. Whereas the research results, suggested that learner performance was not improved when everyday experiences were used in teaching mathematics. Instead, the use of everyday experiences improved learners' attitudes towards mathematics. Lastly, the research findings of mathematics education postgraduate studies, proposed that assessment outcomes was influenced by learners' attitude and anxiety towards mathematics.

The fourth most researched phenomenon in mathematics education postgraduate studies (1995-2004) was technology and resources used in the teaching and learning of mathematics. The technologies that were used in the postgraduate studies were world wide web, Sketchpad, spreadsheets, computer softwares, materials, textbooks, games (chess, tchadji, donkey card, muravarava, cowry shell and coin), graphic calculators, video class system and media. The research questions prioritised in the use of technology and resources in the teaching of mathematics were linked to social background of learners, understanding of mathematics concepts, learner performance and visualisation of geometric concepts. These research questions were mainly descriptive in nature. The use of computers in the teaching and learning of mathematics was researched the most in the postgraduate studies. The mathematics education postgraduate research claimed that the use of computers in the teaching of mathematics improved learners' performance especially for learners from the disadvantaged backgrounds. Some studies researching this phenomenon reported improvement in learners' understanding of mathematical concepts. Additionally, by using technology and resources that promoted visualisation in the teaching mathematics improved learners' conceptualisation of mathematics.

The last phenomenon analysed in this chapter was the affective domain. The affective domain included keywords like affective, anxiety, attitudes, beliefs, emotions, opinion, perceptions, self-concept and self-regulated. Of these keywords, attitudes towards mathematics were researched the most. As a result, a MIR synthesis of attitudes towards mathematics was done. The research questions posed in the mathematics education postgraduate studies linked the affective domain with variables such as learner achievement in mathematics, teaching strategies, intervention programmes and gender differences. Mostly relational research questions were posed in the mathematics education studies researching attitudes. The aggregated mathematics education postgraduate research (1995-2004) claimed that positive attitude towards mathematics directly impacted on the improvement of learners' achievement in mathematics. However, the studies argued that learners' positive attitude towards mathematics can be achieved by the positive role teachers and parents play in supporting learners. In addition, cooperative tasks and functional model, as teaching strategies, improved attitudes towards mathematics as a result improve achievement. Furthermore, intervention programmes like workshops improved attitudes towards mathematics teaching. However, the studies warned that positive attitude towards mathematics was observed in the qualitative data. It could not be observed from the quantitative data whether the positive attitude towards mathematics espoused by the participants in the qualitative data improved their achievement in the tests given to them. Moreover, the studies reported that gender difference did not influence learners' attitude towards mathematics. The next chapter dealt with the research paradigms, design, approaches, and methods used in the corpus of mathematics education postgraduate studies in South Africa (1995-2004).

CHAPTER 8

RESEARCH METHODOLOGIES USED IN MATHEMATICS EDUCATION THESES (1995-2004)

8.1 INTRODUCTION

The previous chapter dealt with the research phenomena, questions and claims found in the mathematics education postgraduate research in South Africa (1995-2004). The research questions posed in the postgraduate studies about phenomena were addressed by gathering and analysing data to reach particular claims about the phenomena. Depending on the type of research questions posed in a study, the research paradigm, design, approach, methods, and sites are selected. As discussed in chapter 7, the three types of research questions, descriptive, relational and explanatory, lead to exploratory, correlational and experimental research designs respectively. Though this chapter focused on the research paradigms, designs, and methods, it was important to relate them to the phenomena and questions in the studies. This chapter not only sought to address the trends of research paradigms, designs, approaches, methods, and research sites in the corpus of mathematics education postgraduate studies (1995-2004), or the identity of the students who chose those paradigms, designs and methods and the institutions in which they graduated. The chapter also focused on the research phenomena and the kinds of research questions that were phrased in the studies with prominent paradigms, designs, approaches, methods and sites. Before engaging with the analysis, in the next paragraph the conceptualisation of research paradigms, designs, approaches and methods is discussed.

A research paradigm is philosophical in nature and is a set of assumptions and beliefs the researcher uses to guide the thinking during the research (Jonker and Pennink, 2010). Research design is about what constitutes appropriate evidence in addressing the research question(s) (Mouton, 2008). Research approach, sometimes referred to as research methodology, is about how we can produce the evidence in the study (Mouton, 2008). Lastly research methods deal with the methods of selecting participants, measurement, data collection and analysis (Mouton, 2008). Sometimes there is no clear distinction between research design, methodology, approaches, and methods. Consequently, sometimes researchers use these concepts interchangeably or in conflicting meanings. In developing the coding system to capture data on research paradigms, design, approaches, and methods, I used the interpretation that was developed by the PPER's research team. In developing the coding system for the PPER data on research paradigms, designs, approaches and methodologies, the research team had meetings and workshops discussing, amongst other things, these terminologies.

A list classifying these concepts was developed to ensure consistency in the capturing of data from postgraduate studies. As was discussed in chapter four, the data on research paradigms, designs, approaches, and methods were gleaned, as self-reported, from the education theses and captured by one member of the PPER team. To check for the reliability of the captured data, a second member of the PPER research team read the theses for the second time checking whether there is agreement. For this reason, I base my analysis on my own and colleagues' understandings of the research paradigms, designs, approaches, and methods developed through the meetings and workshops. Table 8.1 (on page 222) show how these research paradigms, designs, approaches, and methods were listed and coded into SPSS and EndNote. Table 8.2 shows an example of how the data were captured from the theses. The analysis began with the identification of the paradigms, designs, approaches, methods, and sites used in the mathematics education postgraduate theses and the silences. Secondly, a MIR synthesis of the prominent paradigms, designs, approaches, methods, and sites was done including the research phenomena and questions. Thirdly, the data from the theses was triangulated with the interview data of the selected supervisors for mathematics education postgraduate studies (1995-2004). The next subsection analysed the research paradigms.

8.2 ANALYSIS OF RESEARCH PARADIGMS IN MATHEMATICS EDUCATION POSTGRADUATE THESES IN SOUTH AFRICA (1995-2004)

From the analysed data, nine paradigms were read from the theses data. These were constructivism/ constructivist, critical, deconstructivism, eclectic, feminism, hermeneutics/

Table 8.1 Research paradigms, designs, approaches, and methods coded into SPSS and EndNote.

Research Paradigms		Research Approaches	Research designs			
Constructivism	Hermeneutics/Interpretive	Mixed Method	Action research	Documentary	Exploratory	Narrative
Critical	Positivist	Qualitative	Case Study	Eclectic	Grounded theory	Pre-post test
Deconstructivism	Post-structuralism	Quantitative	Comparative method	Ethnography	Literature reviews	Self-study
Eclectic	Structuralism		Conceptual analysis	Evaluation	Longitudinal	Survey
Feminism			Content analysis	Experimental	Participatory	Tracer study
			Correlational	Ex-post facto	Phenomenology	
			Discourse analysis	Explanatory	Phenomenography	

Table 8.2 An example of how research paradigms, designs, approaches and methods were coded

No/ Degree/ HEI/ Race/ Gender	Research Paradigm	Research Design	Research Approach	Sampling	Analysis	Instruments	Participants/ Sample size	Edu level	Location
1 D Wits White Female	Ethnography Case study	Interpretive	Qualitative	Purposive	Thematic Analysis	In-depth interviews Observations Reflective workshop	Teachers (6)	Secondary Grs 8-12	Urban/ township
2 M UCT African Female	Positivist	Experimental	Quantitative	Random	Statistics Analysis	Test Questionnaire (biographical details)	Teachers (46)	FP Grs 1-3	Urban

The literature points to hermeneutic being a form of interpretivism (Denzin & Lincoln, 2000). As a result, in this thesis, interpretivism and hermeneutics were recorded as one category and henceforth both are referred to as interpretivism. Interpretivism was the most popular paradigm (117- 62%) used in the studies (1995-2004), followed by positivism (52-27%). A small number of studies (21-11%) used critical, constructivism, eclectic and feminism paradigms. There were silences of studies using deconstruction, structuralism, and post-structuralism (see Table 8.3). The other paradigms were too few to warrant a synthesis. In the next paragraphs a MIR synthesis was done.

Table 8.3 Research paradigms used in the mathematics education postgraduate theses (1995-2004)

Paradigm	**Doctoral**	**Masters**	**Total**
Interpretivism/ Hermeneutic	16	101	117
Positivism	16	36	52
Critical	3	6	9
Constructivism	2	5	7
Eclectic	3	1	4
Feminism	0	1	1
Total	**40**	**150**	**190**

The identities of the students who used interpretivism and positivism paradigms were analysed, and interpretivism was dominantly used by females (66) than males (50). Race analysis shows that White (55) students, followed by African (50), Indian (9), and Coloured (3) used interpretive paradigm. It was masters (101) students that dominantly used interpretive paradigm, then doctoral (16). These students were from 11 out of 14 HEIs: Wits (41), UJ (17), UCT (17), UKZN (11), UP (8), UNISA (7), RU (5), SU (4), NMMU (3), NWU (3) and TUT (1). It was studies from Wits (41) 76% that framed their studies using interpretive paradigm, and these studies focused on the twelve research phenomena that were identified in chapter 7. The majority of the researched phenomena underpinned by interpretive paradigm (see table 8.4) were pedagogy and cognition, epistemologies and knowledge in most studies.

Contrary to interpretivism, males (30) and females (22) used positivist paradigm, and White (26) students, then African (17), Indian (6), Coloured (2) and Saudi Arabian (1) used positivist paradigm. Likewise, more masters (36) than doctoral (16) students employed the positivist paradigm. These students were from 12 HEIs: UP (12), UNISA (10), SU (6), Wits (5), UJ (5), NWU (4), UCT (3), NMMU (3), UFS (1), UKZN (1), RU (1) and UWC (1) had students who used positivist paradigm. The dominant researched phenomenon using positivist paradigm was assessment (23), and other phenomena researched in studies underpinned by positivist paradigm were: pedagogy (20), Cognition, epistemologies & knowledge (15), technology & resources (11), affective domain (9), socio-cultural political perspectives (4), PRESET (3), attrition rate (1), curriculum policy & development (1), INSET (1), and language (1).

Table 8.4 Research phenomena of studies framed in the interpretive paradigm

Phenomenon	**Studies framed in the interpretive paradigm**	**Studies researching the phenomenon**
Pedagogy	46	77 (60%)
Cognition, epistemologies & knowledge	41	63 (65%)
Affective domain	24	35 (69%)
Assessment	22	53 (42%)
Technology & resources	22	38 (58%)
Language	10	15 (67%)
Curriculum policy & development	9	12 (75%)
INSET	9	12 (75%)
Socio-cultural political perspective	8	17 (47%)
Leadership	2	2 (100%)
PRESET	2	6 (33%)
ABET	1	1 (100%)

The year-by-year analysis of the contrast between interpretive and positivist paradigms showed that 1997 was the only year where more postgraduate theses used positivist than interpretive paradigm (see figure 8-1). The understanding of the anomaly warrants institutional analysis of the postgraduate theses that were produced in 1997 and compare with the two paradigms. In 1997, only six HEIs produced mathematics education postgraduate theses. These institutions were UJ (5), Wits (4), UP (3), UNISA (2), SU (2) and RU (1). These institutions are HWUs with four of these institutions were previously Afrikaans universities (see figure 8-2). Generally, the Afrikaans institutions had more postgraduate theses using positivism than interpretivism, resulting to more mathematics education postgraduate theses that used positivism paradigm in 1997.

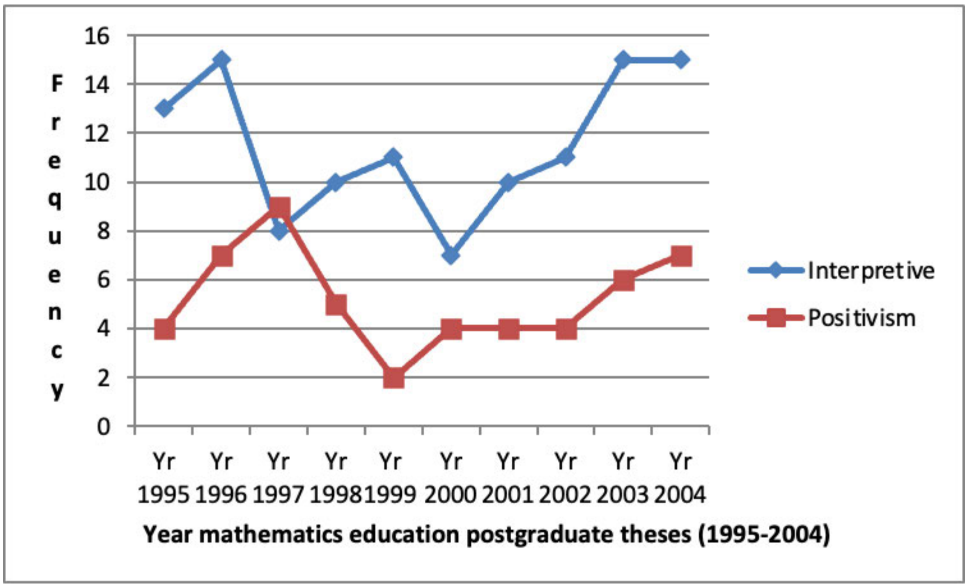


Figure 8.1 Year by year contrast of interpretive and positivism research paradigms in postgraduate theses (1995-2004)

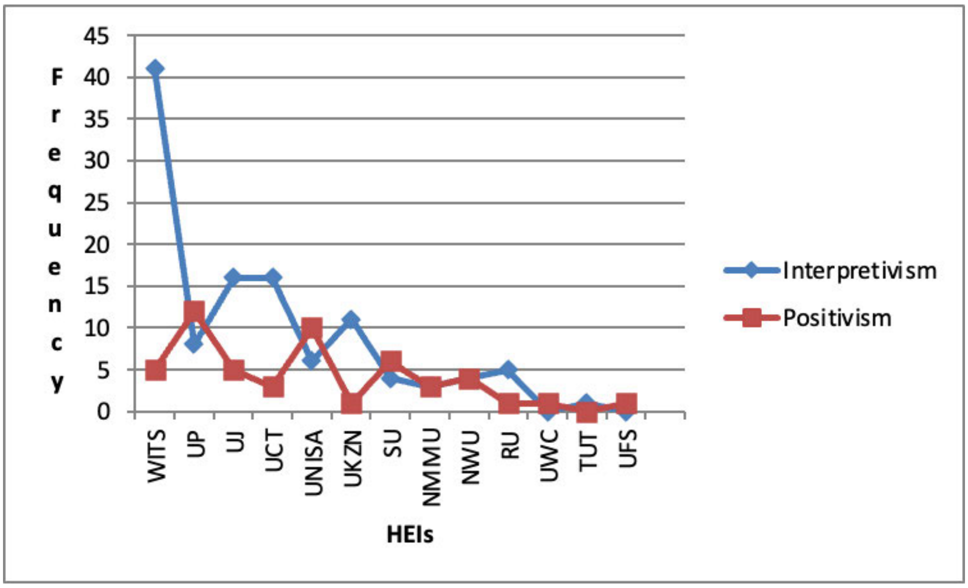


Figure 8.2 Contrast of interpretivism and positivism research paradigms in postgraduate theses (1995-2004) by institutions

The explanation for the popularity of interpretivism paradigm could be linked to mathematics education as a discipline in the social sciences. Social researchers mainly employ interpretivism as a philosophical lens to understand their research phenomena. Prof Y succinctly stated the reason mathematics education postgraduate students chose to use the paradigms in their theses (1995-2004). For him, "[research] tradition of the social science and education are very much part of the social sciences". (Interview with Prof Y 21/4/2008, page 6). This indicates that mathematics education as a discipline within education is likely to employ philosophical traditions for understanding research phenomena. Prof J suggested that the choice of paradigm or methodology depends on the problem:

> Generally, the hard work is for the students to construct this, what we call language of description or to produce the data…We always see data as theoretically constituted rather than just found…and also, we try and direct students in that whereby there's a gap in the theory and empirical that needs to be filled in by the students' work. I mean that's really the important part…But then it depends on the problem, whether one needs to describe it quantitatively or otherwise just depends on the nature of the problem (Interview with Prof J, 2008, page 5).

Research paradigms frame the philosophical dimensions of the study, and the research designs indicate the type of study. In the next sub-section, I analysed the research designs that were used in the mathematics education postgraduate studies in South Africa (1995-2004).

8.3 ANALYSIS OF RESEARCH DESIGNS IN MATHEMATICS EDUCATION POSTGRADUATE THESES IN SOUTH AFRICA (1995-2004)

Many postgraduate studies (73- 38%) used case study research design, then surveys (30), experimental (29) and quasi-experimental (14) in the mathematics education postgraduate theses (1995-2004). The other research designs were sporadic (see table 8.5). None of the postgraduate studies (1995-2004) used discourse analysis, phenomenography, biography, and comparative method research designs. Since enough mathematics education postgraduate studies used case study, surveys and experimental designs, a MIR synthesis was done, and the other research designs are not discussed further.

8.3.1 Case study

The case study research design was used more by females (44) than males (28) students, and one unknown gender. Almost the same number of White (33) and African (31) students used the case study research design, then Indian (7), and Coloured (1). Again, it was the masters (64) as opposed to doctoral (9) postgraduate students that predominantly used case study research design. Most of the students who used case study research design were from Wits (31), and the rest were from UJ (10), UKZN (9), UCT (8), UNISA (4), UP (3), SU (3), NMMU (2), RU (2) and TUT (1). The prevalent phenomena researched with case study design were pedagogy (28) and cognition, epistemologies and knowledge (26) The other phenomenon researched with case study design were affective domain (15), assessment (14), technology & resources (11), INSET (8), Cognition, epistemologies and knowledge (7), language (7), socio-cultural political perspectives (5), leadership (1) and PRESET (1).

Table 8.5 Research designs used in mathematics education postgraduate studies (1995-2004)

Research design	**Masters**	**Doctorate**	**Total**
Case study	64	9	73
Survey	22	8	30
Experimental	21	8	29
Quasi-experimental	7	7	14
Ethnography	2	6	8
Action research	3	2	5
Exploratory	4	1	5
Phenomenology	5	0	5
Evaluation	3	1	4
Grounded theory	4	0	4
Literature review/survey/study	3	1	4
Pre-post test	3	0	3
Ex post facto	1	1	2
Correlational	2	0	2
Narrative	2	0	2
Conceptual analysis	1	0	1
Content analysis	1	0	1
Descriptive method	1	0	1
Discipline of Noticing	1	0	1
Documentary	1	0	1
Explanatory	1	0	1
Participatory action research	1	0	1
Total	**150**	**40**	**190**

As expected, many studies (54) posed descriptive research questions, naming or describing characteristics of the phenomena. The mathematics education postgraduate students (1995-2004) preferred case studies as they are bounded by time or geographical area, which makes it manageable to describe the characteristics of a phenomenon. The examples of descriptive questions that were researched with case study design are: “What part of using models in the teaching of standard eight geometry later assisted student to recall and be able to do geometry problems" (26-Davids, 1995)? "What conceptions do learners have about area" (92-Mhlanga, 2004)? "How can racial mathematical stereotypes and multicultural education in the post-apartheid dispensation be reduced or totally eradicated" (126-Nkotoe, 1996)? Thirty percent (22 out of 73) of the studies that used case study design phrased relational research questions, and explained how the parts of a phenomenon related to one another. Such questions were: "Is there any gender difference with regard to achievement in Euclidean Geometry at senior secondary level in selected South African schools" (25-Cronje, 1995)? "To what extent is social practice theory (in particular the work of Lave & Wenger, 1991 and Wenger, 1998) helpful in explaining the nature of teacher learning in relation to their participation in a mathematics INSET project" (47-Graven, 2002)? "Are the teachers' use of alternative continuous assessment promote and support teaching and learning in mathematics" (137-Pfeiffer, 2003)?

There were few studies (8) that used case study design and posed explanatory research questions. This might follow from the explanatory research that involve manipulation of some parts of the phenomenon in an experiment to determine its effect. However, true experimentation in education is limited as students sometimes use one school or classroom hence the use of case study design. Explanatory research questions posed in the studies were usually in the form of hypotheses that were tested such as. "Educators with advanced methods of teaching mathematics enjoy a high percentage pass" (89-Matlou, 2003). "H_0A: Mathematics anxiety has no effect on mathematics performance. H_1A: There exists a negative relationship between mathematics anxiety and mathematics performance" (53-Hawkey, 1995). In the next subsection I analysed surveys.

8.3.2 Surveys

The data analysis shows that African (14) students used surveys, followed by White (9), Indian (5) and Coloured (2) students respectively. Interestingly, the gender of the students who preferred surveys split evenly between males (15) and females (15). The majority of these students were registered for masters (22) as opposed to doctoral (8) degrees. These students were from UP (8), UJ (6), UNISA (4), Wits (4), NWU (2), UCT (1), UFS (1), UKZN (1), NMMU (1), RU (1) and UNIZULU (1). Surveys were used the most in studies (14) that researched assessment phenomenon. Another research phenomenon with surveys were; affective domain (6), cognition, epistemologies and knowledge (6), pedagogy (6), socio-cultural political perspectives (4), PRESET (3), technology & resources (3), curriculum policy & development (2), INSET (2), attrition rate (1) and language (1). The type of research questions that were posed in mathematics education postgraduate studies that used surveys were descriptive (18) research questions. Contrary to how the dimensions of the phenomenon are described in a case study, surveys present an opportunity for generalising the parts of a phenomenon because they are conducted with larger sample sizes.

The examples of descriptive questions that were posed in the survey studies are as follows. “How do students understand the idea of a limit” (63-Jordaan, 2005)? “What are the teaching strategies and methods that are applied by most of the teachers in the learning and teaching of mathematics in secondary schools in the Kagiso area” (100-Molefe, 2001)? “What is the cause of the problems in the teaching and learning of mathematics in secondary schools in the Soshanguve area” (149-Rampa, 1996)? Almost the same number of studies posed relational (7) and explanatory (5) research questions. The small number of studies that posed relational questions in survey research was an anomaly. Survey, by definition, describe the relationship between parts of a phenomenon and use a large sample size. An example of relational questions: “Is there a relationship between attitudes towards mathematics and achievement in mathematics of South African learners in Grade 7, 9 and 11” (68-Kimble, 2000)? The limited use of explanatory research questions in surveys was expected as surveys are not experimental in nature. An example of explanatory research questions posed in survey studies was the hypothesis “The present mathematics that is being taught in the rural high schools does not play an important role in developing rural and tribal communities in South Africa” (101-Molepo, 1997). In the next subsection I analysed experimental design.

8.3.3 Experimental design

Experimental design in this analysis includes quasi-experimental and pre-post - test designs. In the database there were more experimental (29) than quasi-experimental (14) and pre-post - test (3) studies. For the analysis I used the total of the three which was 46. The identity of the students who used experimental design contrasted with that for the case study design with more males (27) utilising experimental designs than females (16). In addition, contrary to more African students using case studies and surveys, White (25) students employed experimental design more than their African (15), Indian (3), Coloured (2) and Saudi Arabian (1) counter parts. Mainly, masters (31) students used experimental designs than doctoral (15) students. These students were from Wits (8), SU (6), UNISA (7), UP (5), NMMU (4), NWU (4), UCT (4), UJ (3), UKZN (2), UWC (2), and RU (1). There were less number of phenomenon researched in experimental design with pedagogy (23) being the highest. The other phenomena researched in experimental design fall within the affective domain (20), assessment (16), cognition, epistemologies & knowledge (16), technology & resources (14), socio-cultural & political perspectives (5), language (3) and PRESET (2). It is important to point out that it was the first time so much studies researched the affective domain.

It was expected that more studies posed relational (21) and explanatory (19) research questions than descriptive (14). For the experimental design, fourteen studies posed descriptive research questions, which was high. Nevertheless, in some studies, descriptive research questions were posed together with the relational and explanatory questions. The examples of descriptive research questions posed in experimental design studies were: “How can weak Grade 5 learners develop and improve their problem-solving ability in mathematics” (13-Boshoff, 2002)? “Which typical errors reported in literature are most frequent in Clydesdale College PTD students' work in solving linear and quadratic equations” (105-Mosala, 1997)? Typical relational research questions that were posed in the experimental design studies were: “To what extent does WB-activity-based teaching - as a teaching approach using a cultural resource- affect students' performance and attitudes towards (the learning of) mathematics” (20-Cherinda, 2002)? “Is there any relationship between the self-instructional lesson and achievement in mathematics in QwaQwa secondary schools” (98-Mokoena, 1998)?

I observed that these studies researched the relationship between parts of the phenomenon. For example, 98-Mokoena (1998) researched the correlation between self-instructional lesson and achievement and not the cause and effect of the phenomena (self-instructional lesson and achievement). In short, 98-Mokoena might have benefited from using a correlational design instead of presenting his study as experimental". Subsequent to the relational research-determining the relationship of the parts of the phenomenon was experimental research. More studies employing experimental design should have posed explanatory research questions than the 19 out of 46. The following are examples of explanatory research questions posed in the studies using experimental design. “Will exposure to a diagnostic-remedial programme yield a greater number of individuals with improved attitudes toward mathematics” (85-Matlhaga, 1995)? “Why is it that so many students struggle to learn geometry” (24-Cranefield, 2001)? “H_1: Children who are taught through investigative teaching will develop a better understanding of the subject than those who are taught through the traditional method where they only listen and react to the teacher's instructions” (159-Sebela, 1997). In the next subsection, I discussed the three popular research designs: case study, survey and experimental, performing a year-by-year analysis.

8.3.4 Comparison of the three research designs: Case study, survey and experimental design

The year-by-year analysis of the three research designs showed that the case study was prevalent throughout the period 1995 to 2004, except in the year 2000. In the year 2000, both survey and experimental designs were slightly above the case study design (see figure 8.3 below). Nonetheless, the three research designs followed a similar trend with the number of theses that used these designs, were decreased in the first five-year period. There was an increase in the number of theses that used these designs in the second five- year period of (1995–2004). This trend was similar to the year-by-year analysis of the distribution of the number of studies in the corpus pointed out in chapter 5 in figure 5.2 on page 118. Further analysis of the three research designs showed that Wits mathematics education postgraduate students (31 out of 54) used case studies in their theses. A similar trend was observed at UKZN, UCT and UJ (see figure 8.4). This was contrary to the former Afrikaans universities UP, UNISA, SU, NMMU and NWU where more theses used surveys in UP and experimental design in the latter four institutions. The use of surveys and experimental designs in the former Afrikaans universities relates to the observation made previously linking these institutions to an emphasis on positivist paradigm. At the remaining institutions, there was no significant difference between the three research designs.

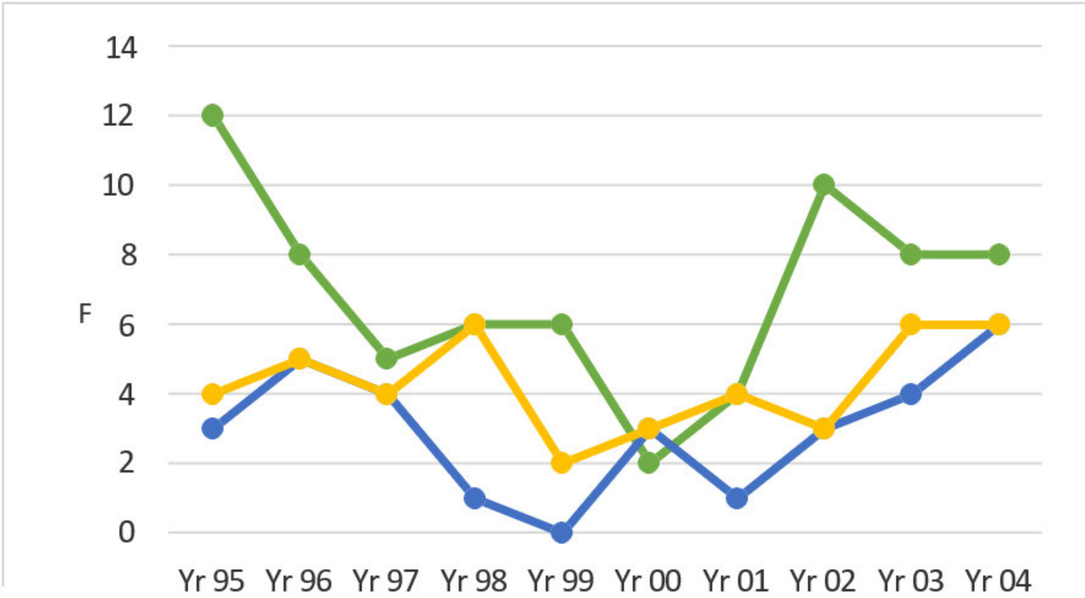


Figure 8.3 Year-by-year analysis of mathematics education postgraduate theses using case study, survey, and experimental designs.

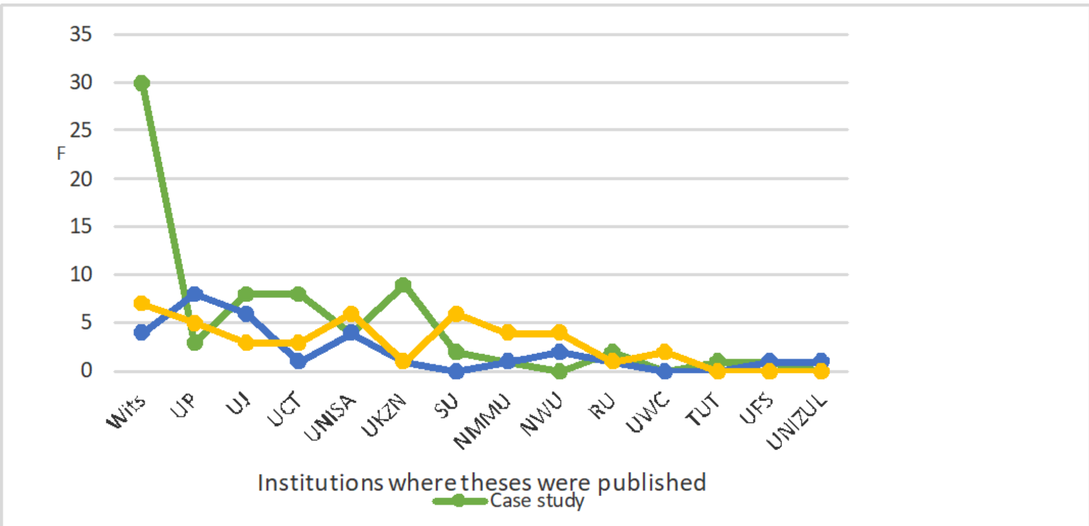


Figure 8.4 Distribution of case study, survey and experimental research design according to HEIs

From the above analysis, several questions emerged; Why did mathematics education postgraduate students, in their theses in 1995 -2004, prefer the case study research design? Why were the case studies used mostly by female in contrast to experimental design preferred by male students? Why did Wits, more than any other institution, use case studies? Why was the experimental design appealing to White students and surveys to African students? Although case study research design was prevalent, why is it that in the ten-year period (1995-2004) there was a decline in the first five-year and an increase in the latter five years? These questions are profound. Each of these questions prompts critical reflection on the complex interplay of individual, institutional, cultural, and temporal factors that shape research practices within the field of mathematics education. By unpacking these questions, I gained deeper insights into the dynamics of research methodology, disciplinary norms, and the socio-cultural context of educational research, with one explanation provided by a supervisor who mentored students to conduct in-depth research of the phenomena.

> Again …that type of bias, certainly I think with me trying to get the students to generate propositions, means that there's almost a natural drift towards case studies so that you can study something in-depth. (Interview with Prof J, 2008, p. 8)

There could be an inclination towards case studies from pressures of students' throughput rates at the universities. Thus, students preferred to research phenomena in familiar contexts such as their place of work or surrounding areas or their teaching. Having analysed the prevalent research designs, phenomena, and the questions, in the following subsection I analysed research approaches linking them to the designs and phenomena.

8.4 ANALYSIS OF RESEARCH APPROACHES IN MATHEMATICS EDUCATION POSTGRADUATE THESES IN SOUTH AFRICA (1995-2004)

Three research approaches were prevalent in the mathematics education postgraduate studies (1995-2004): qualitative, quantitative, and mixed method. Out of 190 mathematics postgraduate theses on the database, 79 (42%) used qualitative research approach. Almost equal number of theses used mixed (56-29%) and quantitative (55-29%) research approaches. More females (53) than males (25) and an unknown gender (1) used qualitative approach, and mainly from the masters (70) students and only 9 from the doctoral studies. The White (38) students dominantly used a qualitative approach, followed by African (33), Indian (7) and Coloured (1) students. Many of these students were registered at Wits (31), then UCT (12), UJ (10), UKZN (8), UP (6), UNISA (5), RU (4), NMMU (2) and SU (1). Almost the same number of male (28) and female (27) students employed a quantitative approach, and thirty-nine masters (39) and 16 doctoral students. It was more White (28) students that used quantitative research approaches, in contrast to African (18), Indian (6), Coloured (2) and Saudi Arabian (1). These students were from 11 HEIs: UP (13), Wits (10), UJ (9), UNISA (8), SU (4), UKZN (3), NWU (3), UCT (2), UFS (1), NMMU (1) and UNIZULU (1). In contrast to using the qualitative approach, more male (34) students used mixed method research approach than female (22) students and more masters (41) than doctoral (15) students used mixed method research approaches. Equal number of African (25) and White (25) students used mixed method research approaches than Indian (4) and Coloured (2) students. These students were from Wits (13), UCT (6), UNISA (6), NMMU (5), SU (5), UKZN (4), NWU (4), UP (4), UJ (3), RU (3), UWC (2) and TUT (1).

In the previous subsection the data showed that generally, particular types of research questions, were researched with specific types of research design. For example, it was shown that descriptive research questions were likely to be researched with a case study design. In this paragraph, I analysed what research phenomena were likely to be investigated with the three research approaches? Further, in the next paragraph I evaluated the association between the prevalent research designs and the three research approaches. Cognition, epistemologies and knowledge, and language research phenomena were researched qualitatively in the mathematics education postgraduate studies (1995-2004). The pedagogy research phenomena were investigated with qualitative and mixed method approaches. In addition, studies that researched assessment were researched quantitatively, including mixed methods. Worth noting were studies focusing on affective domain phenomenon utilized all the three research approaches equally (see table 8.6).

Table 8.6 Studies investigating research phenomena with qualitative, quantitative, and mixed method approaches)

Research phenomenon	**Research approach**			**Total**
	Qualitative	**Quantitative**	**Mixed method**	
Pedagogy	36	12	29	77
Cognition, epistemologies & knowledge	30	18	15	63
Assessment	9	26	18	53
Technology & resources	18	12	8	38
Affective domain	12	12	11	35
Socio-cultural political perspective	6	5	7	17
Language	10	2	3	15
INSET	7	1	4	12
Curriculum policy & development	6	1	5	12
PRESET	1	2	3	6
Leadership	2	0	0	2
ABET	1	0	0	1
Attrition rate	0	1	0	1

Unsurprisingly, Case studies were predominant in the corpus of studies and were mostly framed in a qualitative approach. This was consistent with descriptive research questions mostly phrased in studies using case study design. Naturally, surveys followed a quantitative research approach, which was contrary to what was observed earlier that descriptive research questions were posed mainly in surveys. As expected, studies designed for experimentation used quantitative and mixed method approaches ensuing from the relational and explanatory research questions that were posed primarily in the studies that used experimental design (see table 8.7). In the next paragraph the year-by- year analyses of the three research approaches is done.

Table 8.7 Cross tabulation of the three prevalent research designs with the research approaches)

Research design	**Research approach**		
	Qualitative	**Quantitative**	**Mixed**
Case study	47	8	18
Survey	2	19	9
Experimental	2	22	22

Although more postgraduate studies used a qualitative research approach, a degree and year-by-year analysis revealed an interesting trend. During the period 1995 to 2004 doctoral students mainly used quantitative and mixed research approaches, while masters students used all three research approaches (see table 8-8). In nine out of ten years in the period (1995-2004) there was either no or one doctoral student that used a qualitative research approach per year. There was an exception in the year 2000 where three doctoral students used a qualitative research approach. Further analysis of research approaches by yearly distribution revealed dominance of qualitative research throughout the ten-year period. The 1997 and 1998 were significant because more postgraduate students used quantitative research approaches in their theses. Comparatively, in 2002 and 2003, more postgraduate students used mixed method research approaches in their studies (see table 8.8 and figure 8.5).

Table 8.8 Distribution of research approaches used in mathematics education postgraduate studies by degree and year of publication.

Year	**Qualitative**		**Quantitative**		**Mixed**		**Total**
	M	D	M	D	M	D	
1995	8	0	5	3	4	1	**21**
1996	9	1	6	1	6	0	**23**
1997	6	0	5	5	1	0	**17**
1998	6	0	4	3	1	2	**16**
1999	7	1	2	1	1	2	**14**
2000	3	1	2	1	3	1	**11**
2001	7	1	1	0	5	1	**15**
2002	5	3	3	0	5	5	**21**
2003	7	1	3	1	11	2	**25**
2004	12	1	8	1	4	1	**27**
Sub-Total	**70**	**9**	**39**	**16**	**41**	**15**	
Total	**79 (42%)**		**55 (29%)**		**56 (29%)**		**190**

Additionally, the analysis of the research approaches by institutions showed a similar trend that was discussed earlier in the paradigms and designs. Historically, Afrikaans universities (UP, UNISA, SU, NWU and UFS (see figure 8.6) used quantitative research approaches. This was associated with the paradigmatic choices that were made by the postgraduate students in these institutions. This was confirmed by one supervisor that institutional research culture influenced the choice of research approach in postgraduate studies.

> Yah and also its tradition of the social science and education is very much part of the social sciences, but in this institution anyway…But I think it also stems or comes from the institutional culture. I should imagine that quite a few of the Afrikaans universities like

> Pretoria, and Stellenbosch are still doing a lot of quantitative stuff. I think it's a combination of all sorts of things that come and influence ultimate research approach. Here at Rhodes, education is strongly embedded in a social science culture. (Interview with Prof Y 21/4/2008, page 6)

The interviewee pointed to reasons why the postgraduate students leaned towards certain paradigms and approaches, which was the institutional culture. The professor indicated, rightfully so as shown in the Figure 8.6, that historically Afrikaans universities predominately used quantitative research approaches associated with the positivist paradigm.

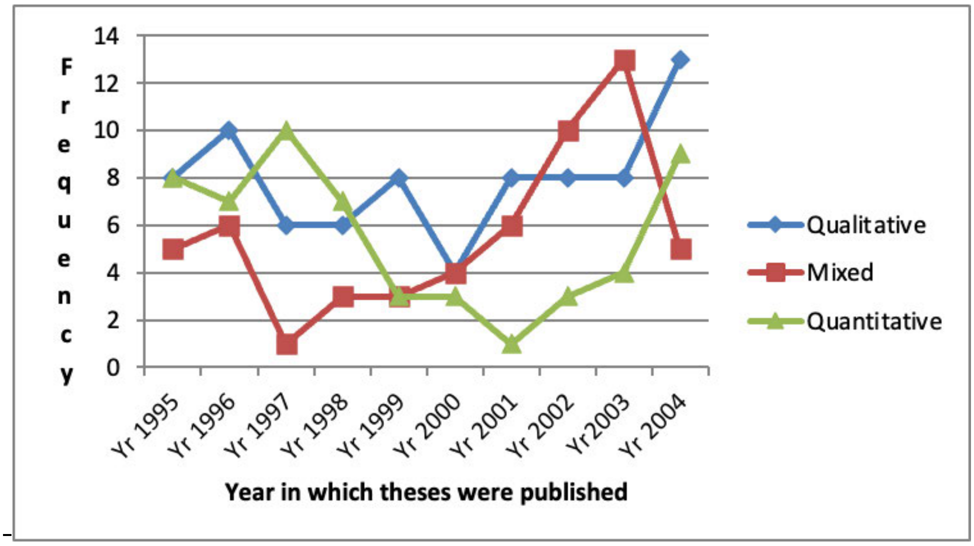


Figure 8.5 Year by year distribution of research approaches used in Mathematics education postgraduate studies.

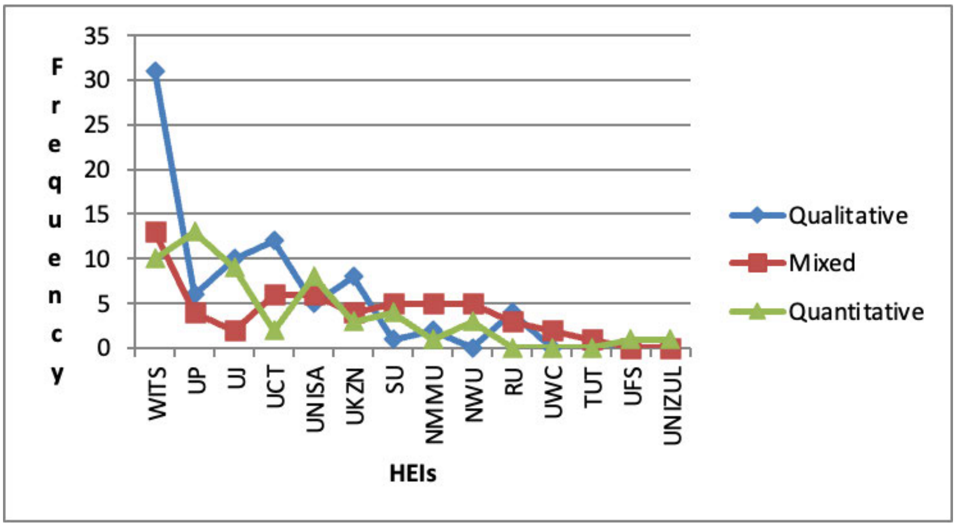


Figure 8.6 Distribution of research approaches used in studies by institution.

In fact, by nature, mathematics education research is in the social sciences, therefore researchers gravitated towards developing a qualitative understanding of research phenomena. Interestingly, the doctoral students gravitated more towards quantitative and mixed methods than qualitative research. This was contrary to the views expressed by the supervisors interviewed who felt that postgraduate students mainly used the qualitative research approach. This was true for the masters students. Prof J expressed his ideas on this subject as follows:

> For the most part you find that using qualitative forms of analysis are preferable because of what we try and get the students to focus on originality. But then the PhD…but nevertheless even at masters level the idea is that the student has to find some way of contributing even in the tiny way to the body of research at the level of theory. So, we want there to be at least some attempt at trying to work towards theory construction. And generally, you find, even if you describe your data in quantitative terms, you still need a more qualitative type of approach in order to generate theory. So that does tend to dominate you know, so let's say there's more of an emphasis on qualitative techniques than quantitative because of the interest in generating propositions, theoretical propositions. (Interview with Prof J, 2008 pp7-8).

Having discussed the research phenomena and questions leading to the prevalent paradigms, designs and approaches, the next subsection present the research methods that were used to generate data for the mathematics education postgraduate studies (1995- 2004).

8.5 ANALYSIS OF RESEARCH METHODS IN MATHEMATICS EDUCATION POSTGRADUATE THESES IN SOUTH AFRICA (1995-2004)

Research methods unlike paradigms, designs and approaches are a-theoretical. Research methods refer to how the study was conducted, how the participants were selected, how the data was collected, and how it was analysed. The analysis in this sub-section dealt with sampling strategies that were used in the corpus of theses, samples and sample size, educational levels and contexts researched in the studies, research instruments used to generate data and the analytical tools used.

8.5.1 Sampling strategies

In the corpus of theses, sometimes more than one group of participants were selected in the studies. That is, sometimes teachers, learners as well as principals, were selected as participants in one study. In such a case, the authors of such studies occasionally used more than one sampling strategy when selecting participants. Sampling strategies that were used in the postgraduate studies in the periods 1995 – 2004 were purposive (125), random (37), convenience (27), stratified (10), volunteer (10), systematic (4) and cluster (1) (see table 8.9). There were silences on quota and snowballing sampling strategies in the corpus of postgraduate theses. Further analysis was done for the three most used sampling strategies beginning with purposive sampling.

Table 8.9 Sampling strategies used in the mathematics education postgraduate theses (1995-2004)

Sampling strategy	Total
Purposive	125
Random	37
Convenience	27
Stratified	10
Volunteer	10
Systematic	4
Cluster	1

Purposive sampling is the selection of participants on purpose. Purposive (125) was mostly used in the mathematics education postgraduate studies (1995-2004) and were masters (100) students as compared to the doctoral (25) students. There were more females (70) than males (54) and unknown gender (1) students that used purposive sampling. Again, White (69) students dominated, and then African (43), Indian (9) and Coloured (4) students used purposive sampling strategy. The majority of these students were from Wits (37), as opposed to UJ (18), UCT (12), UKZN (11), UP (11), UNISA (9), SU (9), NMMU (5), NWU (5), RU (5), UFS (1) and UWC (1). As was expected studies using a qualitative (61) approach selected their participants using purposive sampling. In addition, purposive sampling strategies were prevalent in the case study (51) research design, as pointed out earlier, was also linked with qualitative approaches. Most of these studies were from Wits

University. I noticed that studies that used mixed (35) and quantitative (29) research approaches used less purposive sampling to select the participants. Experimental (21) was the next research design where more purposive sampling strategies were used in the studies to select participants. This was not expected as experimental design is underpinned by positivist paradigm as such probability sampling strategies like random and stratified sampling should be used. In the remaining 14 research designs, the number of studies using purposive sampling was less than 10. In fact, most designs had just one thesis utilizing the purposive strategy.

Random (37) sampling strategy allowed each participant in the population to have an equal chance of being selected and included in the sample. Random sampling strategy was used by 20 male and 17 female students. However, more African (20) students rather than White (9), Indian (6), Coloured (1) and Saudi Arabian (1) students chose the participants of their studies using random sampling strategy. Twenty-six of these students were registered for masters and 11 for doctoral degrees. The spread of the number of studies using random sampling per institution is small. UNISA (8) had the highest studies using random sampling, and the remaining institution were Wits (6), UJ (4), UKZN (4), UP (4), UCT (3), NMMU (2), NWU (2), SU (2), UFS (1) and UWC (1). Generally, studies using mixed (16) and quantitative (18) research approaches had more theses using random sampling. Only three qualitative studies chose the participants randomly. Furthermore, fewer research designs-experimental (16), surveys (11), case studies (4), ethnography (3), Action research (2) and ex post facto (1) were associated with random sampling strategy.

Convenience sampling is the process of selecting a sample that is readily available to the researcher. Convenience sampling was used in 27 studies, and almost equal number of male (14) and female (13) postgraduate students used it. In addition, almost equal number of African (12) and White (11) students used convenience sampling as opposed to Indian (2) and Coloured students. More of these students were registered for masters (21) degree than doctoral (6) degree. The convenience sampling was used in seven institutions: Wits (12), UP (7), UCT (2), UKZN (2), RU (2), NWU (1) and UNISA (1). Which research approach and design was likely to use convenience sampling? The analysis indicated that most studies used case study (13) research design with a convenience sampling strategy.

Other research designs which used convenience sampling were survey (4), action research (2), ethnography (2), experimental (2), experimental (2), exploratory (2), content analysis (1) and evaluation (1). Qualitative (14) research approach used mostly convenience sampling. Quantitative (7) and mixed (6) research approaches were less associated with convenience sampling.

8.5.2 Samples and sample size

Sampling strategies are used to select participants from whom data is collected. Who were the participants in the mathematics education postgraduate theses? Unsurprisingly, people (184 - 97%) and text documents/ computer software (6–3%) were sampled the most in the mathematics education postgraduate studies. Learners (88–46.3%) dominated, followed by teachers (55–28.9%), tertiary students (32–16.8%), lecturers (4–2.1%), children out of school (2 -1%), and facilitators, principals, leader of a project one (1–0.5%) each respectively (see table 8.10). The sample of learners, teachers, principals, students, and lecturers was expected, as most studies were conducted in schooling and tertiary education. The reason a large number of learners and teachers were selected in the postgraduate studies was related to researching down and across. Most postgraduate students preferred researching in familiar contexts, their learners, and colleagues. Although, there was mathematics education postgraduate research conducted in tertiary institutions, there were less lecturers than students who were selected in the studies. Obviously, the mathematics education postgraduate students were researching down. I now turn my attention to the sample sizes in the mathematics education postgraduate studies.

Statistically, a sample is considered large if it has 30 or more participants. Of the 190 postgraduate theses, 89 (46.8%) had a small sample size, 90 (47.4%) used a large sample size and from 11 (5.8%) theses, the samples size could not be gleaned. The sample sizes are distributed as shown in the frequency distribution table 8.11. The smallest sample size used in the postgraduate studies is one and the largest is 3 013. Contrary to the belief that educational research uses case studies with small sample sizes, the data shows a significant number of postgraduate theses (1995-2004) employed large samples. In the next section the educational levels and contexts researched in the studies was analysed.

Table 8.10 Samples selected in the mathematics education postgraduate studies (1995-2004)

Samples	Frequency	Percentage
Learners at school	88	46.3
Teachers	55	28.9
Students at tertiary institutions	32	16.8
Lecturers	4	2.1
Documents/ Literature	3	1.6
Children out of school	2	1
Facilitators	1	0.5
Principals	1	0.5
Teaching Materials	1	0.5
Leader of a project	1	0.5
Computer software	1	0.5
Textbook	1	0.5
Total	**190**	**100.0**

Table 8.11 Frequency distribution of the sample sizes of the participants in the postgraduate theses.

Sample size range	Frequency
0 - 30	89
30 - 60	31
60 - 90	5
90 -120	9
120 -150	4
150 - 180	8
180 - 210	3
210 - 240	3
240 - 270	2
270 -300	2
300 >	23
Missing	11
Total	**190**

8.5.3 Educational levels and contexts researched in the studies

Similar to the sample, mathematics education postgraduate studies were conducted at different educational levels, and the most common level was schooling with 147 (77.4%) out of 190 theses. Within the schooling sector, almost 50% (94 out of 190) of the theses focussed in secondary schooling (see table 8.12). The trend of mathematics education postgraduate theses focusing on schooling was expected as most of the authors of the theses were school teachers. Furthermore, the mathematics school teachers who took up postgraduate studies in mathematics education were working in secondary schools. In South Africa, all primary school teachers are expected to teach mathematics irrespective of whether they are good in it or enjoy it. As such most teachers in primary school are not specialist in mathematics teaching. Generally, it was expected that 50% of postgraduate theses in mathematics education were conducted at secondary schools, as compared to primary schools.

There was a dearth of mathematics education postgraduate research (1995-2004) focusing on early childhood education (ECE) and adult basic education and training (ABET) with just two (1.1%) and one (0.5%) theses respectively (refer to Table 8.12 on the next page). During the period 1995 to 2004, much attention was given to secondary schooling focusing mainly on matric (Grade 12) in South Africa. I now turn to the geographical context where the selected schools were located.

Table 8.12 Levels of the mathematics education postgraduate studies produced in South African HEIs in the period 1995 – 2004.

Level	**Frequency**	**Percentage**
Secondary	94	49.5
Primary	39	20.5
Tertiary	33	17.4
Combined	14	7.4
Post-Secondary	4	2.1
ECE	2	1.1
Service Provider	2	1.1
ABET	1	0.5
Private Sector	1	0.5
Total	**190**	**100**

Different kinds of contexts were considered in the mathematics education postgraduate studies. The data showed that most research was undertaken in urban 87 (45.8%) areas. Combining the urban, township and sub-urban areas, there were 134 (70.5%) of studies, which focused on the urban and peripheral surroundings (see Table 8.13). Fifteen (7.9%) studies focused on understanding mathematics education in the rural areas only. Table 8.13 (on the next page) showed that there was a considerable number 19 (10%) of postgraduate studies conducted in international settings. There was a plausible explanation why the mathematics education postgraduate studies were conducted in urban settings. The universities (Wits, UP, UCT, UNISA, UKZN and SU) that published most mathematics education theses were in the urban areas and drew mostly students located in the urban areas. Not much mathematics education theses were produced from HEIs (UNIZULU, UL, UV and FHU) which are located in rural settings. However, eight institutions (UCT, UJ, UKZN, NMMU, UP, UNISA, TUT and Wits) had mathematics education theses conducted in rural contexts, although were in urban areas. The range of theses conducted in rural areas varied from one to three per institution. Ten African and five White postgraduate students conducted their research in rural contexts. However, there was a noticeable dearth in rural education research in South Africa from 1995 to 2004.The next subsection discussed the research instruments used to generate data in the studies.

Table 8.13 Geographical areas where postgraduate studies were conducted

Geographical area	Frequency	Percentage
Urban	87	45.8
Township	40	21.1
International	19	10.0
Combined urban and rural	17	8.9
Rural	15	7.9
Suburban	7	3.7
National	2	1.1
Combined Township and rural	2	1.1
Nil	1	0.5
Total	**190**	**100**

8.5.4 Research instruments in the mathematics education postgraduate theses (1995-2004)

There was a variety of data generation methods used in the corpus of mathematics education postgraduate studies in South Africa (1995-2004). Twenty different data generation methods were used in the studies and the most popular in the studies were interviews (108), questionnaires (98), test/activity (91), observations (63) and journal entries (10). The remaining 14 data generation methods were used in five studies (see table 8.14). There were silences in data generation methods like collage and collaborative reflections. In the paragraphs, I analysed the interviews, questionnaires, test/activity and observations.

Table 8.14 Research instruments used in the mathematics education postgraduate theses (1995-2004)

Research Instrument	Number of studies
Interview	108
Questionnaire	98
Test/Activity/Worksheets	91
Observation	63
Documents	23
Journal entries	10
Workshop	5
Attitude test	3
Reflective conversation	4
Drawing/photos	2
Literature sources	2
Opinionnaires	2
Textbook	2
Cognitive maps	1
Essays	1
Evaluation programme	1
Field notes	1
Poster	1
Portfolio	1
Software	1

Interviews (108) were the most popular research instruments used to generate data and interviews were popular in social science research. As such interviews dominated in the mathematics education postgraduate studies (1995-2004) to generate knowledge. It was female (65) postgraduate students that used interviews in their studies more than male (42) students and one unknown gender. Most of the students who used interviews were African (51), then White (44), Indian (11) and Coloured (2) students. These students were mainly registered for masters (88) degree as opposed to doctorate (20). The Wits (37) university had the highest number of postgraduate studies in which interviews were used to generate data and the remaining institutions were UCT (13), UKZN (13), UJ (10), UNISA (10), RU (5),

NMMU (6), UP (5), NWU (2), SU (2), UWC (2) and TUT (1). Important to note were few studies from historically Afrikaans universities which used interviews as a research tool. As pointed out earlier, the historically Afrikaans institutions mainly used the positivist paradigm that focused on quantitative studies.

The questionnaire is a research tool used to gather data from several participants over a large geographical area. Ninety-eight studies used questionnaires to generate data and equal number of female (49) and male (49) postgraduate students generated data using questionnaires. Most of the students who used questionnaires were White (46) than African (39), Indian (11), Coloured (1) and Saudi Arabian (1). Again, more masters (71) than doctoral (27) students used questionnaires. Similar to interviews, more Wits (19) studies used questionnaires as a data generation tool. The other institutions were: UP (17), UJ (13), UNISA (13), UKZN (9), NWU (6), UCT (5), NMMU (5), SU (4), RU (3), UFS (1), TUT (1), UWC (1) and UNIZULU (1). Questionnaires were used fairly in all the research approaches: mixed (38), quantitative (38) and qualitative (22). Studies using experimental (26), case study (25) and surveys (25) designs used questionnaires as a research tool.

Mathematics tests, activities, worksheets, and tasks were used in mathematics education postgraduate studies. Ninety-one such research instruments were used in the corpus of mathematics education studies (1995-2004). Tests/ activities were used more by male (51) than female (39) students and one unknown gender. It was mostly White (50), followed by African (33), Indian (4) and Coloured (4) students. Just like interviews and questionnaires, more studies from Wits (31) used mathematics tests and activities to generate data. The other institutions were UP (11), UCT (9), UNISA (9), SU (8), UJ (7), NMMU (4), RU (4), UKZN (3), NWU (3), UWC (1) and UNIZULU (1). The three research approaches, mixed (35), quantitative (31) and qualitative (25), utilised mathematics tests and activities to generate data. Studies using experimental (35), and case study (29) research designs relied on mathematics tests, activities, worksheets, and tasks to generate data. Other research designs which used tests and activities to generate data were surveys (8), ethnography (4), action research (3), evaluation (3), correlational (2), phenomenology (2), content analysis (1), descriptive (1), ex post facto (1), exploratory (1) and grounded theory (1).

Observations (63) were the fourth most popular research instruments used in the mathematics education postgraduate studies (1995-2004) and were dominated by female (36) rather than male (27) students. Almost an equal number of African (31) and White (28) students used observations than Indian (3) and Coloured (1) students. Observation research instruments appealed largely to masters (50) than doctoral (13) students. As the trend in the previous research instruments, Wits (24) had the highest number of studies which used observations for data generation, and then other institutions were: UP (8), UCT (7), UJ (7), UKZN (5), UNISA (4), NMMU (3), NWU (2), SU (2), and RU (1). Similar to interviews, observations were used mostly in qualitative (39) and mixed (20) than in quantitative (4) studies. Following the same trend, observation research instruments was used in case studies (32) research design. Other studies that used observations were framed in the following research designs: experimental (10), ethnography (6), phenomenology (3), surveys (3), action research (2), evaluation (2), exploratory (2), discipline of noticing (1), explanatory (1) and grounded theory (1).

The year-by-year distribution of the four research instruments (interviews, questionnaires, test/activity and observations) showed a decline in the use of these tools in the studies until year 2000, thereafter it increased. Although the interviews were the most popular research instrument used in the studies (1995-2004), the year-by-year analysis showed the interviews being popular in the years 1996, 2001, 2002 and 2004 (see figure 8.7). The distribution of the four research instruments by institutions indicates that Wits University used interviews, questionnaires, test/activity and observations the most. This is not withstanding that Wits had the highest number of theses in the corpus. Interviews which are associated with qualitative research approach were used the most in historically English universities like Wits, UCT, UKZN and RU (see figure 8.8). Questionnaires, mathematics tests and activities were used the most in the studies from historically Afrikaans universities like UP, SU, NWU, UJ and UNISA (see figure 8.8). The aforementioned comments correlate with the observations that were made by Prof J when interviewed:

> I should imagine that quite a few of the Afrikaans universities are still doing a lot of quantitative stuff. (Interview with Prof Y 21/4/2008, page 6).

In the next paragraphs I analyse how data was analysed in the corpus of mathematics education postgraduate studies (1995-2004).

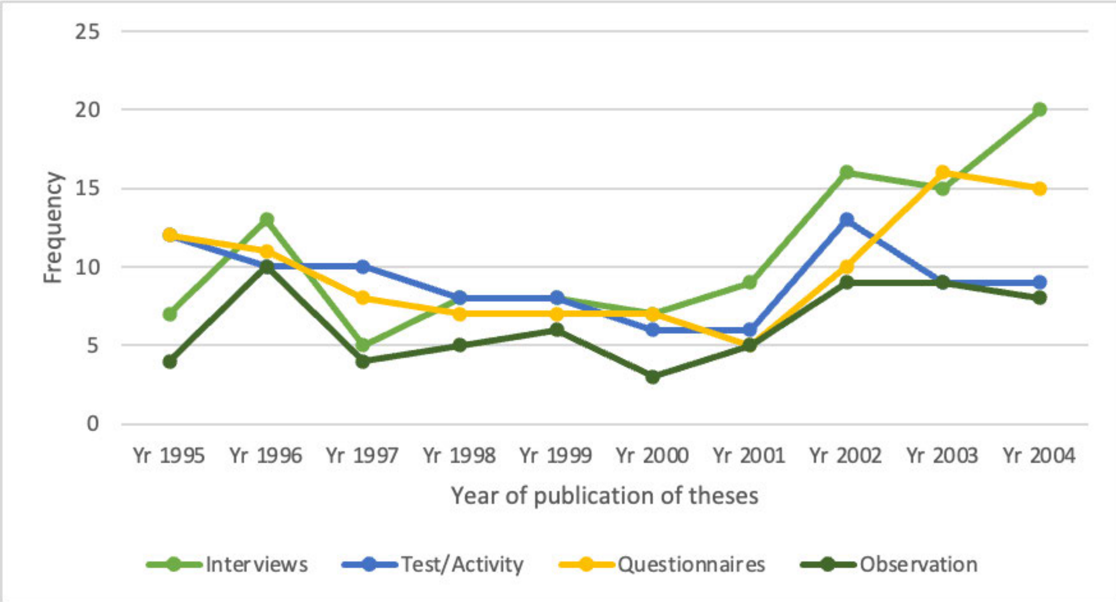


Figure 8.7 **Distribution of interviews, tests/activity, questionnaires and observations by year.**

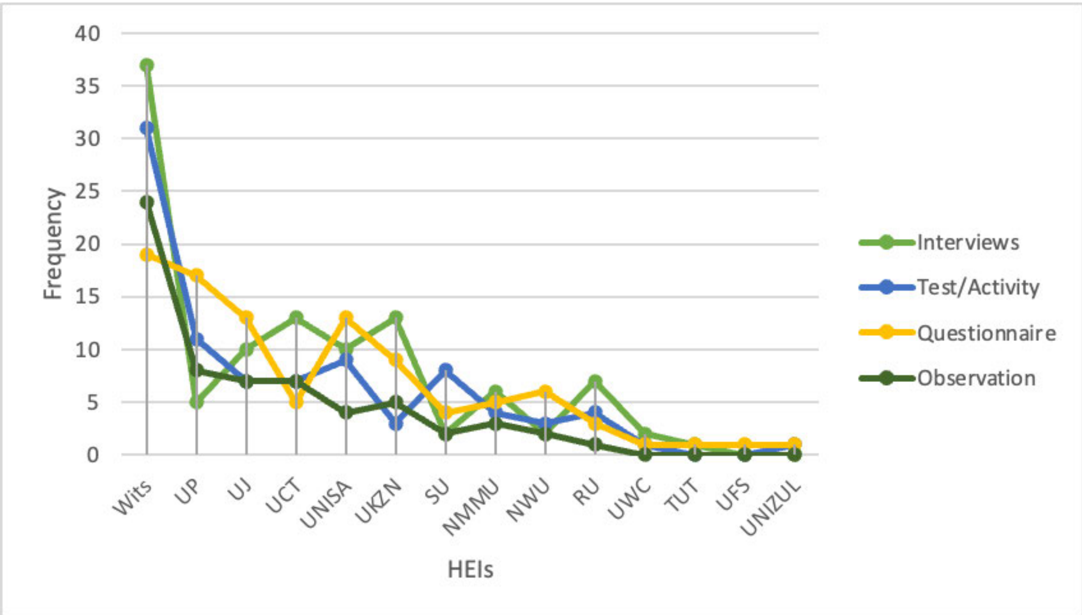


Figure 8.8 **Distribution of interviews, tests/activity, questionnaires and observations by institutions.**

8.5.5 Research analytical tools used in mathematics education postgraduate theses (1995-2004)

Studies sometimes used more than one research instrument to generate data, and also used more than one analytical tool to analyse data. Eighteen analytical tools were self-reported to be used in the studies. Three analytical tools were used the most: statistical (103), thematic (82) and content (25) analysis. The number of studies using the remaining analytical tools is shown in table 8.15. Despite the fact that more studies used qualitative (79) research approach, more studies utilised statistical (103) analysis. The number of studies which used statistical analysis increased when adding studies that used ANCOVA and correlational analysis. The explanation for more studies that used statistical analysis could be studies which used mixed (56), and quantitative (55) research approached were more than those which used qualitative approach (79).

Table 8.15 ***Analytical tools used in the studies***

Analytical tool	**Frequency**
Statistical	103
Thematic	82
Content analysis	25
Coding	15
Correlational	11
Descriptive	5
Discourse analysis	3
Document analysis	2
ANCOVA	1
Activity theory	1
Comparative method	1
Grounded analysis	1
Interrogative method	1
Qualitative	1
System analysis	1
Tasks	1
Textual analysis	1
Van Hiele levels	1

Statistical analysis involves a different number of calculations from descriptive to inferential statistics. Descriptive statistic techniques used in the studies were: correlation (Spearman rank and Pearson product moment), factor analysis, frequencies, regression, scatter gram analysis and time line graphs. The inferential statistic techniques included ANOVA, chi-squared test, Cronbach's coefficient alpha, t-test and F-test. It was the male (61) students that used statistical analytical tools than female (46) students and one unknown gender. More White (54) as opposed to African (45), Indian (7), Coloured (1) and Saudi Arabian (1) students used statistical analytical tools. It was mainly the masters (74) students who used statistical analytical tools than doctoral (34) students. The Wits (29) University students used statistical analysis more than students from UP (16), UNISA (14), UJ (12), NWU (7), NMMU (6), SU (6), UCT (5), UKZN (5), RU (3), UWC (2), UFS (1), TUT (1), UNIZULU (1). Generally, the statistical analytical tools were used mainly in the quantitative (47) and mixed (42) than qualitative (19) research approaches. As expected, studies using experimental (40), case studies (31) and surveys (22) research designs used statistical analysis the most. Studies using other research design- ethnography (4), exploratory (3), evaluation (2), ex post facto (2), phenomenology (2), action research (1), conceptual (1), correlational (1), descriptive (1), discipline of noticing (1), and grounded theory (1) - used statistical analytical tools.

Thematic analysis was used mainly in qualitative research where textual data was summarized into themes. Coding is another way of analysing qualitative data. Therefore, in this thesis, I combined the analysis of the thematic analytical tool to include coding and the total of theses was 92. Thematic and coding analytical tools were used the most by female (55) rather than male (37) students. Equal number of African (40) and White (40) students used thematic and coding analytical tools with the remaining Indian (8) and Coloured (4) students. These were mainly masters (78) as opposed to doctoral (14) students. Wits (28) University had the highest number of studies using thematic and coding analytical tools. Studies from other universities which used these analytical tools were: UJ (16), UKZN (14), UCT (11), RU (6), UNISA (6), NMMU (4), UP (3), UWC (2), NWU (1) and SU (1). As expected, more studies using qualitative (53) research approach preferred thematic and coding analytical tools than mixed (28) and quantitative (11). Logically the studies using thematic, and coding analytical tools were mainly based on case study (46) research design. The remaining studies using thematic, and coding analytical tools were underpinned by surveys (11), experimental (9), ethnographic (6), action research (4), grounded theory (4), exploratory (3), evaluation (2), narrative (2), phenomenology (2), correlational (2), discipline of noticing (1) and literature study (1).

Cohen et al. (2018) define content analysis as "a multipurpose research method developed specifically for investigating a broad spectrum of problems in which content of communication serves as a basis of inference, from word counts to categorisation" (p.164). Twenty-five studies used content analysis as an analytical tool. More masters (23) than doctoral (2) students used content analysis and slightly more female (14) than male (11) students used content analysis. Almost an equal number of White (12) and African (10) students used content analysis than Coloured (2) and Indian (1). For a change, Wits (3) had few students using content analysis as compared to UCT (8) with the highest number of studies using content analysis. The remaining institutions where content analysis was used were UJ (3), UNISA (3), UKZN (2), RU (2), NMMU (1), NWU (1), UP (1), and SU (1). Typically, content analysis was used mainly in studies underpinned by qualitative (17) research approach than mixed (6) and quantitative (2) approaches. These studies were spread around ten research designs: case study (9), experimental (4), surveys (3) action research (2), literature reviews (2), content analysis (1), documentary (1), evaluation (1), narrative (1), and phenomenology (1).

The year-by-year analysis of studies which used statistical, thematic, and content analysis follows a trend that was observed before. There was a decline in the number of studies which used the three analytical tools during the first six years and only increases after the year 2001 (see figure 8.9). Wits, UJ and UKZN had the highest number of studies which used thematic/coding analytical tools (see figure 8.10). Wits, UP, UNISA, SU, NMMU and NWU had the highest number of studies which used statistical analysis as an analytical tool. UP, UNISA, SU, NMMU and NWU are historically Afrikaans universities. The use of statistical analysis in the studies from the three institutions was associated with institutional research culture as mentioned by Prof J and shown in the analysis of research designs, approach, and method in this thesis.

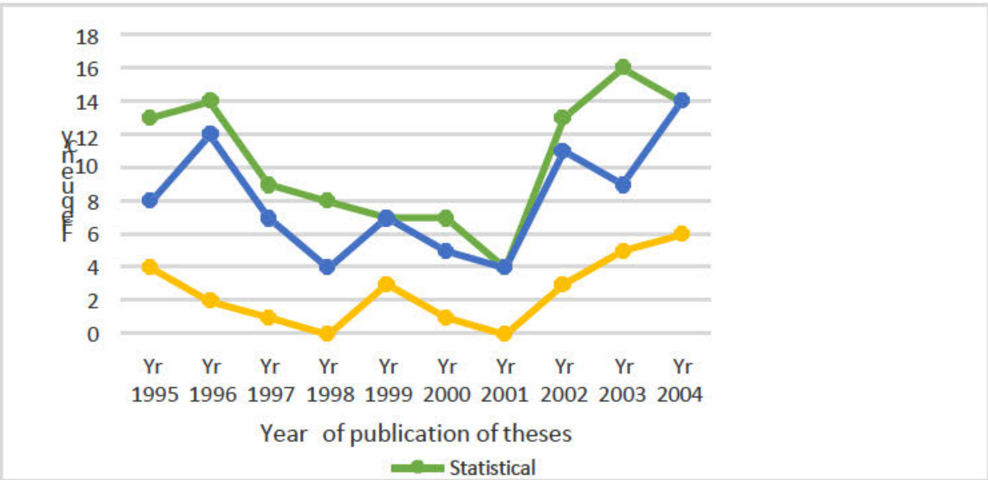


Figure 8.9 : Year-by-year distribution of statistical, thematic and content analyses

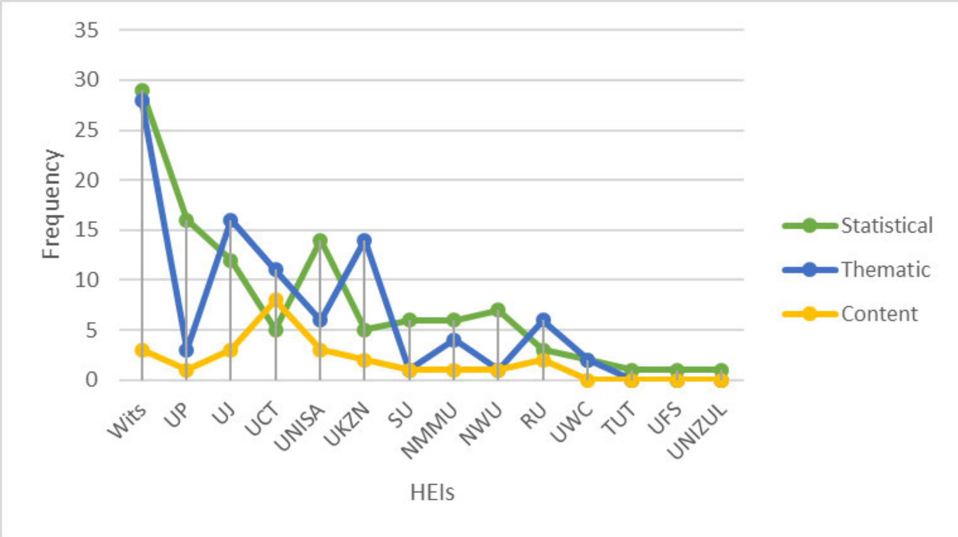


Figure 8.10 : Distribution of statistical, thematic and content analyses by institution

8.6 SUMMARY OF THE TRENDS OF THE RESEARCH PARADIGMS, DESIGNS, APPROACHES AND METHODS IN THE MATHEMATICS EDUCATION POSTGRADUATE THESES (1995-2004)

In this chapter, I set out to document the trends of the use of research paradigms, designs, approaches, and methods in the mathematics education postgraduate studies in South Africa during the period 1995 to 2004. Two research paradigms were prominent in the postgraduate research namely interpretive and positivist. Interpretive was the most widely used paradigm in the mathematics education postgraduate studies. However, theses from historically Afrikaans universities used mostly positivist paradigms. The high use of the interpretive paradigm in historically English universities and positivism in historically Afrikaans institution was associated with institutional research culture. Throughout the period (1995-2004), postgraduate students with the exception in 1997 dominantly used the interpretive paradigm. In 1997 more theses were produced by historical Afrikaans universities resulting in positivist paradigm being popular in that year. Female students dominantly used the interpretivist paradigm. Most of the studies that used interpretivism were from Wits. In contrast, more male students preferred the positivist paradigm. In addition, white students used mainly positivism and were from UP and UNISA. There were silences in deconstruction, structuralism, and post-structuralism paradigms in the mathematics education postgraduate theses (1995-2004). Some studies researching pedagogic phenomena were framed in interpretivist and others in positivist paradigms. Studies researching cognition, epistemology and knowledge research phenomenon were researched mainly in the interpretivist paradigm. Whereas studies researching assessment phenomenon were researched mainly in the positivist paradigm.

Case study, survey and experimental designs were prominent in the mathematics education postgraduate research (1995-2004). There were silences on discourse analysis, phenomenography, biography, and comparative method in the mathematics education postgraduate research (1995-2004). Ethnography was used mostly by doctoral students who would have longer time to spend in the field as opposed to their counter parts. An interesting trend is that although the three research designs (case study, survey and experimental) were prominent in postgraduate research there was a decline in their use in the first five years of the study period and an incline in the latter years. In addition, case studies were popular in postgraduate research from English HWUs. In contrast, surveys and experimental designs were popular in postgraduate research conducted in Afrikaans HWUs. Yet again, this observation was in line with preference of paradigms by mathematics education postgraduate students in South Africa (1995-2004). Case study and surveys were used the most by African students in contrast to white students who used experimental design. Furthermore, it was the female students who preferred case study research design. In contrast, male postgraduate students preferred experimental designs despite that there were more studies written by female students in the corpus data. Even though the case study design was prevalent throughout the period 1995-2004, however it was not the case in the year 2000. Similar to the paradigms, pedagogic phenomena was researched mainly with case study and experimental designs. Assessment was researched mainly with surveys. The affective domain was researched primarily with experimental designs. Descriptive research questions were posed mainly in studies using case study and survey designs. In contrast relational and explanatory research questions were posed mostly in studies researched with experimental designs.

Qualitative research approaches associated with the interpretive paradigm was dominant in the mathematics education postgraduate theses (1995-2004). However, masters preferred qualitative approach while doctoral students used mainly quantitative and mixed research approaches. Female students were likely to use qualitative approaches than their male counter parts. Wits University had the highest number of studies using qualitative and mixed method approaches. The year-by-year analysis revealed that either no or one doctoral student used a qualitative research approach in the nine years of 1995- 2004. Again, studies from historically Afrikaans universities leaned towards quantitative and mixed method research approaches signalling institutional research culture. Studies researching pedagogy phenomena were mainly framed either qualitatively or with mixed methods. Cognition, epistemology and knowledge phenomena were primarily studied qualitatively. Assessment phenomena were mostly researched with quantitative and mixed method approaches.

The sampling strategies that were likely to be used in the postgraduate studies were purposive, random and convenience sampling. Stratified, volunteer, systematic and cluster sampling were used in small number of studies to select participants in the corpus of studies. Quota and snowballing sampling strategies were not used in the postgraduate studies. The purposive sampling was used by White female masters students and it was studies from Wits University that mostly used purposive sampling to select participants. Purposive sampling was mostly used in the studies underpinned by qualitative research approach and case study design. Moreover, a number of studies framed with experimental design used purposive rather than random sampling. Random sampling was used by African masters students more than any other students in the corpus of studies. Studies in which participants were selected randomly came from UNISA and these studies were based on mixed and quantitative research approaches. The studies framed within experimental, surveys and case study research design selected participants randomly. In addition, studies underpinned by case study research design were also likely to select participants using convenience sampling. Also, studies in which participants were selected conveniently used mainly qualitative research approach.

More postgraduate studies were conducted in urban areas closer to where most universities are situated than in rural settings. Furthermore, the postgraduate students were researching across or down by selecting mainly learners and teachers as their participants. The participants selected in the postgraduate studies constituted large sample sizes. Mathematics educational research concentrated in secondary schools, specifically in matric. Primary mathematics education was neglected. Even when schools were mostly researched, there was dearth in knowledge produced in early childhood education and primary education. It was surprising though why there was one thesis in the ABET, because post 1994 there was a formalised training for adults and four levels equivalent to schooling phases were introduced. In fact, OBE was implemented with parallel learning outcomes for adult education. Concepts like lifelong learning accommodating adults were popularised.

Data in this study was predominantly gathered through interviews, questionnaires, tests/activities, and observations. Notably, there were no instances of employing collage and collaborative reflections as data collection methods. Specifically, research conducted by

African female master's students predominantly utilized interviews and observations. The majority of these studies originated from Wits University and English-speaking Historically White Universities (HWUs). Moreover, studies employing interviews and observations predominantly adopted a qualitative approach and case study design. In contrast, questionnaires, mathematics tests, and activities were more commonly utilized as data collection tools by White male master's students, who were predominantly affiliated with Wits University and Afrikaans-speaking HWUs. Research studies framed within experimental, case study, and survey designs were more inclined to utilize questionnaires and tests for data generation.

From 1995 to 2004, postgraduate studies in mathematics education predominantly employed statistical analysis, thematic/coding analysis, and content analysis. Statistical analysis was especially favoured by white male masters students and was used in 85% (34 out of 40) of doctoral studies, reflecting their preference for quantitative and mixed- method approaches. Many studies using statistical analysis originated from institutions like Wits University and Afrikaans HWUs. These analyses typically followed quantitative research methodologies, often incorporating experimental, survey, or case study designs. Conversely, thematic/coding analysis was a preferred tool among female masters students, particularly those engaged in qualitative research. Case study designs frequently utilized thematic analysis. Content analysis was prominently employed by master's students at UCT, primarily within qualitative research frameworks.

Transitioning to the subsequent chapter, the focus shifts to examining the theoretical underpinnings in the corpus of mathematics education postgraduate studies in South Africa during the same period (1995-2004). This examination provides insights into the theoretical frameworks and perspectives guiding the research, highlighting the diversity of approaches and the influences shaping the field during this era. Understanding these theoretical foundations is crucial for comprehending the broader context of mathematics education research and its evolution in post-apartheid South Africa. By analyzing these theoretical underpinnings, a deeper appreciation of the intellectual currents and scholarly contributions that have defined mathematics education research in this transformative period is gained.

CHAPTER 9

THEORIES USED IN MATHEMATICS EDUCATION POSTGRADUATE RESEARCH (1995-2004)

9.1 INTRODUCTION

The previous chapter dealt with the research paradigms, designs, approaches, and the methods that were used in the mathematics education postgraduate studies in South Africa in the period 1995-2004. This chapter focused on the theoretical frameworks chosen by mathematics education postgraduate students in South Africa (1995-2004). The theoretical viewpoints, provides the lens through which the reader views research. Creswell and Creswell (2018) argues that theory "provides a lens that shapes what is looked at and the questions asked" (p.49). In addition, Brown (1979) described the relationship between theory and research as the former determining what data are to be generated and the latter (through research findings) posing challenges to accepted theories. This means the research questions together with the theoretical viewpoints, determine what approach one needs to take when conducting research to arrive at certain findings.

Having analysed in the previous two chapters, research phenomena, questions, claims, paradigms, designs, approaches, and methods, it suffices in this chapter to analyse the theories used in the postgraduate studies. This chapter dealt with (1) what theories were used in the mathematics education postgraduate studies (1995-2004)? (2) What was the identity of the students who conducted research using theories identified in the previous question? (3) Which higher education institutions had studies using theories identified in question one? In addition, it also focused on (4) what research phenomena were underpinned by the predominant theories in the studies? (5) What kinds of research questions were phrased in the studies with prominent theories? (6) How were the theories used in the discussion of the findings in the postgraduate studies? Was it revisited or not? If it was revisited, was it modified, refuted, or supported (Tsatsaroni, Lerman & Xu, 2003)? Consequently, the MIR synthesis of the theories used in the mathematics education postgraduate studies in South Africa (1995-2004) followed the above-mentioned questions.

9.2 ANALYSIS OF THEORIES USED IN MATHEMATICS EDUCATION POSTGRADUATE THESES IN SOUTH AFRICA (1995-2004)

How was the data captured from the postgraduate studies? Parts of either the photocopied or actual mathematics education postgraduate studies were read to ascertain the theories used in the studies. Theories were gleaned from the abstracts, introductory chapters, literature reviews, theoretical frameworks, research design, methodology and analysis chapters. It was important to read the aforementioned parts, as there was no standard format in which the mathematics education postgraduate theses were written. Different HEIs used different writing styles in their postgraduate theses. Sometimes the theory was included in the methodology chapter. If the photocopied thesis had a missing section where theories could be read, that thesis was borrowed from the South African HEI using the inter-loan library system to be read again. Otherwise, the electronic theses were downloaded from the respective libraries and read again.

The theories were captured on two databases, EndNote and SPSS. Further, large textual data like abstracts, research questions and research claims were captured on EndNote for analysis. The data captured first, was the actual theory (e.g. Zone of proximal development) as gleaned from the mathematics education postgraduate studies. Second, the theorist such as Vygotsky were captured. Third, the types of research question posed in the studies were read to determine the type of research. Fawcett and Downs (1986) argued that there is a relationship between theory and research. Fawcett and Downs describe three types of theories: descriptive, relational, or explanatory. These types of theories are generated by respective research designs: descriptive, correlational, and experimental (Fawcett & Downs, 1986). Therefore, it was necessary to analyse the type of research questions which is central in generating theory. Similar to chapters 7 and 8, there were three types of research questions posed in the studies, namely descriptive, relational, and explanatory. Consequently, research questions led to descriptive, relational and explanatory research respectively.

It is important to point out that these three types of research questions are not mutually exclusive i.e. there might be some blurred boundaries between them. Descriptive research questions are exploratory in nature and are phrased as; what is…? These types of questions are meant to describe and classify the parts of a research phenomenon. Relational research questions seek to explain the relationship between parts of the phenomenon. Relational questions are phrased as; to what extent is… Explanatory research questions are linked to experimental research explaining why there are changes in a phenomenon studied (Fawcett & Downs, 1986). The research questions were analysed in chapter 7. Lastly, the analysis chapters were read to determine whether the postgraduate students actually used the theory in the analysis and not simply mentioned in the literature review and/or theoretical framework chapter(s). To illustrate how the mathematics education theses were read to capture data, for no particular reason, the first thesis captured on the databases was used.

Below is the abstract of the selected thesis (1-Adler, 1996) used to illustrate how the data was captured, followed by the classification of the theory and research questions.

> This is a study of *secondary mathematics teachers'* knowledge of the dynamics of learning and teaching mathematics classrooms in South Africa. It probes teachers' articulated and tacit knowledge through a *qualitative methodology* that includes *in-depth interviews, classroom observation*, and *reflective workshops*. The sample is *purposive* and *theoretical*, comprising *six teachers* drawn from *three different multilingual school contexts*. Categories of description and analytical narratives vignettes enable a qualitative, layered analysis of what the teachers said and how they acted.
>
> A *sociocultural theoretical framework* is developed to explain both teachers' knowledge and the learning and teaching of school mathematics. In a multilingual classroom, it is the teacher's role to harness language as a resource, and to assist learners' movement back and forth between their main language and the language of instruction on the one hand, and between every day, educational and mathematical discourses on the other. The complex communicative demands on teachers and learners are best understood within a *social theory of mind*. Here, teaching and learning are dialectical process, deeply interrelated.
>
> The notion of a *'teaching dilemma'* is the key analytic mechanism proposed to open up teachers' knowledge of the complex and dialectical nature of teaching and learning mathematics in multilingual classrooms. This *study confirms* that teaching dilemmas are at once explanatory tools and analytic devices for teaching. They make explicit the tensions inherent in teaching. Once located in a multilingual mathematics classroom, a language of dilemmas becomes generative of dilemmas that highlight tensions specific to the language and mathematical challenges in such classrooms.
>
> *Three key dilemmas emerge in this study:* the dilemma of *code-switching*, the dilemma of *mediation*, and the dilemma of *transparency*. *Evidenced in this study is that dilemmas suggest the need for a choice between opposites, they are never either/or in the complex life-blood of classrooms.* Instead, they are a potential source of praxis. Teachers manage their dilemmas, sometimes fully aware of the choices they make,

> choices that are at once personal, practical and contextual. At times, elements of their practice are obscured.
>
> The *theoretical contribution of this thesis lies in broadening the conception of teaching dilemmas and in extending the language of dilemmas to capture the specificity of the multilingual mathematics classroom.*
>
> The implications of the study for mathematics teacher education are profound yet simple. A language of dilemmas can assist teachers to recognise, talk about and act on the tensions in their practice, and so empower them to make informed and contextually appropriates pedagogical decisions (1-Adler, 1996, pp i-ii, own italics added in the above extract).

The research question posed in 1-Adler's (1996) study is: "What is teachers' knowledge of their practices in this complex multidimensional dynamic"?

Looking first at the theory, the postgraduate student (1-Adler, 1996) was explicit about the use of *sociocultural theory* and *social theory of the mind*. In addition, 1-Adler (1996) indicated the analytical tool *teaching dilemmas* in particular *language dilemmas*. What was not seen in the abstract are the theorists used in the study -*Vygotsky*, *Lampert* and *Lave and Wenger* gleaned from the theoretical framework chapter. Theory informed the empirical study as the postgraduate student developed language dilemmas (code- switching, mediation and transparency) to analyse teachers' knowledge of the complex and dialectical nature of teaching and learning mathematics in multilingual classrooms. Secondly, 1-Adler (1996) posed descriptive research question-: "What is teachers' knowledge of their practices in this complex multidimensional dynamic"? This type of questions was meant to describe and classify the parts of the research phenomena, teachers' knowledge of their practice and multilingual and multicultural classroom settings. Thirdly, 1-Adler (1996) used theory beyond the literature review and theoretical sections in her thesis, especially, in the last but one paragraph of the abstract, Adler signals how she used the theory. "The theoretical contribution of this thesis lies in *broadening* the conception of teaching dilemmas and in *extending* the language of dilemmas to capture the specificity of the multilingual mathematics classroom" (1-Adler, 1996, p.iii The theory of teaching dilemmas in particular the language dilemmas was modified.

Having illustrated above how I captured the data, I began with the analysis of the theories were used in the mathematics education postgraduate studies in South Africa (1995-2004). Ninety-eight percent (187) of the mathematics education postgraduate studies used theoretical framework. The remaining three studies either did not use theory or the section with theory was not photocopied. Table 9.1 shows examples of theories that were used in the mathematics education postgraduate theses in South Africa from 1995 to 2004. The entire list of theories used in mathematics education postgraduate studies are listed in appendix F. Although appendix F showed many theories (171) used in the mathematics education studies, only six theories were used in 10 or more studies. These were constructivism (66), problem-based learning (36), socio-cultural learning theory (15), levels of geometric thought (14), zone of proximal development (13) and co-operative learning (11). In the following paragraphs, I discussed each theoretical framework

9.2.1 Constructivism

Constructivism, sometimes referred to as a constructivist approach was used in most studies in the corpus of mathematics education studies. Three types of constructivism were used in the studies: constructivism, social constructivism, and radical constructivism. The proponents of constructivism theory cited in the studies were Ernest, Piaget, Schoenfeld, Vygotsky and von Glasersfeld. In addition, South African academics Olivier and Olivier, Murray and Human were cited as advocates of constructivism theory in some studies. In relation to research phenomena that theorised using constructivism, 11 out of 13 research phenomena discussed in chapter 7 were theorised using constructivism. Table 9.2 showed that 33 studies focusing on pedagogy phenomenon were theorised mostly by using constructivism. The remaining research phenomena; cognition, epistemology and knowledge (22), assessment (15), technology and resources (14), affective domain (12), language (4), socio-cultural political (4), curriculum policy & development (3), INSET (3), PRESET (3) and Leadership (1), also were theorised using constructivism. Constructivism is found in many disciplines such as psychology, philosophy, sociology, and education. As such more studies focusing on pedagogy and cognition, epistemology and knowledge were theorised using constructivism.

Table 9.1 ***Example of theories used in the mathematics education postgraduate studies (1995-2004). The entire list of theories is in Appendix F***

Theories	*F*	Theories	*F*	Theories	*F*
Abstraction	1	Code theory	1	Cyclic models	1
Achievement	1	Cognitive conflict	1	Diagnostic instrument	1
Action theory	1	Cognitive cartography	1	Discourse structure/ procedure	2
Activity theory	3	Cognitive development	8	Domains of mathematics practice	1
Affective schema	1	Cognitive inherent	1	Educational ideologies	1
Approaches to teaching algebra	1	Cognitive mapping/schema/ taxonomy	3	Enactivism	1
A prior synthetic	1	Cognitive theory of reading process	1	Enculturation	1
Areas of thinking	1	Collectivism	1	Ethno mathematics	3
Assessment in the pedagogy	1	Communities of practice	2	Evaluability assessment	1
Attentional Model for learning math	1	Computer application	2	Experiential learning	1
Attitude	3	Concept definition, image & development	6	Factor analysis	1
Bantu education	1	Conceptions of learning	1	Feminism	1
Beginning situation	1	Connectionist theory of reading	1	Functional model	1
Behavioural oriented theory	1	Constructivism/ Constructivist	66	Games	2
Bilingualism	1	Cooperative learning	11	Gendered learning styles/ stereotyping	2
Biography Transformation Model	1	Critical Mathematics Education	4	Gender and mathematics	2
Bloom's taxonomy	1	Critical theory	1	Generic technology	1
Chaos theory	1	Culture of learning and teaching	1	Geometry learning / schema	2
Classification & framing of knowledge	7	Cultural models/ schemata for readability	3	Group process model	1
Classical test theory	1	Cumulative learning model	1	Guided discovery	2
Classroom management	1	Curriculum	1	Habitus	1

Table 9.2 Research phenomena theorised using constructivism in the mathematics postgraduate studies in South Africa (1995-2004)

Research phenomenon	# of studies using constructivism	# of studies focusing on the research phenomenon	% of studies using constructivism
Pedagogy	33	77	43
Cognition, epistemology & knowledge	22	63	35
Assessment	15	53	28
Technology & resources	14	38	37
Affective domain	12	35	34
Language	4	15	27
Socio-cultural political	4	17	27
Curriculum policy & development	3	12	25
In-service Education & Training	3	12	25
Pre-service Education & training	3	6	50
Leadership	1	2	50

The findings indicate that more female (38 out of 66) than male (28) postgraduate students theorised their studies using constructivism. These were mainly masters (58) as opposed to doctoral (8) students, with almost an equal number of White (30) and African (27) students, then Indian (7) and Coloured (2) who theorised their studies using constructivism. Constructivism theory was used the most in the postgraduate studies from UJ (15) and Wits (15), and the remaining universities were UKZN (7), NWU (5), UP (5), UNISA (5), SU (4), RU (4) NMMU (3), UCT (2) and UWC (1).

The analysis of research questions for the studies theorised using constructivism, indicated that more studies posed descriptive research questions (44). This could be because of masters studies that did not necessarily have to develop theory. This is a basic type of research in which theory has not been developed and as such intended to describe the phenomenon. The following are examples of descriptive research questions posed in the postgraduate studies (1995-2004): “What part of using models in the teaching of standard eight geometry later assisted student to recall and be able to do geometry problems?” (26-Davids, 1997). “What access do teachers have to the regulating principles underpinning the 'new primary mathematics' curriculum?” (75-Long, 1995). “What approaches do learners use to solve problems that require the use of algebraic expressions and equations in a contextual situation?” (138-Phiri, 2003). “What does "mathematical thinking" entail? What cognitive process of mathematical thinking are involved during mathematical problem solving?” (148-Ramnarain, 1999). “How should we change the manner in which students learn so that they become active participants in their learning experiences?” (189-Wilson, 2002).

The second most posed research questions in the studies theorised using constructivism was relational (28). Relational research questions investigate the important characteristics of the phenomenon. Following are examples of relational research questions posed in the postgraduate studies: “To what extent does the students' understanding of the nature of definitions change while involved in a process of formulating definitions within a Sketchpad context?” (46-Govender, 2002). “How did the implementation of an absolutist, as opposed to a constructivist, pedagogy affect the pupils' levels of understanding of the concept "variable"?” (134-Padoa, 1995). “What is the influence of cognitive mapping as a strategy for teaching mathematics according to the constructivist approach to a grade nine class with visual disability?” (178-van der Spuy, 1997). “Is there any relationship between attitude, curriculum, and methods of teaching and learning difficulties in mathematics?” (167-Sibaya, 1999). “Will cognitive (brain) mapping help a learner to understand and develop mathematics?” (76-Loubser, 1997).

There were 11 out of 66 studies theorised on constructivism presented explanatory research questions. These types of questions produce explanatory theories. Examples of explanatory research questions/hypotheses from the data are:

> H: Everyday mathematics enhances matric pupils' performance and motivation. (49- Grinker, 1998)
>
> H_0A: Mathematics anxiety has no effect on mathematics performance.
> H_1A: There exists a negative relationship between mathematics anxiety and mathematics performance. (53-Hawkey, 1995)
>
> Why do students, after having successfully completed matric mathematics, find it difficult to adapt to first year post matric level mathematics (N4) at a technical college? (136- Pereira, 1995)

Having discussed above the different types of research questions giving rise to different types of research theorised with constructivism, I now analyse how theory was used in the postgraduate studies.

How was constructivism used in the mathematics education postgraduate studies? Was it revisited or not? If it was revisited, did the mathematics education postgraduate students modify, refute, or support it? Fifty percent of the studies using constructivism did not revisit the theory (see table 9.3). Despite that almost equal numbers of White (30) and African (27) students used constructivism in their studies, a high percentage (70% - 18) of African students did not revisit the theory. White (8), Indian (4) and Coloured (2) students did not revisit constructivism theory (see table 9.3). Almost equal numbers of female (17) and male (16) students did not revisit constructivism theory. The studies in which theory was not revisited were mostly from UJ (8) and Wits (8) with the remaining from UKZN (5), SU

(3), NWU (2), UP (2), UCT (1), NMMU (1) and RU (1). All the doctoral studies in which theory was not revisited, were from UJ.

Table 9.3 Use of constructivism theory in the mathematics education postgraduate theses in South Africa (1995-2004)

How was theory used?	Number of studies	Degree		Race			
		Masters	Doctoral	A	W	I	C
Not revisited	33	29	4	19	8	4	2
Supported	27	19	8	7	17	3	0
Modified	6	4	2	1	5	0	0

In 33 studies, constructivism as a theory was revisited and was either supported, or modified, however in 27 studies constructivism as a theory was supported. Contrary to theory not revisited, it was mostly White (17) students followed by African (7), and Indian (3) students that supported constructivism theory in their studies (see table 9.3). More female (17) than male (10) students supported constructivism theory, and most of these students were from UJ (6). The rest of the students were from Wits (5), UNISA (4), UKZN (2), MNNU (2), NWU (2), RU (2), UCT (1), UP (1), UWC (1) and SU (1). Constructivism was supported as a theory of teaching in the studies as evidence in the research claims of some of the studies:

> Constructivism is seen as the synthesis of critical aspects of teaching and curriculum development which will stem the perpetuation of mathematics anxiety. Constructivism provides the didactic approach to develop each individual's intellectual autonomy and mathematics power, by instilling a problem-solving attitude and a self-confidence when doing mathematics. (53-Hawkey, 1995).
>
> In conclusion, it can be assumed that constructivist learning theory principles served as a foundation for this study which effectively promoted learning." (130-Oosthuizen, 1996)
>
> It appears that the most important reason for their negative conception is that they were not adequately equipped for the constructivist approach towards mathematics teaching. This study then proposes that for teachers to be able to teach from a constructivist paradigm they need relevant constructivist training, more support from each other. They need to change their teaching conception to a constructivist conception of teaching. (152-Roos, 1996)
>
> Course design and development should be based on the Post-Fordist notion in the constructivist paradigm (189-Wilson, 2002)
>
> The analysis of covariance of the data indicated that those students who had experienced the constructivist approach to teaching and learning algebra improved statistically significantly ($p<0.0001$) in relation to those pupils who had experienced the traditional approach to teaching and learning algebra (134-Padao, 1995).

In six studies the theory was modified and was written by five White and one African students. Four of these students were female and two males. These students were from UP

(2), NWU (1), UJ (1), RU (1) and Wits (1) which are HWUs. They were registered for masters (4) and doctoral (2) studies. In one study it was accepted that social constructivism is dynamic:

> The framework sheds more light on the dynamic of social constructivism and recognises one of the emergent properties of the CSCML environment could act as a catalyst to reshape and redirect traditional educational practices (87-Matthee, 1998).

Having discussed who used constructivism and how it was used in the postgraduate studies, it is important to understand why was there prevalence towards constructivism as a learning theory in the HWUs. Prof J succinctly captures the possible reason why constructivism was prevalent in the HWUs. Prof J suggested that the former Afrikaans university in the Western Cape introduced constructivism in South Africa. This was observed earlier, the South African academics linked to constructivism, were from HWUs. Below is the excerpt from the interview with Prof J, to this effect:

> Prof J: I mean the people at Stellenbosch spent a lot of time on constructivist-inspired mathematics education that they called problem-centred driven. They did quite a lot of creative work on that stuff and they really constructed a sort of pilot almost for change of curriculum from the old curriculum to the present…But again, they really inserted more than anyone else, the dominance of ideas of constructivism in mathematics education locally. I mean this university was for a long time very heavily influenced by humanistic mathematics coming out of the UK which was also influenced quite heavily by ideas grounded in psychology…You had the sort of white liberal universities tending to draw on that UK influence and then the other universities, Afrikaner universities especially seemed to be well, not all of them … I think Stellenbosch had a bit of a battle, but Stellenbosch certainly introduced that and then it seemed to spread. In addition, they seem to gain a very strong foothold, managed to persuade at least the Western Cape to adopt a new curriculum for mathematics that was constructed along the lines of constructivism. I mean there was a whole battle between the Dutch church and Stellenbosch University.
>
> Interviewer: With regards to Mathematics?
>
> Prof J: Yah, because they were saying that the constructivist ideas were undermining all sorts of things held sacred by the church like the authority over the people etcetera.
>
> Interviewer: Interesting.
>
> Prof J: And so you know, in the Afrikaans press over here, De Bield and so on, there was a whole flurry of exchanges between the lecturers at Stellenbosch and the press. I mean they did see it as something that was quite undermining our traditional values. (Interview with Prof J, 2008, p. 15-17).

Despite academics from SU having propagated constructivism in South Africa, there weren't overwhelmingly many studies using constructivism theory in SU. UJ (15) and Wits (15) had more studies using constructivism than SU (4) (see table 9.4). In the next subsection I analyse problem-based learning.

Table 9.4 Comparison of studies using constructivism from SU, UJ and Wits.

HWU	Number of studies using constructivism	Total number of studies from the HWU in the data base	Percentage
Wits	15	54	28
UJ	15	21	71
SU	4	10	40

9.2.2 Problem-based learning

The second most used theory in the mathematics education postgraduate studies was problem-based learning (36). Problem based learning included problem solving and problem centred approaches. George Poyla was the theorist cited the most in the studies related to problem-based learning. Other theorists who were cited were Bell, Cobb, Cockcroft, Dewey & Fraser, Ernest, Gagne, Handler, Klein and Tobin. The South African academics cited in the studies with respect to problem-based learning were Human, Olivier, Murray and Human and van Niekerk. Of the 36 studies, 28 theorised using problem-based learning and dealt with pedagogy phenomenon. The remaining research phenomena researched in the studies using problem-based learning were: cognition, epistemology & knowledge (12), assessment (7), technology & resources (6), affective domain (3), curriculum, policy & development (2), language (2), ABET (1), PRESET (1) and socio-cultural political perspectives (1) (see table 9.5). In contrast to constructivism, more males (21) than females (15) theorised their studies with problem-based learning. Most of these students were White (19) as opposed to African (13), Indian (3) and Coloured (1) and were registered for masters (28) degree than doctorate (8). There was no institution that stood out where more students theorised their studies with problem-based learning. The studies theorised with problem-based learning were distributed in the institutions as follows: UJ (6), UP (6), UNISA (6), Wits (6), RU (3), UKZN (2), NWU (2), SU (2), NMMU (1), TUT (1), and UWC (1).

Table 9.5 ***Research phenomena theorised using problem-based learning in the mathematics postgraduate studies in South Africa (1995-2004)***

Research phenomenon	Number of studies using problem-based learning	Number of studies in the data base using the research phenomenon	%
Pedagogy	28	77	36
Cognition, epistemology & knowledge	12	63	19
Assessment	7	53	13
Technology & resources	6	38	16
Affective domain	3	35	9
Curriculum policy & development	2	12	17
Language	2	15	13
ABET	1	1	100
PRESET	1	6	17
Socio-cultural political perspective	1	17	6

There were three types of research questions posed in the studies theorising problem-based learning, namely descriptive, relational, and explanatory. Seventeen studies theorising problem-based learning posed descriptive research questions, which elicit description or classify certain characteristics of the phenomenon or groups. Some of the descriptive questions posed in the studies were: “What language difficulties do learners experience when solving algebraic word problems?” (55-Guambe, 2004). “How can weak Grade 5 learners develop and improve their problem-solving ability in mathematics?” (13- Boschoff, 2002). “What approaches do learners use to solve problems that require the use of algebraic expressions and equations in a contextual situation?” (138-Phiri, 2003). “What cognitive process of mathematical thinking are involved during mathematical problem solving?” (148-Ramnarain, 1999). “What is junior primary teachers' conception of problem centred mathematics teaching?” (152-Roos, 1996). In these studies, theory has not been developed and as such the parts of the phenomenon are described. Thus, the kind of knowledge produced through such studies was descriptive in nature. If little is known about a phenomenon, then grounded theory is developed through descriptive research.

There were 18 studies out of 36 theorising problem-based learning which posed research questions evaluating relationship between characteristics of a phenomenon. These types of questions were phrased like: To what extent does A affect B or what is occurring here? Below are relational questions posed in some studies:

> Would an emphasis on the problem-centred approach lead students to a better understanding of the solution of systems of linear equations? (44-George, 2001)
>
> What is the impact of mathematics tutorials on problem-solving abilities and critical thinking? (77-Louw, 2003)

> What effect does the direct instruction in problem solving strategies have on the mathematical problem-solving performance of Grade 8 learners? What effect does direct instruction in problem solving strategies have on the attitude and approach of Grade 8 learners towards problem solving in particular and mathematics in general? (148-Ramnarian, 1999)

The type of relational questions posed in the studies as shown above, produced knowledge which highlighted the relationship between parts of a phenomenon. These types of questions can be posed after the important parts of the phenomenon are known in the mathematics education field. There were seven studies that theorised problem-based learning and posed research questions that were explanatory in nature leading to experimentation. An example of the explanatory research questions posed in the studies was: "Will learners better approximate the gradient concept, while they must first be exposed to a numerical understanding through curve fitting from a problem-approach" (28- de Witt, 1998)? These types of questions surpass the relational knowledge to predicting the cause and effect of the changes in a phenomenon, and ultimately these types of questions produced explanatory theory.

How was problem-based learning used in the mathematics education postgraduate studies? Was it revisited or not? If it was revisited, did the mathematics education postgraduate students modify, refute, or support it? Was problem-based learning only mentioned in the theoretical framework and literature review chapters but not referred to in the analysis chapters? As expected, in many postgraduate studies theories were not revisited (21). The studies in which theory was not revisited were written by almost the same number of White (10) and African (9) students, and little number of Indian (1) and Coloured (1) students. The students who did not revisit theory were mainly masters (17) than doctoral (4) students. They were from UP (6), UJ (4), UNISA (4), Wits (3), SU (2), RU (1) and TUT (1). Theory was supported in 15 studies. The studies in which theory was supported were written mainly by White (9) as well as African (4) and Indian (2) students. Almost equal number of female (8) and male (7) students supported theories that were used in their studies. These students were registered for masters (11) than doctoral (4) degrees. They were registered at Wits (3), UJ (2), UKZN (2), NWU (2), RU (2), UNISA (2), NMMU (1), and UWC (1). In these studies, problem-based learning was supported to be the learning theory which enabled learners to learn mathematics better. It was suggested as well that mediation and constructivism could improve learners' problem-solving skills. Below are some excerpts from studies which supported problem-based learning:

> Teachers should use the interactive method to teach problem solving as well as mathematical content. Problem solving is the overall umbrella under which meaningful mathematical knowledge construction occurs (13-Boshoff, 2002).

> The findings of the empirical investigation have revealed that the strategies-based problem-solving approach is a viable and effective one (148-Ramnarian, 1999).
>
> The results show that with mediation there is an improvement in the pupils' problem-solving abilities (32-Dirks, 1996).
>
> This would seem to indicate that the constructivist and investigative approach to teaching produces better results than the traditional approaches (159-Sebela, 1997).

The next subsection focused on socio-cultural theory used in the studies.

9.2.3 Socio-cultural theory

Fifteen studies were theorised using socio-cultural theory. Socio-cultural theory included social practice theory advocated by Lave and Wenger and sociolinguistic theory propagated by Vygotsky and Gawned. There were eight out of 13 research phenomena that were theorised with socio-cultural theory. These were cognition, epistemology & knowledge (7), language (6), pedagogy (4), technology & resources (4), assessment (3), affective domain (3), ABET (1) and socio-cultural political perspectives (1). It was female (11) than male (4) postgraduate students that used more socio-cultural theory. The same number of African (6) and White (6) students as well as Indian (2) and Saudi Arabian (1) theorised their studies with socio-cultural theory. Twelve of these students were registered for masters and three doctoral degrees. Studies using a socio-cultural lens were from Wits (11), UKZN (2) and UNISA (2) only.

Regarding the kind of research questions that were posed in the studies with socio-cultural theory, only nine studies descriptive research questions were posed, and the following are examples. “What is teachers' knowledge of their practices in this complex multidimensional dynamic” (1-Adler, 1996)? “In what kinds of teaching and learning environment are youth at-risk being taught” (155-Rughubar, 2003)? For relational questions, six studies were identified. “How can racial mathematical stereotypes and multicultural education in the post-apartheid dispensation be reduced or totally eradicated” (126-Nkotoe, 1996)? “To what extent do the concepts of subject matter knowledge, pedagogical content knowledge and curricular knowledge, provide a useful tool of analysis to illuminate the knowledge practices that take place in the classroom” (58-Howie, 2004)? There were three studies that posed explanatory questions. For example, 85-Matlhaga (1995) posed the explanatory question: “Will exposure to diagnostic-remedial programme help greater numbers of disadvantaged children improve their achievement in algebra and in geometry?”

How was socio-cultural theory used in the studies? The theory was not revisited in 8 out of 15 studies. The theory was supported in four studies. 126-Nkotoe (1996) in her study supported socio-cultural theory by arguing "Despite constraints, multicultural mathematics education remains one of the potentially efficacious means of achieving a new pluralistic, prejudiced-free democracy". Socio-cultural theory was modified in two studies. 1-Adler (1996) argued that "the theoretical contribution of [her] thesis lies in broadening the conception of teaching dilemmas and in extending the language of dilemmas to capture the specificity of the multilingual mathematics classroom". The socio-cultural theory was refuted in one study. 8-Berger (1996) argued that:

> The qualitative analysis of the interview data suggests that the calculator functioned primarily as a tool which amplified the zones of proximal development of the students, increasing efficiency and speed, rather than as a semiotic system which had been internalised. The quantitative analysis of the statistical data failed to support this notion of amplification. It is suggested that the add-on status of the graphic calculator undermined the possibility for statistical significance on this amplification effect (p. iii).

The professors' responded differently to the question about the use of socio-cultural political theories in mathematics education research in South Africa. On one hand, one professor supported the use of socio-cultural political theories in the post-apartheid South Africa.

> Oh, definitely. I think that the field of mathematics education outside of South Africa was very cognitive. Mathematics education is still dominantly psychological and development oriented in method so it's more driven by mathematics itself and cognition than questions of social questions of learning and the interaction between those. There's certainly a shift and I think that our role in South Africa contributed a huge amount to put on the map. (Interview with Prof X, 4/4/2008, p.27).

Prof X suggested that the South African political situation in the 1980s and early 1990s assisted the international mathematics education field to shift from cognitive to social theories. The South African political situation demanded that not only cognitive tools be used in research, but also sociocultural, political and gender lenses in understanding research phenomena. However not all supervisors shared the same sentiments about socio, cultural political perspective of mathematics education in South Africa. Prof J shared his views about ethnomathematics as follows. I must spell out that Prof J uses sociology of education in his research work:

> …so with ethnomathematics the idea is that mathematics is specialized in different ways, in different contexts. So, carpenters have a particular way of using mathematics, doctors or mathematics professors etcetera. So, this is the general idea, so you know domestic workers, bakers whatever, they all have some form of mathematics that they use, but the idea became quite attractive for a while because of its perceived liberatory potential, that it started recognizing mathematics all over because of the way in which it was defined. So, you know all the masses of people who were subjugated under apartheid, according to this definition of mathematics, automatically and intrinsically must be producing mathematics according to the study. I mean that was it's attraction so it seems strong sort of culturally affirming and political motivation for this.
>
> Interviewer 1: Do you think that this is still continuing?
>
> Prof J: Yah, I still tend to find that there is still quite a lot of that going on. And then there have been a lot of students who were busy studying doing projects that were related to ethnomathematics. I mean we haven't really done any here because we tend to be highly critical of the idea.
>
> Interviewer 2: Why? Why is that?
>
> Prof J: Why? Because we think it is taking mathematics and allowing mathematics to colonize non-mathematical spaces. So, it is almost like a form of imperialism for me. You know…because it goes along with the idea that mathematics is important in everyday life, that you need mathematics in your everyday life to be able to live your life. I just think that's nonsense. (Interview with Prof J, 2008, p. 13).

The next subsection focused on the levels of geometric thought theory used in the postgraduate studies.

9.2.4 Levels of geometric thought

Fourteen studies were theorized with levels of geometric thought, which are van Hiele and Hoffer. Seven out of 13 research phenomena were theorized with the levels of geometric thinking. These were cognition, epistemology and knowledge (11), pedagogy (7), technology and resources (4), assessment (3), INSET (1), language (1) and socio-cultural political perspectives (1). The students who used the levels of geometric thinking were mainly females (9) than males (5). Equal number of African (5) and White (5) students used the levels of geometric thinking as well as four Indian students. These students were registered for masters (10) and doctoral (4) at nine institutions: UCT (3), UKZN (3), UNISA (2), UJ (1), NMMU (1), NWU (1), SU (1), Wits (1) and UNIZULU (1).

The research questions that were posed in the studies theorized with the levels of geometric thinking were seven studies posed descriptive research questions leading to descriptive research. Examples of such questions are: “What is the level of Grade Seven learners' understanding of geometry in historically black primary schools of the Eastern Cape in terms of van Hiele levels” (41-Feza, 2004)? “What are children's thinking about three - dimensional containers in other contexts in terms of van Hiele levels of thinking” (73-Lampen, 2001)? There were eight studies which posed relational research questions and the examples are: “Is there any gender difference with regard to achievement in Euclidean Geometry at senior secondary level in selected South African schools” (25- Cronje, 1995)? “Does the van Hiele model appropriately describe students' progress through the course” (88-Mc Auliffe, 1999)? Three studies posed explanatory research questions. “No differences exist in mathematics test performance among pupils grouped according to the following characteristics: variables sex, age, class, stream, mathematics grade” (166-Sibaya, 1995). Depending on the type of research questions posed this impact on how theory was used in the studies. For descriptive studies, theory was at a developmental stage. Relational research investigated how theory was related to the research phenomena in the studies. Explanatory research took the theory to the next level trying to understand why parts of a phenomenon work.

I noticed that theory was not revisited in 10 studies and studies which did not revisit theory were masters (9) and one doctoral thesis. The theory was supported in four studies, and the example of how this was done in the studies is as follows “Furthermore, it reaffirmed the idea that learners can be taught from a general to the more specific, enabling them to develop a better understanding of concepts being taught” (112-Mudaly, 2004). The next theory that was analysed is the zone of proximal development.

9.2.5 Zone of proximal development

Thirteen studies were theorised using Vygotsky’s Zone of Proximal Development (ZPD). Nine out of 13 research phenomena were theorised with ZPD and these were pedagogy (6), technology and resources (4), cognition, epistemology and knowledge (3), affective domain (2), assessment (2), curriculum policy and development (2), language (2), ABET (1) and

PRESET (1). There were mainly female (10) than male (3) postgraduate students and only White (7) and African (6) students theorised their studies with ZPD theory. Eleven of these students were registered for masters and two doctoral degrees and studied at Wits (7), UJ (2), UCT (1), NWU (1), UP (1) and US (1). There were eight studies that posed descriptive research questions in the studies with ZPD, and the following are examples: "How does an individual learner come to know or understand a mathematical object to which the initial access is the various signs (such as words and symbols) of the definition" (9-Berger, 2002)? "How do learners interpret consolidation activities in an OBE-styled textbook" (95-Mofolo, 2003)? Relational questions were posed in six studies. "The extent to which mathematical expertise impacts on a facilitator's ability to mediate mathematical knowledge" (145-Rademeyer, 1997). "Is there any relationship between attitude, curriculum, and methods of teaching and learning difficulties in mathematics" (167-Sibaya, 1999)? There were no explanatory research questions posed in the studies theorised with ZPD.

Regarding the use of ZPD theory in the studies, five out of 13 studies did not revisit the theory. The following are examples of how ZPD was supported in studies. "It is suggested that the formation of mathematical concepts by learners in inclusive classrooms in general could be enhanced by the teachers' working within the learners' zone of proximal development and by employing qualitatively different scaffolds that support the learners" (67-Khumalo, 2000). "The qualitative analysis of the interview data suggests that the calculator functioned primarily as a tool which amplified the zones of proximal development of the students, increasing efficiency and speed, rather than as a semiotic system which had been internalised" (8-Berger, 1996). The theory was modified in three studies, and an example is 9-Berger (2000). "Appropriation theory is a large first step in the elaboration of Vygotsky's theory of concept formation to the mathematical domain particularly at higher mathematical levels where mathematical ideas are presented through mathematical signs rather than concrete objects". The next theory analysed is co-operative learning theory.

9.2.6 Co-operative learning theory

Eleven studies were theorised using co-operative learning theory. Theorists associated with co-operative learning were Richards, Platt and Platt, Stevens, Slavin and Vygotsky. Co-operative learning theory was used in four out of 13 research phenomena. These were pedagogy (7), assessment (4), affective domain (2) and curriculum, policy & development (2). Only African (6) and White (5) students theorised their studies with co-operative learning, and these were six male and four female students including one student whose gender was unknown. Mostly these were masters (9) than doctoral (2) students and were from UJ (3), NMMU (2), NWU (2), UNISA (2), RU (1) and Wits (1).

From the analysed data, four studies posed descriptive research questions such as: "How do mathematics teachers in a primary school learn about co-operative learning in their classrooms" (16-Campbell, 1999)? "What level of understanding do the respondents have to OBE and Cooperative learning" (184- Volschenk, 2004)? There was six studies that posed relational research questions and the examples of such questions are: "What is the impact of the application of the Hour-glass model of cooperative learning on the learning of mathematics in crowded classrooms" (161-Sekao, 2004)? "To what extent presented as cooperative learning teaching method an optimal solution for knowledge and skills development for the student" (14-Buys, 1998)? Only two studies posed explanatory research questions and the example is, "Are the mathematics test results of students who have been exposed to the chosen co-operative learning strategy any different to those of students who are exposed to standard strategies" (141-Potgieter, 2003)?

The theory was not revisited in four studies, but was supported in seven studies. This is suggested in the claims of the studies such as, "The teachers who applied the Hour-glass model revealed that they coped easier with crowded mathematics classes when using cooperative small groups" (161-Sekao, 2004). "Co-operative learning provides for active involvement of student in the learning process" (14-Buys, 1998). "The findings of the study suggest that the cooperative and learning task does assist in promoting favourable attitudes towards mathematics among the students" (83-Mashaba, 1998). Having discussed the prevalent theories in the postgraduate studies (1995-2004) it is important to understand why students choose the theories they used in their studies.

9.2.7 Why did the postgraduate students choose the theories used in their studies?

Textual analysis of the postgraduate theses alone provides limited information on the possible reasons why students choose certain theories in their studies. However, the interview with Prof X and Y shed light on this phenomenon. Prof X's experiences of supervision as a doctoral student, reveals that she learnt about theories from communities such as Psychology of Mathematics Education (PME) and Southern African Research on Mathematics Science and Technology Education (SAARMSTE). In turn, as a supervisor, she encouraged her students to present at conferences while studying or learn from other experts in the field. This is how she related her story:

> Professor [her supervisor] is a philosopher and I knew she would look after the rigour of the thesis. She didn't know the field at all so I had somebody who was quite far away who was a Vygotskyian. There were very few Mathematics educators who were working in a Vygotskyian framework. So, she had expertise on activity theory and Vygotskyian work and you'll see if you look at my PhD, … Vygotsky did not give me the tools with which to understand professional learning and I turned to Shulman for that and then I had to pull the two together. But, that's why I went outside the country to find somebody to supervise me so she was more at a distance. I was on my own, there was no community, I had to set up my own community and PME became my community. Because it was an established conference [and] it was more dominantly psychology, but there were people interested in socio-cultural theory and I went every year to PME when I was doing my PhD so that I had a community to interact with in my work. I didn't have it with colleagues where I was studying and I didn't have it in my supervisors that were close at hand. So, I had to construct it. And I suppose I knew how important that was so it wasn't how I was supervised, it is what happened while I was doing my PhD that I made sure that my students were part of a community themselves and became part of the community so they had to go to PME, they had to go to SAARMSTE. (Interview with Prof X, 4/4/2008, p.18).

The above suggests that students need not choose theories that their supervisors are familiar with but that are most relevant for the study. Students can engage with the mathematics education community to further understand the theory they are using in their studies. Contrary, Prof Y suggested that the changing ways of knowledge production from individualistic research to "emerging culture of research teams" (Lerman, Xu & Tsatsaroni, 2002, p.32) might influence what students research. Supervisors in research teams could influence their postgraduate students into using a particular theory relevant for the project. Prof Y argued that:

> So, we supervise across a very large variety of topics. I still think that we have a lot of influence and a lot of impact on what the student research. If the research forms part of the funding project, that is pretty direct and focused. So, one would recruit into that stream and into that theme straight away (Interview with Prof Y, 21/4/2008, p.7).

Though most of the theories in appendix F were used generally in all HEIs, one theorist was used only in two institutions. Bernstein's work on *classification and framing*, *pedagogic discourse* and *symbolic control* was used specifically at Wits and UCT. One possible influence of a particular theorist in a certain institution could be because of a powerful and influential researcher(s) who publish(es) using that theory a lot.

9.3 SUMMARY OF THE TRENDS AND EMERGING ISSUES ON THEORIES USED IN THE MATHEMATICS EDUCATION POSTGRADUATE THESES (1995-2004)

In this chapter, I set out to document the trends in the theories used the mathematics education postgraduate studies in South Africa during the period 1995 to 2004. Specifically, I wanted to find out first, what theories were used in the studies (1995-2004)? Secondly, what was the identity of the students who conducted research using theories identified in this chapter and from which HEIs were these students? Thirdly, what research phenomena were researched using the predominant theories in the studies? Fourthly, what kinds of research questions were phrased in the studies with prominent theories? Lastly, how was the theory used in the discussion of findings in the postgraduate studies? Was it revisited or not?

Many theories (171) were used in the corpus of mathematics education postgraduate theses in South Africa (1995-2004). However, only six theories were used in 10 or more studies. These were constructivism, problem-based learning, socio-cultural, levels of geometric thought, zone of proximal development and co-operative learning theory. Pedagogy and cognition, epistemologies and knowledge were the most researched phenomena in the studies theorised with the aforementioned theories. While female more than male students preferred to theorise their studies using constructivism, socio-cultural, levels of geometric thought and ZPD theories, male more than female students preferred problem-based learning. In the corpus of studies, the distribution of the race of the students was Whites (91- 47%), African (76-40%), Indian (17- 9%), Coloured (5-3%) and other (1-1%). With that said, only problem-based theory was preferred more by White students than their counterparts. In the studies using other five theorises, there were more or less equal number of White and African students using them.

Notwithstanding that there were more masters than doctoral studies in the corpus, and the selection of theories depended on the nature of each study, it was the masters students who chose the six prevalent theories. The studies theorised with constructivism, problem-based learning and levels of geometric thought were from most universities in the database. The studies theorised with co-operative learning, socio- cultural and ZPD were from fewer HEIs.

What is worth noting is that studies that theorised with constructivism were dominantly from Wits and UJ, despite that it was the academics from SU who propagated constructivism in South Africa in the early 1990s. In addition, irrespective that South Africa was in the post-apartheid era in 1995-2004, few studies (15) were theorised with socio-cultural theory. Moreover, these studies were from only three institutions namely Wits, UKZN and UNISA. In fact, there were two views from the interviewed professors, as part of the data for my study. On one hand, it was suggested that South Africa played a significant role in shifting the international mathematics education community to theorising in the socio-cultural and political theories. On the other hand, the use of socio-cultural and political theories was not welcomed due to knowledge fights between the everyday and scientific mathematical knowledge. Furthermore, most studies theorised with ZPD were from Wits.

The research questions posed in the studies theorised with the six theories (constructivism, problem-based learning, socio-cultural, levels of geometric thought, ZPD and co-operative learning) were basically descriptive and relational. Few studies had explanatory research questions. This suggests that most studies focused on the development of theory related to the phenomena researched. These studies name and classify the parts of the research phenomena studied which leads to theory generation. In addition, most studies posed relational research questions, where the relationship between parts of the phenomenon were investigated. Thus, in these studies, theory was developed after the essential parts of the phenomenon was known. The prevalence of descriptive and relational theories in the corpus of theses could be the result of more masters than doctoral studies. Very few studies posed explanatory research questions that linked to experimental research, explaining why there are changes in a phenomenon studied. Having discussed the type of theories developed in the studies theorised with the six theories, I summarised how these theories were used.

In the studies using the six theories mentioned above, theory was not revisited in 50% of the studies. Most of the studies where theory was not revisited were masters. The reason could be that masters dissertations do not necessarily have to produce new knowledge. In addition, in the studies theorised with constructivism, it was mostly the African students who did not revisit the theory. The students might have thought of the impossibilities and lack of skills to critic powerful scholars who came up with those theories. However, one professor suggested that learning communities such as conferences and cohorts could assist postgraduate students with theorising in their studies. In the other 50% of studies in which theory was revisited, it was mainly supported rather than modified or refuted. These were studies theorised using problem-based learning, levels of geometric thought, ZPD and co-operative learning. The studies that were theorised with constructivism and problem-based learning, it was dominantly supported by White students. Moreover, these studies were from HWUs. Constructivism theory was modified in a small number of studies by White female students from HWUs. Similarly, socio- cultural theory was modified in few studies by white students from HWUs. Over and above, socio-cultural theory was refuted in one study by a White female student. Having discussed the six theories which were prevalent in the studies, I summarise the sporadic theories.

There were silences on theories like abstraction, action theory, chaos theory, classical test theory, code theory and item response theory from within the disciplines of mathematics and statistics. Bernstein's theories of classical framing, pedagogic discourses and symbolic control were limited to two institutions, which are Wits and UCT. One professor suggested that sometimes postgraduate students are influenced into what to study and how to conduct research because of the changing nature of producing knowledge through research projects. Further, the mathematics education postgraduate students relied heavily on theories from psychology, sociology, and philosophy discipline areas. In the next chapter, the implications of how theory was used in the studies is discussed. How should the postgraduate students be encouraged to revisit theory in their studies? The preliminary research claim is that students should be encouraged to read extensively about the theory they intend using to research the phenomenon before posing research questions. Research questions and design should be directed by the level at which theory to be used in the study is at in the field. Whether it is descriptive, relational, or explanatory.

9.4 KNOWLEDGE PRODUCTION AND TRANSFORMATION IN MATHEMATICS EDUCATION THESES (1995-2004): PROGRESS, INEQUALITIES, AND SYSTEMIC CHALLENGES

The analysis of mathematics education theses from 1995 to 2004 provides valuable insights into the production and transformation of knowledge in South Africa's higher education system during the early post-apartheid years. By examining where and how this knowledge was generated, the study highlights both progress and persistent inequalities in postgraduate research. This summary addresses the critical question of "so what?" by exploring the impact of institutional structures, research themes, and systemic challenges on the evolution of mathematics education scholarship.

Most mathematics education theses during this period were produced in historically white universities (HWUs), particularly at Wits, which benefited from structured supervision models and strong research cultures. The research themes reflected a growing focus on equity issues, such as gender disparities in mathematics achievement, language and learning, and alternative teaching methodologies. However, historically black universities (HBUs) contributed only a small fraction of mathematics education theses, underscoring persistent inequalities in postgraduate research access and output in the early years of democracy in South Africa.

The data presentation and analysis suggest that while transformation intent was evident in research topics and methodological choices—such as participatory and critical paradigms—systemic challenges, including funding disparities and institutional support, continued to shape who produced knowledge. While progress was made in diversifying mathematics education research, the findings highlight that significant barriers remained, necessitating targeted interventions to create a more equitable and transformed research landscape. These trends are further explored in Chapter 10, where their implications for mathematics education research and transformation in South African higher education are examined in greater detail.

CHAPTER 10
DISCUSSION OF THE FINDINGS OF THE MIRS OF KNOWLEDGE PRODUCED THROUGH MATHEMATICS EDUCATION POSTGRADUATE RESEARCH (1995-204) AND CONCLUSION

10.1 INTRODUCTION

Chapter Five gave an overview of the corpus of mathematics education postgraduate theses that were produced in South African universities in the first decade of post-apartheid era. The subsequent four chapters (6-9) analysed the produced types of mathematics education knowledge in South African universities through the postgraduate research. Since 1995 to 2004 was the first decade in the post-apartheid era in South Africa, it was important to analyse the identity (race, gender, and language) of the postgraduate students who produced mathematics education knowledge and the type of institutions where this knowledge was produced. As indicated in the first chapter, the period post 1995 in South Africa was significant in the restructuring of higher education institutions to remove traces of apartheid policies. Therefore, this study intended to explore the trends of who was producing mathematics education knowledge and in which institutions. This chapter connects the findings from the previous five analyses chapters in relation to the overarching research question posed in this thesis: *What kinds of knowledge were postgraduate studies producing in mathematics education research in South Africa during the period 1995-2004*? In addition, this chapter summarized the key research findings in relation to the Giddens' structuration theory and discussed the value and contribution thereof. Further, the limitations of the study were reviewed. Lastly, the opportunities for future research is proposed.

10.2 SUMMARY OF GIDDENS' STRUCTURATION THEORY

In chapter three, I discussed Giddens' structuration theory which underpins this study. Giddens theory is constituted by the following constructs: *structure* and *agency, time* and *space*, *systems* and *structural principles*. Tuner (1986) proposed a diagram that shows the interrelationship amongst the concepts in Giddens' structuration theory as shown in Figure

3.1 below from chapter three. Structure and agency are connected as Giddens argues for duality of the two concepts. Structure is associated with rules (*university programme & discipline rules*) and resources (*financial, online databases, analytical softwares & research communities*) which agents (*postgraduate students & supervisors*) can use in a system (*HEIs & mathematics education community*) over time and space. Agents can act on the system using their practical and discursive consciousness, and also have unconscious dimension. This unconscious dimension results in "sense of trust" through "ontological security". The "ontological security" is achieved through 'routinization interactions' (predictable over time) and regionalization (space). Though Giddens argues why he focused on ontology only, this study saw the need for epistemological and methodological questions of knowledge production. This was a result of this study focusing on knowledge produced by postgraduate students who were learning at different institutions. Each institution (system) had its own rules and resources for postgraduate education. How the postgraduate students produced knowledge (methodological issues) was important in this study.

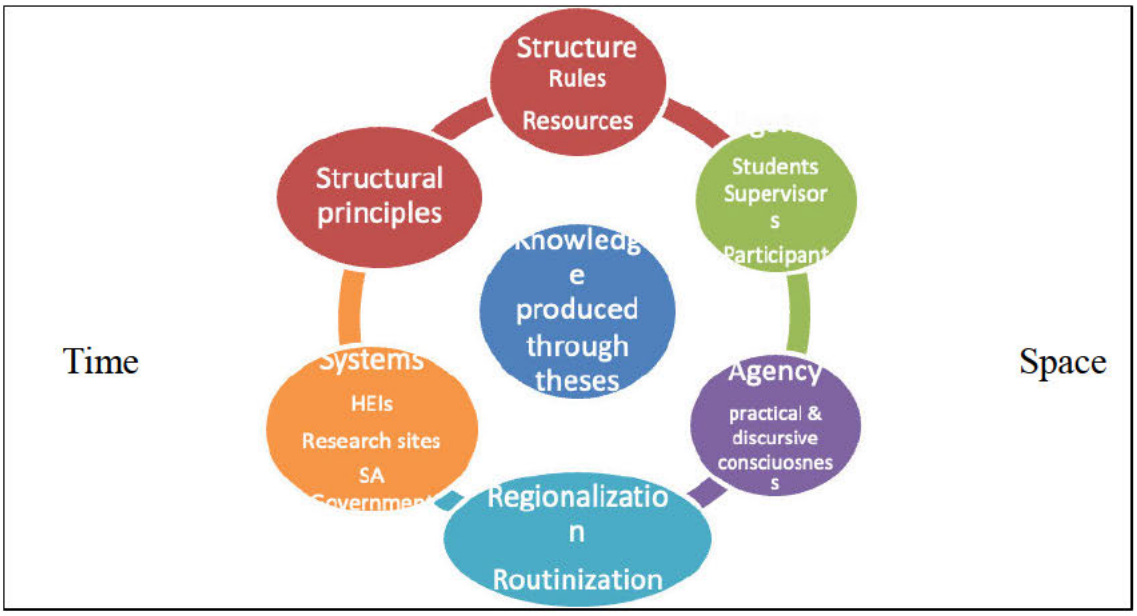


Figure 3.1. Key elements in the structuration theory (Adopted from Tuner 1986)

Gidden's constructs of time and space proved to be of profound importance in analysing mathematics education postgraduate theses in South Africa during the period from 1995 to 2004. Building upon the groundwork laid by Khuzwayo's (2005) prior research, which investigated research trends in South Africa between 1948 and 1994, my study extended his time frame (apartheid era) to a post-apartheid era in South Africa. Giddens' framework allowed me to examine not only the temporal evolution of mathematical education research but also the spatial dynamics that played a pivotal role in shaping this field. The concept of historical white universities and their impact on white female postgraduate students emerged as a significant aspect of the spatial dimension. By considering Giddens' notion of space within the context of these universities and their role in the academic journey of white female postgraduates, I was able to uncover intricate connections between institutional history, gender, and research output. This multidimensional approach, integrating Giddens' concepts of time, space, and historical context, enriched my analysis and provided a comprehensive understanding of the intricate factors influencing mathematics education research in South Africa during the specified time frame.

In short, Giddens' concepts in structuration theory offered a valuable framework to address the research question about the kinds of knowledge produced in mathematics education research in South Africa between 1995 and 2004. Structuration theory highlighted the dynamic interplay between temporal changes and varied social circumstances, offering light on the multifaceted character of knowledge production during this important period in the country's history. It shed light on what elements influenced the research landscape and the implications of this information for the improvement of mathematics education in South Africa by analysing the interplay between human agency and social structures.

10.3 OVERACHING TRENDS IN THE CORPUS OF MATHEMATICS EDUCATION THESES PRODUCED IN SOUTH AFRICAN UNIVERSITIES IN THE FIRST DECADE OF POST-APARTHEID ERA

A closer examination of knowledge production through mathematics education theses in South African universities during the period 1995-2004 unveils intriguing disparities that prompted me to delve deeper into the factors influencing such patterns. This subsection focuses on three prominent findings that shed light on the landscape of mathematics education research during this decade: the disparity between historical white and black universities in mathematics education theses production, the prominence of white female postgraduate students as knowledge producers, and the prevalence of English as the primary language driving mathematics education knowledge production. Each of these findings opens the door to a broader discussion on historical inequalities, gender dynamics, and linguistic influences within the academic pursuit of mathematics education in South Africa.

10.3.1 HWUs produced more mathematics education theses than HBUs

Only 5% (190) of the 3 779 educational theses in the PPER database were mathematics education postgraduate theses. These mathematics education postgraduate theses were produced in 14 out of 19 HEIs in the PPER database. Most of the mathematics education studies were produced in HWUs (98%). The finding that HWUs were still producing mathematics education knowledge despite a decade of democracy in South Africa, underscores the persistent effects of historical racial segregation on the country's education system. This finding is in line with the research conducted by Cloete, Mouton, and Sheppard (2015), which demonstrated that HWUs in South Africa maintained their status as the primary institutions for awarding PhD degrees between 1996 and 2012, the disparities between HWUs and HBUs extend beyond the realm of doctoral degrees. These findings mirror the persisting disparities in educational opportunities and resources that have their roots in South Africa's historical context of segregation and inequality. Such disparities, evident both in advanced research degrees and specific academic disciplines like mathematics education, highlight the need for continued efforts to address systemic imbalances in the higher education landscape.

Beale (1998, p.ii) makes similar observations about the disparities between HWUs and HBUs providing valuable insights into the root causes of this imbalance. Addressing these disparities requires concerted efforts, including increased funding, resource allocation, research-oriented environments, and societal changes, to create a more inclusive and equitable educational landscape for all students and researchers. Only through such efforts can South Africa hope to achieve a truly diverse and thriving mathematics education research community. However, it is not surprising that despite numerous policies to restructure the South African universities system post-1994, the benefit of these policies was not immediately efficacious. One example of such policy is mergers of HWUs and HBUs in close proximity, which came into effect in 2004, the end of the study's research period. The mergers were supposed to empower the previously disadvantaged HEIs by combining them with HWUs closer to them, but this was not successful (Jansen, 2003). Instead, this policy did not show growth in the mathematics education theses produced in the newly configured institutions. One such case is the merger between the University of Natal (HWU) and University of Durban Westville (HBU). “During this period UDW had an average of 48 doctoral students enrolled per year compared to UN which averaged 39. However, UDW had 25 graduates compared to UN’s 3 graduates” (Samuel & Vithal, 2011, p.80).

On the positive note, there was an increase in the enrolment of previously disadvantaged students into postgraduate studies in South African universities. The National Plan for Higher Education reported such efforts “between 1995 and 1999, masters and doctoral enrolments as a proportion of total head count enrolments increased from 5% to 5.7%, i.e. from 28 700 to 32 600”. (DoE, 2001, p.69). Cloete et. al. (2015) research shows a shift in postgraduate enrolments mirroring the South African demographics. In their paper, they show this shift in postgraduate enrolments from 1996 figures which were 13% African, 4% Coloured, 5% Indian, and 78% White students to 48% African, 6% Coloured, 8% Indian and 38% White students in 2012. However, Mkhize (2022) cautions against taking the 48% of African enrolment in postgraduate studies at face value, arguing that the 48% includes Africans from other African countries (p.40). The question then is how many Africans from South Africa made up this 48% of African postgraduates’ enrolment? In addition, did this enrolment translate into throughputs?

The most interesting finding was that even though the HWUs produced more mathematics education postgraduate theses, Wits more than doubled these studies compared to any other HWUs. Wits, as a historically white university, had a distinctive advantage in producing more mathematics education theses compared to other HWUs. One key factor contributing to this achievement was the presence of two prominent centers dedicated to mathematics education research: RADMASTE and Marang. These centers fostered a conducive environment for research and innovation in the field, attracting scholars, educators, and students interested in mathematics education. Additionally, the strategic location of mathematics education within the Faculty of Science further contributed to its prominence. This positioning allowed for interdisciplinary collaborations and access to a diverse range of resources and expertise, enabling students and researchers to delve deeper into the subject matter. Consequently, Wits University became a hub for pioneering research in mathematics education, producing a wealth of mathematics education theses that made significant contributions to the field's advancement. Nevertheless, this trend is similar to the one observed by Rollnick et al. (2009). Mathematics education academics who published the most (2000-2006) are from Wits, UCT, UKZN, UP, UNISA and UWC. This might have an influence on throughput rate of mathematics education postgraduate theses in these institutions with the exception of UWC.

There could be other plausible explanations why more mathematics education theses were produced at Wits (54 mathematics education theses) than in other institutions (where the most is 23 theses per institution). First, the supervisors of the postgraduate students, and the research culture of that particular institution during the period 1995 to 2004 played an important role in knowledge production. The Wits postgraduate cohort supervision model, could have assisted in the graduation rates. Prof X from Wits alluded to this point when interviewed. Similar, doctoral cohort supervision model was used at UKZN towards the end of the period 1995-2004. Samuel and Vithal (2011) argue that "alternate models of doctoral research teaching and learning pedagogy could address the challenge of under-productivity of doctoral graduands in the South African higher education system" (p.76). But whether the doctoral cohort supervision model is adopted in other universities in South Africa is not known. However, since 2003, learned organisations such as SAARMSTE, hold annual research schools to support postgraduate students in the STEM field from the Southern parts of Africa.

A further, possible explanation could be that mathematics education, as a discipline, was not established at UFS. Instead, many institutions had education studies or curriculum studies where mathematics education was the context but not a discipline area with academics focusing their energies on developing this discipline area. Moreover, another possible explanation could be funding. Some supervisors attracted funders for their research projects and included postgraduate students within their projects. This increased the number of postgraduate students graduating in mathematics education. Lastly, in some institutions, the practice was only the full masters and doctoral theses were submitted in the library. Consequently, several mathematics education theses might have not been photocopied because they were not in the universities' libraries.

Funding was an important factor in shaping the disparity between HWUs and HBUs in the production of mathematics education theses. Access to well-funded research projects could have allowed postgraduate students to do significant research while receiving financial support and effectively completing their studies. HWUs, particularly those with experienced supervisors and established research networks, were more likely to receive substantial financing for large-scale research projects like the PPER and Lesson Study initiatives. These projects not only advanced mathematics education research, but also provided opportunities for postgraduate students to acquire financial assistance to further their postgraduate studies. In contrast, HBUs, which historically received less research money and had fewer senior academics with expertise negotiating large grants, failed to provide comparable chances for their students. The ability of a supervisor to secure external funding frequently dictated the amount of financial aid available to postgraduate students, influencing both enrollment and completion rates. As a result, students at HWUs had more access to structured research environments, mentorship, and money, expanding the knowledge gap in mathematics education between HWUs and HBUs. Addressing financial inequities is critical to developing a more equitable higher education landscape in which postgraduate research opportunities are driven by the demands of a diverse academic community rather than historical privilege.

10.3.2 White female postgraduate students produced more mathematics education theses in South Africa in the period 1995-2004

The prominence of white female postgraduate students in mathematics education research at the national level aligns with broader trends seen in higher education, where efforts to address gender disparities have been underway. Contrary to the common understanding that white males are dominant in research, they were not well represented in the data. The substantial contribution of white female postgraduate students to the field showcases their dedication and commitment to advancing mathematics education during the period (1995-

2004). It could also be the supposition that with the political freedom gained in 1994 for everyone, women felt empowered to take postgraduate studies, more importantly in mathematics education. Another important point is that education is predominantly a female profession. The larger percentage of these women were white signaling a recommitment to South African education. This is contrary to the idea that after completing their studies, white students relocate to overseas countries (Bertram et al., 2007; Khan et al. 2021. Rizvi, 2005). Still, maybe there was pressure for a postgraduate qualification post 1994 with all races equal in South Africa. The colour of one's skin could not secure one a job position but relevant qualifications.

One of the inconsistencies in the trend discussed above was that in the Limpopo province (UL & UV), there were more male postgraduate students who produced education theses (see table 5.2). However, in both the institutions in the Limpopo province, there were no mathematics education postgraduate theses produced in the period 1995-2004. This could be result of academic staff residing in the Limpopo province not undertaking their mathematics education postgraduate studies within the province in the period 1995-2004 but studying elsewhere in the country or abroad. This unanticipated finding implies that this *locale* could not contribute to the generation of mathematics education knowledge through postgraduate theses. However, the regional disparity in the Limpopo province (UL & UV) raises questions about the underlying factors shaping this outcome. Cultural and societal norms, institutional support, and access to resources could be influential elements contributing to the higher representation of male postgraduate students in educational knowledge production in this specific region. Understanding the contributors to knowledge production in this area provided valuable insights into the dynamics of academic research and the impact of various social factors on scholarly output. The field of mathematics education is critical for shaping educational practices and improving learning outcomes in this essential subject.

10.3.3 Most of the mathematics education postgraduate theses (1995-2004) were written in English

In the period 1995-2004, there were only 33 out of 190 mathematics education postgraduate theses written in Afrikaans. This was despite the South African Government "spending on Afrikaans students was most generous" in the apartheid era (Beale, 1998, p.ii). In fact, "Zulu is the home language of 23.8% of South Africans, followed by Xhosa with 17.6%, Afrikaans with 13.3%, Pedi with 9.4%, and both English and Tswana with 8.2%" (Pretorius, 2006, p.32). English is the home language for fewer South Africans than IsiZulu, IsiXhosa, Afrikaans and Sepedi. But the “divided university system produced far more white graduates, in a wider range of disciplines, than black graduates. South African universities were isolated internationally, and the development of an indigenous intellectual culture and research capacity was hindered, especially at the Afrikaans medium and black institutions” (Beale, 1998, p.iii). This resulted in English language enjoying the *lingua franca* in South Africa. However, the shift towards English-language theses in the post-apartheid era signifies a significant change in educational dynamics. This trend could be attributed to several factors, including the growing internationalization of academia, the recognition of English as a global lingua franca, and the desire of South African scholars to broaden their research and connect with a wider audience. Additionally, it may reflect a conscious effort to promote inclusivity and encourage a more diverse and unified academic environment within the country. Moreover, as indicated in chapter 1, the English HWUs were founded earlier than the Afrikaans medium HWUs and this could have contributed to more theses written in English in the corpus of mathematics education theses reviewed for this study..

10.3.4 Understanding who, where and how mathematics education knowledges was generated in South Africa (1995-2004) through postgraduate theses using Gidden’s structuration theory

The present findings were consistent with Giddens’ concepts of *time*, *space*, and *system* in the structuration theory. In exploring the overarching trends in the mathematics education knowledge produced through postgraduate studies in South Africa in period 1995-2004, Giddens' concepts of time, space and system from structuration theory provide useful insights. Time relates to the chronological ordering of events, and space refers to the social environments in which activities occur, whereas systems connect with the HEIs and mathematics education community. Giddens' concept of time assisted to throw light on the evolving patterns of who and where was the mathematics postgraduate education research in South Africa over the given period. During this time, while the country experienced tremendous political and social transformations, including the end of apartheid and the establishment of a democratic government, there was little change in the patterns of knowledge production in postgraduate research. These patterns still resembled the findings in Khuzwayo (2005) study, which focused on research in mathematics education in the apartheid era.

Furthermore, Giddens' concept of space is critical in comprehending the many social contexts in which postgraduate studies in mathematics education research were carried out. During the period under discussion, the South African higher education scene underwent changes as universities adapted to the changing political atmosphere. The spatial dimension of structuration theory illustrates how positions, institutional affiliations, and socio-cultural contexts influenced knowledge production. This variety of space is likely to have contributed to a wide range of study views and discoveries in mathematics education. In fact, postgraduates who mainly contributed to mathematics education knowledge were located in institutions (spaces) which benefitted from the South African policies prior to 1994 namely HWUs. The fact that the space of mathematics education research (1995-2004) through theses was dominated by former white universities and white female postgraduate students, signals that knowledge production was gendered and racially biased towards one race in South Africa. Over and above this, despite English being the mother tongue of 8.2% South Africans, it dominated the space of knowledge production in mathematics education theses. The resistance to Afrikaans being used as the language of instruction in South African schools during the 1976 Soweto uprising and the democratic dispensation allowed English to enjoy the lingua franca thus influenced in which language was the knowledge generated.

Although agency represents the capacity of individuals to act and make choices within social structures, the dynamics of agency become particularly intriguing when examining the historical dominance of historically white universities in South Africa's mathematics knowledge generation during the period 1995-2004. In the context of postgraduate research, agency was evident as postgraduate students held the power to shape their research questions, methodologies, and the outcomes of their theses. However, the limitations of the study's research design became apparent when trying to unravel the complex factors contributing to the prevalence of mathematics education theses produced by white females at historically white universities during that era. Notably, this study lacked the crucial perspective of the postgraduate students themselves, as they were not interviewed. This absence of direct insights from the students hindered a comprehensive understanding of the choices, motivations, and contextual factors that led to their concentration in this specific field and demographic. Integrating this aspect into the broader discourse on agency and knowledge generation underscores the interplay between individual choices and structural influences, shedding light on how historical patterns in higher education have shaped certain disciplines and demographic trends, such as the concentration of mathematics education theses produced by white females at historically white universities.

10.4 EXPLORING THE LANDSCAPE OF MATHEMATICS EDUCATION POSTGRADUATE RESEARCH IN SOUTH AFRICA

In the realm of education, particularly in the domain of mathematics, research serves as a vital conduit for understanding the nuances of teaching, learning, and curriculum development. The period spanning from 1995 to 2004 witnessed a surge of postgraduate research endeavours in mathematics education within the diverse and evolving landscape of South Africa. This section delves into various facets of this academic pursuit, shedding light on the phenomena that were investigated, the questions that were posed, the paradigms and designs that framed the research, the instruments that were employed to gather data, the theoretical underpinnings that guided the studies, and the overarching claims that were drawn from the body of mathematics education postgraduate research during this transformative period. Through a comprehensive exploration of these subheadings, this subsection aims to unravel the rich tapestry of insights generated by postgraduate researchers, contributing to the advancement of mathematics education and pedagogy within the South African context.

10.4.1 Research phenomena researched in mathematics education postgraduate research in South Africa (1995-2004)

The dominant research phenomena researched in the mathematics education studies (1995-2004) were about the affective domain, assessment, cognition, epistemologies and knowledge, pedagogy, technology, and resources. There were paucities in studies researching socio-cultural political perspectives, languages, in-service education, curriculum policy, development and implementation, attrition rates of learners taking up mathematics, and adult basic education (see table 7.2) amongst mathematics education theses. The scarcity of mathematics education research focusing on socio-political issues and policymaking is an anomaly considering that post 1994, South Africa was undergoing the period of transition into democracy. This finding supports Vithal and Valero's (2003) argument of mathematics education research not focusing on policy-making issues, considering the education policies that were introduced during this period. Vithal and Valero (2003) argue that "the absence of a broader policy-related research agenda means that not enough research and discussion seem to be taking place about how policies related to mathematics curricula are being developed at national or local levels… what forces are driving successive waves of national reforms in mathematics curricula within the broader socio-political transformations" (pp. 565-566). There were no studies researching gifted students/learners, history of mathematics education amongst other research areas. "To some extent this is dependent on the readiness of the teaching community to consider mathematics education issues, they already have more than enough on their plate in terms of their own basic qualifications, school organisation issues, and new curricula to adopt" (DST, 2008, p.11).

10.4.2 Research question posed in mathematics education postgraduate research in South Africa (1995-2004)

The research questions posed in the phenomena indicated above were directed at learners' understanding of geometry, algebra and trigonometry concepts and were descriptive in nature (refer to table 7.4). This signals the preoccupation of mathematics education postgraduate students with developing conceptual understanding of high school mathematics concepts. Research claimed that strategies like modelling, scaling, curve- fitting and technologies like sketchpad and spreadsheets improved learner understanding of mathematics concepts. However, on the contrary some studies reported negative results of research on cognition and learner understanding of mathematics concepts. In particular the authors of the studies cited language, conceptual understanding, cultural meaning, and extra tuition as impeding on learner understanding of mathematics concepts. In addition, some studies claimed that teachers had low levels of understanding mathematics (70- Kühne, 2004; 88-Mc Auliffe, 1999; 152- Roos, 1996 & Mnisi, 1996) and how children learn mathematics (24-Cranfield, 2001; 73-Lampen, 2001; 97-Mokapi, 2001; 129- Oliphant, 1996 & 138-Phiri, 2003). This finding suggests that teachers' limited mathematics knowledge impacts negatively on learners' performance in mathematics.

During the period from 1995 to 2004, a significant paucity of research that focused on mathematics education emerged within South African postgraduate theses, particularly in the realm of primary mathematics education. This research gap becomes even more pronounced when juxtaposed with the persistent underperformance of South African learners in mathematics during the same period. Despite the evident challenges faced by learners in mastering mathematical concepts, the academic exploration and scholarly investigation into effective teaching methodologies, curriculum design, and pedagogical innovations within the primary mathematics education landscape remained notably limited. This dearth of research not only hindered the development of tailored interventions to address the learning deficits but also hindered the potential for data-driven improvements within the educational system. As such, the need for heightened attention, investment, and comprehensive research endeavours in primary mathematics education became increasingly evident to uplift the educational outcomes of South African learners and equip them with the mathematical skills necessary for their future success.

10.4.3 Research paradigms and designs framing the mathematics education postgraduate research in South Africa (1995-2004)

Two research paradigms were prominent in the postgraduate research namely interpretive and positivist. Interpretive was the most popular paradigm used in the mathematics education postgraduate studies. However, theses from historically Afrikaans universities used mostly the positivist paradigm related to large scale research. Table 8.11 (on the next page) showed that 90 mathematics education studies used large samples sizes to generate data. Statistically, a sample size of 30 is considered large. The high use of the interpretive paradigm in historically English universities and positivism in historically Afrikaans institution was associated with institutional research culture. Throughout the period (1995- 2004), postgraduate students with the exception in 1997 dominantly used interpretive paradigm. In 1997 more theses were produced by historical Afrikaans universities resulting in positivist paradigm being popular in that year. Female students were likely to use the interpretivist paradigm. Most of the studies using interpretivism were from Wits. Contrary more male students preferred positivism. In addition, white students used mainly positivism and were from UP and UNISA. There were silences in deconstruction, structuralism, and post-structuralism paradigms in the mathematics education postgraduate theses (1995-2004). Some studies researching pedagogy phenomenon were framed in interpretivist and others in positivism paradigms. Studies researching cognition, epistemology and knowledge research phenomena were researched mainly in the interpretivist paradigm. Whereas studies researching assessment phenomenon were researched mainly using positivism.

Table 8.11

Frequency distribution of the sample sizes of the participants in the postgraduate theses.

Sample size range	**Frequency**
0 - 30	89
30 - 60	31
60 - 90	5
90 -120	9
120 -150	4
150 - 180	8
180 - 210	3
210 - 240	3
240 - 270	2
270 -300	2
300 >	23
Missing	11
Total	190

Case study, survey and experimental designs were prominent in the mathematics education postgraduate research (1995-2004). There were silences on discourse analysis, phenomenography, biography, and comparative method in the mathematics education postgraduate research (1995-2004). Ethnography was used mostly by doctoral students who would have longer time to spend in the field as opposed to their counter parts. An interesting trend was that although the three research designs (case study, survey and experimental) were prominent in postgraduate research there was a decline in their use in the first five years of the study period and an incline in the latter years. In addition, case studies were popular in postgraduate research from English HWUs. In contrast, surveys and experimental designs were popular in postgraduate research conducted in Afrikaans HWUs. Yet again, this observation is in line with preference of paradigms by mathematics education postgraduate students in South Africa (1995-2004). Case study and surveys were used the most by African students in contrast to white students who used experimental design. Furthermore, it was the female students who preferred case study research design. In contrast, male postgraduate students preferred experimental designs despite that there were more studies written by female students in the corpus data. Even though the case study design was prevalent throughout the period 1995-2004, however it was not the case in the year 2000. Similar to the paradigms, pedagogy phenomena were researched mainly with case study and experimental designs. Assessment was researched mainly with surveys. The affective domain was researched primarily with experimental designs. Descriptive research questions were posed mainly in studies using cases study and survey designs. Contrary relational and explanatory research questions were posed mostly in studies researched with experimental designs.

Qualitative research approaches associated with the interpretive paradigm was dominant in the mathematics education postgraduate theses (1995-2004). However, masters students preferred the qualitative approach while doctoral students used mainly quantitative and mixed research approaches. Afrikaans universities leaned towards quantitative and mixed method research approaches signalling institutional research culture. Most mathematics education postgraduate studies (1995-2004) were conducted in urban areas closer to where most universities are situated and not rural settings. During the years 1995-2004, a notable missed opportunity existed in the space of mathematics education research in South Africa, as studies largely overlooked the exploration of educational practices in rural settings. The absence of research in this context deprived educators and policymakers of valuable insights into addressing the unique challenges faced by students in remote areas. The scarcity of studies focusing on the efficacy of teaching methods, curriculum adaptations, and resource allocation in rural South African schools hindered the development of targeted interventions. Consequently, the potential to bridge the urban-rural education gap and enhance learning outcomes remained unrealized, highlighting the unfortunate oversight in research during that period. DST (2008) argued in the review of mathematical sciences research, fourteen years after democracy in South Africa, that rural mathematics education is the "area that is not being met in research activity" (p.12).

Over and above the research contexts, mathematics education postgraduate students (1995-2004) were researching across or down by selecting mainly learners and teachers as their participants. The participants selected in these studies constituted large sample sizes. Mathematics educational research concentrated in secondary schools, particularly matric. As indicated earlier, primary mathematics education was neglected, and early childhood education did not have research during this period. The latter was still in infancy during this period, which is a possible reason why was little researched. It is surprising though why there was only one thesis in the ABET, because post 1994 there was a formalised training for adults. Four levels equivalent to schooling phases were introduced. In fact, OBE was implemented with parallel learning outcomes for adult education. Concepts like lifelong learning accommodating adults were popularised.

10.4.4 Research instruments used to generate data in the mathematics education postgraduate research in South Africa (1995-2004)

Data was generated from the participants using mainly interviews, questionnaires, test/activity and observations. There were no studies using collage and collaborative reflections to generate data. The most popular analytical tools used in the postgraduate studies (1995-2004) were statistical, thematic/coding and content analysis. Statistical analysis was predominantly used by White male master students. What is worth noting is 85% (34 out of 40) of doctoral studies used statistical analytical tools in line with the quantitative and mixed method approach chosen mainly by these studies. Most of the studies employing statistical analysis were from Wits University and Afrikaans HWUs. Naturally studies using statistical analysis were framed within quantitative research approach and experimental, survey and case study designs. On the other hand, studies using thematic/coding analytical tool were written mostly by female students doing masters. These studies were framed in the qualitative research approach. Studies based on case study design used mainly thematic analysis. Content analysis was popular at UCT and used mainly by masters students. Content analysis related to the research phenomena studied in mathematics education postgraduate studies which focused on mathematics concepts. These studies were framed within the qualitative research approach.

10.4.5 Theories used in the mathematics education postgraduate research in South Africa (1995-2004)

Many theories (171) were used in the corpus of mathematics education postgraduate theses in South Africa (1995-2004). However, only six theories were used in 10 or more studies. These were constructivism, problem-based learning, socio-cultural, levels of geometric thought, zone of proximal development and co-operative learning theory. Theories are not the same qualitatively and quantitatively and are not at the same level. Constructivism and socio-cultural theories are accepted as theories, however problem-based learning may not be taken necessarily as a theory. Problem based learning could be using constructivist theory. This is what is known as networking of theories (Bikner-Ahsbahs, Dreyfus, Kidron, Arzarello, Radford, Artigue, Sabena, 2010). Integration of research theories "lead to a frame for the analysis of a phenomenon from different perspectives, improve theories through clarifying their identities and boundaries, create methodologies for connecting theories, help researchers deepening a research question, lead to a renewed understanding of the role of theories in mathematics education" (Bikner-Ahsbahs et.al. 2010, p.1-148).

There were silences on theories like abstraction, action theory, chaos theory, classical test theory, code theory and item response theory from within the disciplines of mathematics and statistics. Bernstein's theories of classical framing, pedagogic discourses and symbolic control were limited to two institutions, Wits and UCT. One professor suggested that sometimes postgraduate students are influenced into what to study and how to conduct research because of the changing nature of producing knowledge through research projects. This is supported by what this professor indicated during the interview: "I still think that we have a lot of influence and a lot of impact on a lot of what the student research. If the research forms part of the funding project, that's pretty direct and focused. So, one would recruit into that stream and into that theme straight away" (Prof Y, 21/4/2008, p.6). Further, the mathematics education postgraduate students relied heavily on theories from psychology, sociology, and philosophy discipline areas.

Theories and findings generated through postgraduate theses contribute to a more comprehensive understanding of the complex dynamics of mathematics education in South Africa. These findings may inform policy and practice, addressing issues related to equity, inclusivity, and the overall improvement of mathematics education in the country. The understanding of specific research phenomena, questions, methodologies, theories, and findings in the mathematics education theses (1995-2004) indicate the individual researchers' choices.

10.4.6 Research claims reached in the mathematics education postgraduate in South Africa (1995-2004)

The claim made in the postgraduate research studies, highlighting teachers' low levels of mathematics knowledge and knowledge of their practice, was intrinsically connected to the educational landscape of South Africa during the years 1994 to 2005. This period marked a significant shift as all South African learners were suddenly required to study mathematics in schools. However, this transition presented a formidable challenge due to insufficient and scarcity of qualified mathematics teachers. Many educators possessed certificates from teacher colleges but lacked comprehensive training in mathematics instruction. In response, initiatives like the Advance Diploma in Education (ACE) were introduced to upskill teachers and enhance their pedagogical prowess. Moreover, those who had been teaching without formal teaching qualifications for an extended period were compelled to upgrade their credentials through the National Professional Diploma in Education (NPDE). The situation underscored the critical need for improving teachers' subject knowledge and teaching methodologies, thereby highlighting the relevance and significance of the research's findings regarding teachers' inadequate mathematics knowledge and instructional practices.

Over and above teachers' low levels of mathematics knowledge, the landscape of postgraduate research has been marked by a thought-provoking discourse centered around the utilization of everyday knowledge in the teaching of mathematics concepts. This dialogue stems from a dichotomy observed in various studies, where the incorporation of everyday knowledge into mathematics teaching has yielded divergent outcomes. On one hand, some research (49-Grinker, 1998; 117-Nakidien, 2004; 127-Nyabanyaba, 1998; 156- Sambo, 2003) highlights the beneficial role of integrating relatable, real-world contexts into mathematics instruction, facilitating learners' grasp of intricate concepts. This approach resonates with learners, bridging the gap between abstract mathematical concepts and their practical applications. However, on the other hand, an equally compelling body of research suggests that the incorporation of everyday knowledge can occasionally hinder learners' comprehension of mathematics concepts (Cooper & Dunne, 2000; Sethole, Goba, Adler & Vithal, 2006). This counterintuitive effect is thought to arise from the potential confusion stemming from the blending of familiar contexts with abstract mathematical principles. This scholarly discourse underscores the need for a nuanced understanding of the dynamic interplay between everyday knowledge and mathematics concepts, urging educators to consider both the advantages and potential pitfalls when navigating this intricate terrain particularly in South Africa.

The aggregated research findings within mathematics education theses spanning the years 1995 to 2004 present a compelling argument against the existence of gender-based disparities in learner performance within the South African context. Extensive analysis and empirical investigations conducted during this period consistently pointed towards the absence of significant gender differences in mathematical achievement (4-Arigbabu, 2003; 18-Cassy, 1997; 25-Cranfield, 2001; 25-Cronje, 1995; 105-Mosala, 1997 & 162-Semata, 2004). These theses, characterized by their methodological rigour and diverse sampling strategies, converge on the notion that male and female learners demonstrated comparable levels of competence and success in mathematics education. This collective body of work challenges prevailing stereotypes and underscores the importance of equitable educational practices in fostering a balanced learning environment, transcending gender-based distinctions and promoting equal opportunities for all learners in South Africa's mathematics classrooms.

The postgraduate research in mathematics education conducted between 1995 and 2004 delved into the impact of various teaching strategies on assessment outcomes. Among the strategies investigated were problem solving, incorporation of everyday experiences, utilization of chess in teaching, and the implementation of tutorial sessions. Notably, the research findings revealed a significant correlation between the integration of problem-solving techniques and enhanced learner achievement in mathematics. This highlighted the efficacy of fostering critical thinking and analytical skills in learners to bolster their mathematical prowess. Conversely, the outcomes from the research indicated that the use of everyday experiences as a teaching tool did not directly translate to improved learner performance (43-Gee, 1997; 49-Grinker, 1998; 55-Hermelin, 2004 & 77-Louw, 2003). However, surprisingly, this method did help to improve learners' attitudes towards mathematics, highlighting the potential to improve their perspective and involvement with the subject. This thorough investigation of teaching strategies sheds light on the complex connections between pedagogical paradigms and their various impacts on academic performance and the overall educational experience.

Lastly, the research claim gleaned from postgraduate studies in mathematics education suggests a compelling link between learners' attitudes and anxiety towards mathematics and their assessment outcomes. This proposition underscores the significant role that emotional factors play in shaping academic performance. By delving into the intricate interplay between learners' perceptions of mathematics and their levels of anxiety, the postgraduate studies shed light on the potential impact these emotional dimensions have on cognitive processes during assessment tasks. These postgraduate studies (68- Kimble, 2000; 84-Mathe, 1997; 85-Matlhaga, 1995; 132-Osei, 1995; 144-Pylman, 2001; 157-Scholtz, 1996 &176-Thijsse, 2002) deepen our understanding of the complex nature of mathematics learning by highlighting the need of developing a positive outlook and controlling anxiety to promote better educational results. The findings highlight the need to improve pedagogical strategies that enable learners to develop confidence and resilience when learning mathematics as well as the need assisting learners to be cognitively engaged when solving tasks. More recently, Zondo's (2021) research explored learners' cognitive engagement when responding to a Euclidean geometry task yielding similar result. "Learners who performed well in the tasks remained persistent, motivated and willingly engaged with the task. These results suggest that when learners remain cognitively engaged in their learning of Euclidean Geometry, better academic performance is expected" (Zondo, 2021, p.ii).

10.4.7 Exploring the landscape of mathematics education postgraduate research in South Africa (1995-2004) through the lens of Giddens' Structuration Theory

Giddens' structuration theory provided a useful framework for understanding the intricate interactions between social structures, agency, time, space, systems, and structural principles in the context of mathematics education research in South Africa (1995-2004). For example, some theories used in postgraduate studies were prevalent in a particular HEI or region in South Africa. The application of theories like Bernstein's theory and constructivism in institutions like Wits University and Stellenbosch University (SU) can be understood through the lens of structuration. These theories became part of the institutional practices and educational frameworks, reflecting the ongoing interplay between the theories themselves and the institutional contexts in which they are applied.

The fact that South Africa was once colonized by Britain has contributed to the prevalence of certain theories, such as those from British educational traditions, in the postgraduate studies of mathematics education (1995-2004). Prof J (2008) when interviewed, alluded to the aforementioned saying "this university was for a long time very heavily influenced by humanistic mathematics coming out of the UK which was also influenced quite heavily by ideas grounded in psychology…You had the sort of white liberal universities tending to draw on that UK influence". Structuration theory highlights how the colonial history has shaped the educational landscape in South Africa by introducing specific educational models, curricula, and theories. Structuration theory helps us understand how theories of mathematics education, originating in European countries, have influenced the way education is perceived and practiced globally. The spread and adoption of these theories in different countries, including South Africa, can be seen as the result of the ongoing interplay between global educational trends and local contexts.

Nevertheless, South Africa's contribution to the field of mathematics education through theories related to socio-cultural inclination reflects the dynamic nature of structuration. As South Africa transitioned to the democratic era in 1994, its unique history and socio-cultural context likely played a role in shaping theories that emphasize the social and cultural aspects of mathematics education. Structuration theory recognizes how local contexts and historical developments interact with broader educational theories to create new perspectives and approaches. In summary, the concept of structuration helped to understand how the interplay between global educational theories, local contexts, historical influences, and institutional practices shapes the field of mathematics education in South Africa, as evidenced by the prevalence of certain theories and the emergence of locally relevant perspectives. However, it is worth noting that within this dynamic interplay, dissenting voices also emerged. For instance, when one professor argued against the use of ethnomathematics theory in South Africa, they were likely challenging the compatibility of this theory with the country's specific educational goals and challenges. His argument was "we think it is taking mathematics and allowing mathematics to colonize non-mathematical spaces. So, it is almost like a form of imperialism for me. You know…because it goes along with the idea that mathematics is important in everyday life, that you need mathematics in your everyday life to be able to live your life. I just think that's nonsense" (Prof J, 2008, p. 13). This dissent highlights the complexity of reconciling global theories with local realities, as well as the ongoing negotiation between various stakeholders within the field of mathematics education. Such disagreements underscore the need for continuous dialogue and critical examination of educational theories to ensure that they are contextually appropriate and effective. In conclusion, the concept of structuration provides a lens through which we can grasp the multifaceted nature of mathematics education in South Africa. It allowed the recognition of the intricate dance between global educational theories, local contexts, historical influences, and institutional practices that collectively shape the field. By understanding this interplay, we can appreciate both the prevalence of certain theories and the emergence of locally relevant perspectives, while also acknowledging the importance of constructive debates around their application and suitability.

The research claims from the postgraduate theses highlight low teachers' knowledge thereby affirming the importance of addressing knowledge gaps in the education system. This might have signalled why the corpus of mathematics education theses (1995-2004) focused on classroom practices rather than broader social issues. The focus on classroom practices during that period might reflect the prevailing discourses and priorities within the education field during that era. Thus, structuration theory acknowledges the temporal dimension of social life and how structures change over time. In addition, the fact that white female postgraduate students contributed more to knowledge generation through theses and influenced the research discourse of the time reflects both agency and habitus. Agency refers to individuals' capacity to make choices and enact change within a structure. The students' choices to pursue specific research topics and their contributions demonstrate agency. Habitus refers to the ingrained dispositions, behaviours, and preferences that individuals acquire through socialization. The dominance of certain demographics (white females) in shaping research topics could be attributed, in part, to their habitus and social positioning.

Furthermore, structuration theory allows us to explore how gender differences in mathematics performance are socially constructed rather than inherently determined. By understanding the societal norms and expectations that contribute to gender disparities, educators can adopt inclusive strategies to ensure equal opportunities and outcomes for all learners in mathematics education.

10.5 LIMITATIONS OF THE STUDY

One of the limitations of this study was the absence of interviews with mathematics education postgraduate students who wrote the theses in the post-apartheid era (1995- 2004). Without conducting these interviews, the understanding of why these postgraduates produced specific kinds of mathematics education knowledge during that period remains incomplete. The insights gained from direct interactions with the postgraduate students could have shed light on their experiences, perspectives, and motivations, providing valuable context to the research. As a result, the study may lack a comprehensive exploration of the factors that influenced the production of mathematics education knowledge in the post-apartheid era, potentially limiting the depth of the findings. Future research endeavours should consider incorporating interviews with relevant participants to address this limitation and provide a more comprehensive understanding of the dynamics at play during that time.

Another notable limitation of this study was its narrow focus on the period from 1995 to 2004. Although this timeframe was crucial for understanding mathematics education knowledge generated through postgraduate theses in the post-apartheid era in South Africa, certain aspects of teaching and learning mathematics were overlooked taking into cognisance other significant shifts in education that occurred in later years. Notably, during the post-2004 era, there were prominent movements like the "fees must fall", which highlighted issues of access and affordability in higher education. Whether levelling the playing field by increasing accessibility of all racial groups into higher education institutions or not, it affords epistemological access to mathematics education research to all students of racial groups ensuring higher throughput rates? Additionally, the growing emphasis on the decolonization of education in South Africa and a focus on indigenous knowledge systems gained momentum, potentially foregrounding these themes in postgraduate research. CIKS (n.d.) in Scherer and Sooryamoorthy (2022) concurs with this notion arguing that the Institute of Indigenous Knowledge Systems, founded in 2004 at UKZN, “endeavours to create a paradigm shift in knowledge production (research), by promoting indigenous ways of knowing (epistemology)” (p.30). Therefore, this study's time-bound approach may have missed capturing the broader context of evolving educational priorities and perspectives in the postgraduate landscape.

10.6 CHARTING PATHS FORWARD: EVALUATING POSTGRADUATE MATHEMATICS EDUCATION RESEARCH IN POST APARTHEID SOUTH AFRICA'S FIRST DECADE

Based on the limitations mentioned in the study and the relevance of Khuzwayo's (2005) work, several future research directions can be suggested to address these gaps and further enrich the understanding of mathematics education in South Africa and postgraduate education.

10.6.1 Post-apartheid era postgraduate students' perspectives

Conducting interviews with mathematics education postgraduate students who wrote theses in the post-apartheid era (1995-2004) would provide valuable insights into the changes and developments in mathematics education during that specific period. This qualitative research could explore the postgraduate students' experiences, challenges, and perceptions of the education reforms implemented after apartheid leading to their choice of the research phenomena for their mathematics education theses (1995-2004).

10.6.2 Longitudinal study of mathematics education reforms

Instead of focusing only on the period from 1995 to 2004, a longitudinal study covering a broader time span, including later years up to the present could be done. This approach will help capture the long-term impacts of the education reforms and provide a comprehensive view of the changes in mathematics education over time and whether mathematics education postgraduate students have interest in researching these educational changes.

10.6.3 Comparative analysis with pre-apartheid and post-apartheid eras

Building on Khuzwayo's (2005) historical overview of mathematics education research during the apartheid years, the research could compare the educational policies, practices, and outcomes between the pre-apartheid, apartheid, and post-apartheid eras. Such a comparison would shed light on the continuities and discontinuities in mathematics education across different political regimes. In particular, this kind of research will signal whether mathematics education postgraduate students are preoccupied with socio, cultural and political dimension of mathematics knowledge mirroring the politics of apartheid era in South Africa, or whether they are interested in the issues affecting their practice. Understanding their experiences and perceptions of the reforms can provide additional context and insights into the practical implications of the changes in mathematics education in South Africa. Further investigation on the impact of socioeconomic and cultural factors on mathematics education in the post-apartheid era could be done. Considering how these factors may have influenced postgraduate students' choices in pursuing mathematics education research. Alongside postgraduate students, a consideration of interviewing mathematics educators and teachers who worked in schools during the pre and post-apartheid era.

10.6.4 Quantitative analysis of educational outcomes

One of the claims in the postgraduate research studies contended that teachers had low levels of mathematics knowledge and knowledge of their practice in the period (1995- 2004) in South Africa. Therefore, qualitative research could be supplemented with quantitative data analysis, examining educational outcomes in mathematics during the post-apartheid era. This could include performance on national assessments, enrolment rates in mathematics-related programmes, and measures of equity and access in mathematics education. By addressing these future research directions, scholars can gain a more nuanced and comprehensive understanding of the dynamics of mathematics education in South Africa during the post-apartheid era. This would also allow for a more informed evaluation of the impact of educational reforms and provide valuable lessons for policymakers and educators aiming to improve mathematics education in the future.

10.7 CONTRIBUTION TO MATHEMATICS EDUCATION RESEARCH

This study’s contributions unfold across four distinct yet interconnected subsections, each shedding light on a crucial facet of mathematics education postgraduate research in South Africa (1995-2004). Firstly, I delve into the realm of Methodologically Inclusive Research Synthesis, employing a comprehensive approach that amalgamates diverse methodological frameworks to offer a nuanced perspective. Secondly, I underscored the significance of the period (1995-2004), delving into the immediate post-apartheid era and its reverberations, unearthing socio-political currents that shaped educational landscapes. My exploration extended to postgraduate education, where I dissected the transformative journey of scholars, analysing the multifaceted impact of postgraduate studies on both individuals and the broader academic sphere. Finally, I delved into the rich tapestry of knowledge cultivated through mathematics education postgraduate theses, unravelling the intricate web of insights, innovations, and novel paradigms that emerge from these scholarly endeavours. Together, these subsections contributed to a holistic understanding of this study’s research domain, highlighting its multidimensional significance and offering a platform for nuanced discussions and future explorations.

10.7.1 Methodologically inclusive research synthesis

The methodologically inclusive research synthesis of mathematics education postgraduate theses in South Africa (1995-2004) holds the potential to contribute significantly to the advancement of mathematics education knowledge in the post-apartheid era. By encompassing diverse research methodologies and phenomena, this study offered a comprehensive and nuanced understanding of the state of mathematics education research during this crucial period of transition in South Africa. By identifying common themes, the study aimed to shed light on the areas where significant research contributions have been made and explore potential gaps in the knowledge base. These themes included pedagogical practices, curriculum development, teacher knowledges, student learning outcomes, and challenges faced in mathematics education. It is recommended that future research can help shape the direction of future studies and contribute to enhancing mathematics education for all learners in South Africa.

This study on methodologically inclusive research synthesis represented a significant advancement in the field of educational research. While the concept of methodologically inclusive research synthesis was introduced by Suri in the late 1990s, this study's contribution extends beyond the established framework by incorporating a broader scope of analysis. While Suri (2010) primarily focused on synthesizing research from diverse methodologies within specific phenomenon (cooperative learning in secondary mathematics), this study breaks new ground by not only encompassing a variety of methodologies but also examining a wider range of research phenomena.

By delving into the realm of mathematics education and specifically investigating the trends and patterns in knowledge production within the South African context, this study offered a unique perspective on the evolution of educational research. The decision to concentrate on postgraduate theses from South African universities added depth and richness to my analysis, shedding light on the development of educational thought and practice in a specific cultural and academic setting.

In essence, this study's innovative approach of methodologically inclusive research synthesis, applied to the dynamic field of mathematics education and grounded in the South African context, offered a multifaceted understanding of knowledge production and its evolution. By venturing beyond the boundaries of previous research synthesis models, this study not only contributed to the methodological discourse but also enhanced the comprehension of the intricate interplay between methodologies, phenomena, and cultural contexts in educational research.

Although methodologically inclusive research synthesis contributes to the field of education, there are criticisms of validity and legitimacy of the conclusions levelled against it. Suri (1998) argues that the criticism about research syntheses lacking validity in comparison to primary research studies, is not compelling. This is because research syntheses have a different goal-they aim to uncover broader patterns and insights that emerge when multiple studies are analysed collectively. By aggregating and examining various studies, research syntheses contribute to advancing knowledge in a particular field, revealing commonalities and transcendent features that might not be apparent when looking at single studies in isolation (Suri & Clarke, 2009, p.406).

10.7.2 <u>The significance of the period (1995-2004) immediate post-apartheid era in South Africa</u>

This study's temporal focus on the period from 1995 to 2004 captured a crucial era in the field of mathematics education, allowing for a comprehensive exploration of the transformations that have taken place over time. This temporal lens provided insights into the changing paradigms, theories, research methodologies, research phenomena and claims that have shaped the landscape of mathematics education within South Africa.

The postgraduate theses conducted in South Africa during the immediate post-apartheid era exhibited notable gaps in addressing the socio-political issues intertwined with mathematics education. Despite the country undergoing significant changes, such as the "fees must fall" movement and the pursuit of decolonized education, these theses predominantly concentrated on the pedagogical aspects of teaching and learning mathematics. This emphasis on instructional methods and curriculum development overlooked the broader context of mathematics education within a society undergoing transformative socio-political shifts. In fact, the contributions of people's education and the emergence of ethnomathematics at the end of apartheid underscored the potential for culturally relevant mathematical learning, the theses of this era appeared to disregard the integration of these insights into the fabric of post-apartheid mathematics education. The evolving landscape of education in South Africa demanded an exploration of how ethnomathematics could address historical inequalities and promote inclusivity, yet this important aspect remained largely unexplored. Although, the South African government in the period immediate apartheid era, tried to address one historical inequality of opening access to mathematics to all South African learners, the postgraduate theses have demonstrated that this shift had negative results as teacher had low mathematics knowledge.

Moreover, the failure to engage with the pressing issues of decolonization and equity in education signalled a missed opportunity to critically assess the role of mathematics education in reshaping societal narratives. The postgraduate theses could have delved into the ways in which mathematics education could actively contribute to dismantling colonial legacies and fostering a more just and equitable society. By not addressing these socio-political issues, the theses inadvertently perpetuated a narrow view of mathematics education that disconnected it from its potential to drive meaningful social change. In short, the postgraduate theses conducted in South Africa during the immediate post- apartheid era exhibited a notable gap by primarily focusing on the teaching and learning of mathematics while neglecting the crucial socio-political dimensions and the potential of ethnomathematics to address broader issues of equity, decolonization, and societal transformation.

10.7.3 Postgraduate education in the post-apartheid era

Postgraduate education in post-apartheid South Africa has undergone a significant transformation, marked by efforts to address historical inequalities and promote a more inclusive and diverse academic landscape. In the decades following the end of apartheid, the country's higher education sector aimed to rectify the imbalances of the past, which were evident in various aspects of academic research, including paradigms and representation. Historically, theses produced by HWUs in South Africa, often followed a positivist paradigm, reflecting a Western-oriented approach to research that may not have adequately captured the multifaceted realities of the country. Moreover, these theses were predominantly authored by white females, which further limited the representation of diverse perspectives within academic discourse. This skewed representation was exacerbated by the predominant use of English as the medium of communication in academic writing, despite it being the mother tongue of only a minority (8.2%) of the South African population. This linguistic bias underscored the need to embrace the linguistic diversity that characterizes the nation and promote research and scholarship in various indigenous languages.

Research findings have shed light on the significance of cohort supervision in enhancing research outputs among postgraduate students. The importance of collaborative learning and mentorship within academic communities has been highlighted, leading to increased research productivity and a more nurturing academic environment. This emphasis on cohort supervision has contributed to the expansion of research output across various disciplines, ultimately strengthening the country's knowledge generation capabilities. This study observed that Wits University generated a certain quantity of theses (54 out of 190) focused on mathematics education. This highlighted three approaches to postgraduate education: one involving cohort supervision, second, the collaboration between the science faculty (specifically the mathematics discipline) and the education staff (specifically those focused on mathematics education). This collaboration aimed to enhance the research productivity among postgraduate students in mathematics education. Third, the importance of having centres such as RADMASTE and Marang within the faculty or school of education promoting mathematics education.

10.7.4 Knowledge cultivated through mathematics education postgraduate theses

By meticulously examining a corpus of postgraduate theses, this study shed light on several key aspects that collectively fostered a comprehensive understanding of prevailing research theories, paradigms, and phenomena within the domain of mathematics education. This study critically examined the theoretical underpinnings and research paradigms that were prevalent within the mathematics education landscape during the designated period. By identifying the dominant research theories, such as constructivism and cognitive psychology, this study illuminates the intellectual frameworks that shaped research inquiries and directions during this decade. This not only provided a historical perspective but also offered valuable insights into the evolution of thought within the field.

A notable concern in the postgraduate education landscape (1995-2004) has been the dominance of research theories rooted in European contexts. This Eurocentric perspective has, at times, hindered the promotion of indigenous ways of knowing and understanding, which are crucial for capturing the unique experiences and knowledge systems of South

Africa's diverse cultures. Efforts are underway to rectify this imbalance by actively integrating indigenous knowledge and research methodologies into postgraduate education, thus fostering a more inclusive and culturally sensitive academic environment (CIKS, n.d.).

Through a systematic analysis of mathematics education theses, this study unearthed prevalent research phenomena that captured the attention of postgraduate students during the specified timeframe. By categorizing and analysing research topics, this study highlighted trends such as teacher knowledge, gender differences in mathematics performance, the integration of everyday knowledge in teaching mathematics, and the impact of emotional disposition on learners' mathematical achievement. This comprehensive overview of research phenomena contributes to a nuanced understanding of the focal points of research efforts and inquiries during the studied years.

By aggregating and synthesizing the research claims made in the postgraduate theses, this study created a comprehensive narrative of the contributions made to the field of mathematics education. The examination of teacher knowledge shed light on their poor understanding of mathematical concepts. This suggests the need for their continuous professional development. If the teachers' poor understanding of mathematics concepts is not rectified, this negatively impacts on the learners' mathematical understanding. The investigation of gender differences in mathematical performance contributed to addressing equity and inclusivity issues, while the exploration of everyday knowledge usage and emotional disposition enriched the comprehension of effective teaching and learning strategies in mathematics. This study's findings have direct implications for mathematics education policy and classroom practice. By identifying prevailing research themes, theories, and paradigms, the work generated in this study provides educators, policymakers, and curriculum developers with valuable insights into evidence-based approaches to enhancing mathematics education.

10.8 CONCLUSION

In conclusion, postgraduate education in post-apartheid South Africa is characterized by a dynamic interplay between historical legacies and contemporary aspirations for inclusivity and diversity. Efforts to address imbalances related to paradigms, language, representation, and knowledge systems are integral to fostering a more equitable and socially relevant higher education sector. By embracing these challenges and opportunities, South Africa's postgraduate education system is poised to contribute meaningfully to both local and global knowledge production while reflecting the rich tapestry of the nation's cultural heritage.

References

Adler, J., Alshwaikh, J., Essack, R., & Gcsamba, L. (2017). Mathematics education research in South Africa 2007–2015: Review and reflection. *African Journal of Research in Mathematics, Science and Technology Education*, *21*(1), 1–14.

Adler, J., Ball, D., Krainer, K., Lin, F.-L., & Novotna, J. (2005). Reflections on an emerging field: Researching mathematics teacher education. *Educational Studies in Mathematics*, *60*, 359–381.

Adler, J., Pournara, C., Taylor, D., Thorne, B., & Moletsane, G. (2009). Mathematics and science teacher education in South Africa: A review of research, policy and practice in times of change. *African Journal of Research in Mathematics, Science and Technology Education*, *13*(sup1), 28–46.

Agudelo-Suárez, A.A., Gil- González, D., Vives-Cases, C., Love, J.G., Wimpenny, P. & Ronda-Pérez, E. (2012). A metasythesis of qualitative studies regarding opinions and perceptions about barriers and determinants of health services' accessibility in economic migrants. *BMC Health Services Research 2012* 12:461.

Akala, B.M., (2019). Affirmative Action for Gender Justice in South African and Kenyan Education Systems. Africa Education Review https://doi.org/10.1080/18146627.2017.1406807

Allen, M., & Preiss R.W. (1997). Comparing the persuasiveness of narrative and statistical evidence using meta-analysis. *Communication Research Reports*. *14*(2), 125-131. https://doi.org/10.1080/08824099709388654.

Anthony, L. (2001). Characteristic features of research article titles in computer science. *IEEE Transactions on Professional Communication*, *44*(3), 187–194.

Archer, M. (1996). Social integration and system integration: developing the distinction. *Sociology*, *30*(4), 679–699.

Balfour, R., Moletsane, L. Karlsson, J., Pillay, G., Rule, P., Nkambule, T., Bengesai, A., Davey, B., Lekena, L., Molefe, S., Madiya, N., & Goba, B. (2008). *Project Postgraduate Educational Research in Education: National Issues, Trends, and Reflections (1995-2004).* Unpublished 4th Progress Report, 30 December, 2008.

Balfour, R. J., Moletsane, R., & Karlsson, J. (2011). Speaking truth to power: understanding education research and the educational turn in South Africa's new century: introductory article. *South African Journal of Higher Education*, *25*(2), 195–215.

Baloyi, M.C., & Naidoo, G. (2016). Higher education mergers in South Africa A means towards an end. *African Journal of Public Affairs*, *9* (3), 19-29.

Bansilal, S., Goba, B., Webb, L., James, A., & Khuzwayo, H. (2012). Tracing the impact: A case of a professional development programme in Mathematical Literacy. *Africa Education Review*, *9*(sup1), S106–S120.

Bangert-Downs, R.L.,& Rudener, L.M. (1991). Meta-analysis in educational research. Practical Assessment, Research & Evaluation, 2(8). Available online: http://PAREonline.net/getvn.aspn?v=2&n=8.

Barley, S. R. & Tolbert, P.S. (2014). Institutionalization and Structuration: Studying the Links between Action and Institution. Article downloaded on 30 April 2014 at Digital Commons @ILR: http://digitalcommons.ilr.cornell.edu/articles/130)

Beale, M. A. (1998). *Apartheid and university education, 1948-1970.*

Begle, E. G. (1979). *Critical Variables in Mathematics Education: Findings from a Survey of the Empirical Literature*.

Bellomo, C., & Strapp, R. (2008). A survey of advanced mathematics topics: a new high school mathematics class. *International Journal of Mathematical Education in Science and Technology*, *39*(1), 13–22.

Bengesai, A. V., Goba, B. B., & Karlsson, J. (2011). Titles as discourse: Naming and framing research agendas as evident in theses titles in 1995-2004. *South African Journal of Higher Education*, *25*(2), 252–268.

Bertram, C., Wedekind, V., & Muthukrishna, N. (2007). Newly qualified South African teachers: staying or leaving? *Perspectives in Education*, *25*, 77-89. https://api.semanticscholar.org.

Bikner-Ahsbahs, A., Dreyfus, T., Kidron, I., Arzarello, F., Radford, L., Artigue, M., & Sabena, C. (2010). In M. M. F., Pinto, & T. F., Kawasaki (Eds.). *Proceedings of the 34th Conference of the International Group for the Psychology of Mathematics Education*, 1, pp. 145-175. Belo Horizonte, Brazil: PME.

Bisimbaeva, D. (2022). Choosing a title for a scholarly paper. *Education and Self Development*. *17*(2), 6.

Botha, R. J. (2002). Outcomes-based education and educational reform in South Africa. *International Journal of Leadership in Education*, *5*(4), 361–371.

Brieger, D., Amerena, J., Attia, J., Bajorek, B., Kim, H. Chan, Connell, C., Freedman, B., Ferguson, C., Hall, T., Haris, H., Hendriks, J., , Hespe, C., MBBS, Hung, J., Kalman, J.M., Sanders, P., Worthington, J., Tristan, D., Yan, M.D., & Zwar, N. (2018). National Heart Foundation of Australia and the Cardiac Society of Australia and New Zealand: Australian Clinical Guidelines for the Diagnosis and Management of Atrial Fibrillation 2018. Heart, Lung and Circulation (2018) 27, 1209–1266. https://doi.org/10.1016/j.hlc.2018.06.1043.

Browder, D. M., Spooner, F., Ahlgrim-Delzell, L., Harris, A. A., & Wakemanxya, S. (2008). A meta-analysis on teaching mathematics to students with significant cognitive disabilities.

Exceptional Children, *74*(4), 407–432.

Brown, H. I. (1979). *Perception, theory, and commitment: The new philosophy of science*. University of Chicago Press.

Carter, B., & Sealey, A. (2000). Language, structure and agency: What can realist social theory offer to sociolinguistics? *Journal of Sociolinguistics*, *4*(1). https://doi.org/10.1111/1467-9481.00100

Cloete, N., Mouton, J., & Sheppard, C. (2015). Doctoral Education in South Africa. https://www.researchgate.net/publication/346876473

Cohen, L., Manion, L., & Morrison, K. (2018). *Research Methods in Education*. London: Routledge Taylor Francis.

Cooper, B., & Dunne, M. (2000). Introduction: background, issues and overview of the book. *Assessing Children's Mathematical Knowledge: Social Class, Sex and Problem-Solving*.

Cooper, H.M., & Lindsay J.J. (1998). Research synthesis and meta-analysis. In L. Bickman & D.J. Rog (Eds.). *Handbook of applied social research methods*. Thousand Oaks: SAGE Publications.

Cranton, P. (2001). Interpretive and critical evaluation. *New Directions for Teaching and Learning*, *2001*(88). https://doi.org/10.1002/tl.33

Creswell, J.W., & Creswell, J.D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. Thousand Oaks: Sage.

Coghlan, D., & Brannick, T. (2005). *Doing action research in your own organization* (2nd ed.). London: Sage.

Denzin, N.K. & Lincoln, Y.S. (Eds.) (2000). *Handbook of Qualitative Research* 2nd Ed. Thousand Oaks: Sage.

Department of Education (2001). National Plan for Higher education. Ministry of Education February 2001. Pretoria.

Department of Education. (2002). *Language policy for higher education.* Pretoria: Department of Education.

Department of Basic Education (2010). Intermediate Phase Curriculum and Assessment Policy Statement: Mathematics. Pretoria, South Africa.

Department of Basic Education (2013). National Education Evaluation Development Unit Summary report. Pretoria: Department of Basic Education.

Department of Basic Education (2022). National Senior Certificate 2021 Diagnostic Report Part 1: Content Subjects. Pretoria: Department of Basic Education.

Dillon, J. T. (1982). In Pursuit of the Colon: A Century of Scholarly Progress: 1880-1980. *The Journal of Higher Education, 53*(1). https://doi.org/10.2307/1981541

Edmondson, J. (2002). Asking Different Questions: Critical Analyses and Reading Research. *Reading Research Quarterly*, *37*(1). https://doi.org/10.1598/rrq.37.1.5

Enders, J. (2005). Border crossings: Research training, knowledge dissemination and the transformation of academic work. *Higher Education*, 49 , 119–133.

Evans, I. (1990). The racial question and intellectual production in South Africa. *Perspectives in Education*, *11*(2), 21–35.

Fawcett, J., & Downs, F. (1986). *The relationship of theory and research*. Norwalk, CT: Appleton Century Crofts.

Fennema, E. (1989). The Study of Affect and Mathematics: A Proposed Generic Model for Research. *Affect and Mathematical Problem Solving*, 205–219. https://doi.org/10.1007/978-1-4612-3614-6_14

Field, A. P. (2016). *Can meta-analysis be trusted?* Retrieved from https://www.researchgate.net/publication/228750320

Foucault, M. (1978). *Politics and the study of discourse, ideology and consciousness, 3*.7-26.

Friedman, L. (1989). Mathematics and the gender gap: A meta-analysis of recent studies on sex differences in mathematical tasks. In *Review of Educational Research*. 59(2), pp.185-213.

Gane, M. (1983). Anthony Giddens and the crisis of social theory. *Economy and Society* 12, pp368-398.

Giddens, A. (1971). *Capitalism and Modern Social Theory*. Cambridge: Cambridge University Press.

Giddens, A. (1976). *New Rules of Sociological Method*. New York: Basic.

Giddens, A. (1979). *Central Problems in Social Theory*. London: Macmillan.

Giddens, A. (1981). *A contemporary Critique of Historical Materialism*, Vol 1, *Power, Property and the State*, London: Macmillan.

Giddens, A. (1982). On the relation of sociology and philosophy. In P. Secord (ed.), *Explaining Human Behaviour*. Beverly Hills, CA: Sage.

Giddens, A. (1984). *The Constitution of Society: Outline of the Theory of Structuration*. Berkeley: University of California Press.

Giddens, A. (1971). *Capitalism and modern social theory: An analysis of the writings of Marx, Durkheim and Max Weber*. Cambridge University Press.

Giddens, A. (1993). *New rules of sociological method*. Stanford University Press.

Glaser, B. G., & Strauss, A. (1967). *The Discovery Grounded Theory: Strategies for Qualitative Inquiry*. Chicago: Aldin.

Glass, G.V. (1976). Primary, Secondary and Meta-Analysis of Research. *Educational Researcher*, *5*(10),3-8.

Glass, G.V., Mc Gaw, B., & Smith, M.L. (1981). *Meta-Analysis in Social Research*. Beverly Hills, CA: SAGE Publications.

Goba, B., Balfour, R. J., & Nkambule, T. (2011). *The nature of experimental and quasi–experimental research in postgraduate education research in South Africa: 1995–2004*. Retrieved from https://repository.nwu.ac.za/handle/10394/8119

Goetz, J. P., & LeCompte, M. D. (1984). Ethnography and qualitative designs in ethnographic research. *New York: Academic*.

Govender, K. & Dhunpath, R. (2011). Student experiences of the PhD cohort model: Working within or outside communities of practices? *Perspectives in Education*, 29(3): 88-99.

Graham, S., & Perin, D. (2007). *Writing next: Effective strategies to improve writing of adolescents in the middle and high schools*. New York: Carnegie Corporation. Retrieved from www.carnegie.org/literacy.

Guba, E. G. (1990). *The alternative paradigm dialog. In. EG Guba.(ed). The paradigm dialog.* Sage, Newbury Park, CA.

Haidet, P., Jarecke, J., Adams, N. E., Stuckey, H. L., Green, M. J., Shapiro, D., … Wolpaw, D. R. (2016). A guiding framework to maximise the power of the arts in medical education: a systematic review and metasynthesis. *Medical Education*, *50*(3), 320–331. https://doi.org/10.1111/MEDU.12925

Hallock, R., & Dillner, K.M. (2016). Should title lengths really adhere to the American Psychological Association's twelve word limit? *The American Psychologist*. *71*(3), 240-242.

Haugaard, M. (1997). The constitution of power: a theoretical analysis of power, knowledge and structure. Manchester University Press.

Hay, D. & Monnapula-Mapesela, M. (2009). South African Higher Education Before and After 1994: A Policy Analysis Perspective. In E. Bitzer, Higher Education in South Africa: A Scholarly Look Behind the Scenes, Stellenbosch: Sun Press., pp:3-20.

Hays, J. C. (2010). Eight Recommendations for Writing Titles of Scientific Manuscripts. Public Health Nursing, 27(2), 101–103. https://doi.org/10.1111/J.1525-1446.2010.00832.X

Heller, M. (2007). Distributed knowledge, distributed power: A sociolinguistics of structuration. *Text and Talk*, *27*(5–6), 633–653. https://doi.org/10.1515/TEXT.2007.029/MACHINEREADABLECITATION/RIS

Herman, C. (2017). Looking back at doctoral education in South Africa. *Studies in Higher Education*, *42*(8), 1437–1454. https://doi.org/10.1080/03075079.2015.1101756

Hitchcock, G., & Huges, D. (1995). *Research and the teacher 2nd ed*. London: Routledge.

Hunter, J. E., Schmidt, F. L., & Le, H. (2006). Implications of direct and indirect range restriction for meta-analysis methods and findings. *Journal of Applied Psychology*, 91, 594–612.

Hyland, K. (2002). *Teaching and Researching Writing*. Harlow, Essex: Longman.

Jalilifar, A. (2010). Writing titles in applied linguistics: A comparative study of theses and research articles. *Taiwan International ESP Journal*, *2*(1).

Janks, H. (1997). Discourse: Studies in the Cultural Politics of Education Critical Discourse Analysis as a Research Tool Critical Discourse Analysis as a Research Tool. *Online) Journal Politics of Education*, *183*(3).

Jansen, J. (1991). "The racial question and intellectual production in South Africa: A critical response to Ivan Evans", *Perspectives in education*, 12(2),107-110.

Jansen, J. (2003). Mergers in South African higher education: Theorising change in transitional contexts. *Politikon*, *30*(1). https://doi.org/10.1080/0258934032000073897

Johnstone, B. (2008). Discourse Analysis, 2nd ed. *Oxford*, *I*(July).

Jojo, Z. (2020). Mathematics education system in South Africa. *Education Systems around the World*, 129–140.

Jonker, J., & Pennink, B. W. (2010). The essence of research methodology: A concise guide for master and PhD students in management science. In *The Essence of Research Methodology: A Concise Guide for Master and PhD Students in Management Science*. https://doi.org/10.1007/978-3-540-71659-4

Jørgensen, M., & Phillips, L. (2012). Discourse Analysis as Theory and Method. In *Discourse Analysis as Theory and Method*. https://doi.org/10.4135/9781849208871

Kallaway, P. (1997). Reconstruction, Reconciliation, Rationalisation in South African Politics of Education. In P. Kallaway, G. Kruss, A. Fataar & G. Donn (eds.). *Education After Apartheid: South African Education in Transition.* Cape Town: University of Cape Town Press, pp. 34-49.

Karlsson, J., Balfour, R., Moletsane, R. & Pillay, G. (2009). Researching postgraduate educational research in South Africa. South African Journal of Higher Education 23(6), pp 1086–1100.

Kaspersen, L. B. (2000). Anthony Giddens: An introduction to a social theorist. Oxford: Blackwell Publishers Ltd.

Kearney, M. H. (1998). Ready-to-wear: Discovering grounded formal theory. *Research in Nursing & Health*, *21*(2). https://doi.org/10.1002/(sici)1098-240x(199804)21:2<179::aid-nur8>3.3.co;2-9

Kearney, M.H. (2001). New directions in grounded formal theory. In R. Schreiber & P.N. Stern (Eds.), *Using grounded theory in nursing* (pp. 227 -246). New York: Springer.

Kahn, M., & Oghenetega, J. (2021). Origins and destinations known: A tracer study of international African doctoral graduates from South Africa's universities. *Industry and Higher Education*. *35*, 559 – 569.

Khuzwayo, H.B. (2000). *Selected views and critical perspectives: An account of mathematics education in South Africa from 1948 to 1994*: Unpublished PhD thesis, Aalborg University, Denmark.

Khuzwayo, H.B. (2005). A history of mathematics education research in South Africa: the apartheid years. In R. Vithal, J. Adler & C. Keitel, *Researching mathematics education in South Africa: perspectives, practices and possibilities*. Cape Town: HSRC Press.

Kirby, J. T. (1997). Aristotle On Metaphor. *American Journal of Philology*, *118*(4), 517–554. https://doi.org/10.1353/AJP.1997.0056

Kort, W. & Gharbi. J.E. (2013). Structuration theory amid negative and positive criticism. In International Journal of Business and Social Research (IJBSR) 3(5), pp.92-104.

Lakoff, G., & Johnson, M. (1980). *Metaphors we live by*. Chicago: University of Chicago Press.

Landi,M.T., Chatterjee, N., Yu, K., Goldin, L.R., Goldstein, A.M., Rotunno, M., Mirabello,L., Jacobs, K., Wheeler, W., Yeager, M., Bergen, A.W., Li, Q., Consonni, D., Pesatori, A.C., Wacholder, S., Thun, M., Diver, R., Oken, M., Virtamo, J., Albanes, D., …, & Caporaso, N.E. (2009). A Genome-wide Association Study of Lung Cancer Identifies a Region of Chromosome 5p15 Associated with Risk for Adenocarcinoma. *The American Journal of Human Genetics* 85, 679–691.

Lategan, L. O. K. (2009). The university as key concept in higher education studies. *Higher Education in South Africa: A Scholarly Look behind the Scenes*, *1*, 53.

Lather, P. (1991). *Getting Smart: Feminist Research and Pedagogy within/in the Postmodern*. https://doi.org/10.4324/9780203451311

Lelliott, A., Mwakapenda, W., Doidge, M., du Plessis, J., Mhlolo, M., Msimanga, A., Mundalamo, F., Nakedi, M., & Bowie, L. (2009). Issues of teaching & learning in South Africa: A review of research, policy and practice in times of change. In *African Journal of research in Mathematics, Science and Technology Education*. Special edition 2009.

Lindquist, I., Engardt, M., & Richardson, B. (2010). Learning to be a physiotherapist: a metasynthesis of qualitative studies. *Physiotherapy Research International*, *15*(2), 103–110. https://doi.org/10.1002/PRI.461

Luppicini, R. (2005). A Systems definition of educational technology in society. *Educational Technology and Society*, *8*(3).

Mabokela, R.O., & Mawila, K.F.N. (2004). The Impact of Race, Gender, and Culture in South African Higher Education. *Comparative Education Review* , 48(4), 396-416.

Macrae, M. (1994). A legacy of apartheid: The case of mathematical education in south Africa. *International Journal of Educational Development*, *14*(3). https://doi.org/10.1016/0738-0593(94)90041-8

Madikizela-Madiya, N., Goba, B. B., & Nkambule, T. (2016). Developing a researcher identity: A reflective narration of postgraduate students' supervision experiences in a research project. *South African Journal of Higher Education*, *27*(4). https://doi.org/10.20853/27-4- 271

Maharaj, A. (2008). Some insights from research literature for teaching and learning mathematics. *South African Journal of Education*, *28*(3). https://doi.org/10.15700/saje.v28n3a182

Mamdani, M. (1999) "There can be no African Renaissance without an Africa-focused intelligentsia". In M.W. Makgoba (ed.). *African Renaissance-The new struggle*, South Africa: Tafelberg Publishers Ltd.

Martin, J. R., & Rose, D. (2003). *Working with discourse: Meaning beyond the clause*. Bloomsbury Publishing.

Mkhize, N. (2022). The state of doctoral training in South Africa: Current and emerging practices. In *Doctoral Training and Higher Education in Africa*. https://doi.org/10.4324/9781003183952-3

Morgaine, C. A. (1999). Alternative paradigms and professionalizing childhood care and education: The oregon example. *Child and Youth Care Forum*, *28*(1). https://doi.org/10.1023/A:1021946517804

Morrison, S., Graven, M., Venkat, H., & Vale, P. (2023). A 20-year review of South African Early Grade Mathematics research articles. *African Journal of Research in Mathematics, Science and Technology Education. 27*(3) 304-323.

Mouton, J. (2008). How to succeed in your master's & doctoral studies: A South African guide and resource book. Pretoria: Van Schaik.

Mungra, P. (2007). Metaphors among titles of medical publications: An observational study. *Ibérica*, *14*.

Murgatroyd, L. (1989). Only half the story: some blinkering effects of 'malestream' Sociology. In D. Held and J.B. Thompson, *Social theories of Modern Societies: Anthony Giddens and his Critics*. Cambridge: Cambridge University Press

Ndlovu, M. (2013). Revisiting the efficacy of constructivism in mathematics education. *Philosophy of Mathematics Education Journal*, (27).

Neuman, W.L. (1997). *Social Research Methods: Qualitative and Quantitative Approaches*. 3rd. Edition, Boston: Allyn and Bacon.

Nkambule, T., Bengesai, A., Davey, B., Lekena, L., Molefe, S., Madiya, N., & Goba, B. (2008). *Project Postgraduate Educational Research in Education: National Issues, Trends, and Reflections (1995-2004)*.

Noblit, G.W. & Hare, R.D. (1988). *Meta-Ethnography: Synthesizing Qualitative studies*. Newbury Park: Sage Publications. https://doi.org/10.4135/9781412985000.

Oliver, P. (2013). *Writing Your Thesis*. 1–248.

O'Sullivan, D. (2006). Meta-analysis. In G.M. Breakwell, S. Hammond, C. Fife-Shaw, & J.A. Smith (Eds.). *Research methods in Psychology* 3rd ed. London: SAGE publications.

Outhwaite, W. (1990). Agency and structure. In J. Clark, C. Modgil, & Modgil, S., Anthony Giddens: *Consensus and Controversy*. London: The Falmer Press.

Paterson, B.L., Thorne, S.E., Canam, C. & Jillings, C. (2001). *Meta-Study of Qualitative Health Research. A Practical Guide to Meta-Analysis and Meta-Synthesis*. Thousand Oaks, CA: Sage Publications.

Paulsen, C.A and Dailey, D. (2002). *A Guide for Education Personnel: Evaluating a Program or Intervention*. American Institutes for Research: Washington.

Pitt, C. (2018). Former political prisoner graduates with master's degree-almost 50 years after submission. *News 24* retrieved on 2018-11-05.

Planas, J.A. (2009). Hispanic nursing students' journey to success: A meta-synthesis. In *Journal of Nursing Education*. 48(9), 504-513.

Pretorius, S.G. (2007). South Africa. In: C.C. Wolhuter, E.M., Lemmer & N.C. de Wet (eds). *Comparative Education: Education systems and contemporary issues*. Pretoria: Van Schaik.

Pring, R. (2004). *Philosophy of Education: Aims, Theory, Common Sense and Research*. New York: Continuum.

Rizvi, F. (2005). Rethinking "Brain Drain" in the Era of Globalisation. *Asia Pacific Journal of Education*, *25*, 175-192. https://api.semanticscholar.org.

Rollnick, M., Adler, J., & Setati, M. (2009). The institutional location of research in Mathematics and Science Education in South Africa. *African Journal of Research in Mathematics, Science and Technology Education*, *13*, 115–130. https://doi.org/10.1080/10288457.2009.10740665

Rose, J. (1998). Evaluating the Contribution of Structuration Theory to the IS Discipline. In Proceedings of the European Conference on Information Systems (BAETS, W.R.J. Ed), Euro-Arab Management School, Granada

Şahin, D., Calp, Ş., Bulut, P., & Kuşdemir, Y. (2013). Investigation of the graduate theses in the department of primary teacher education in terms of various criteria. *Journal of World of Turks*, *5*(3), 187–205.

Samuel, M., & Vithal, R. (2011). Emergent frameworks of research teaching and learning in a cohort-based doctoral programme. *Perspectives in Education*, *29*(3).

Schalk, L., Roelle, J., Saalbach, H., Berthold, K., Stern, E., & Alexander Renkl, A. (2020). Providing worked examples for learning multiple principles. Applied Cognitive Psychology. https://doi.org/10.1002/acp.3653.

Scherer, C. & Sooryamoorthy R. (2022). Understanding higher education in Africa from distinct geographies: Reflections on the episteme of doctoral education. In C. Scherer & R. Sooryamoorthy. *Doctoral Training and Higher Education in Africa*. London and New York: Routledge.

Schoenfeld, A. H. (2000). Purposes and Methods of Research in Mathematics Education. In Notices of the AMS June /July 2000, 47(6), pp. 641-649.

Setati, M., Adler, J., & Rollnick, M. eds. (2009). *African Journal of research in Mathematics, Science and Technology Education*. Special edition 2009.

Sethole, G., Goba, B., Adler, J., & Vithal, R. (2006). Fine-Tuning a Language of Description for Mathematics Items which Incorporate the Everyday. *Mathematics Classrooms in Twelve Countries*, 117–130. https://doi.org/10.1163/9789087901622_009

Shaddock, A. (2021). *Using data to improve learning: a practical guide for busy teachers.* 3rd edn, Camberwell: ACER Press.

Sierpinska, A. (2003). Research in Mathematics Education Through a Keyhole. *CMESG/GCEDM Proceedings*.

Sierpinska, A., & Kilpatrick J. (1998). *Mathematics Education as a Research Domain: A search for Identity.* An ICMI Study.

Silverman, D. (2024). *Interpreting Qualitative Data*. 1–100.

Skovsmose, O. (1985). Mathematics Education versus Critical Education. *Educational Studies in Mathematics*. *16*(4) 337-354.

Skovsmose, O. (1994). *Towards a Philosophy of Critical Mathematics Education*. Springer.

Soudien, G., & Baxen, J. (1997). Transformation and outcomes-based education in South Africa: Opportunities and challenges. *Journal of Negro Education*, *66*(4). https://doi.org/10.2307/2668172

Stones, R. (2017). *Structuration theory*. Bloomsbury Publishing.

Subotzky, G. (1997). Redefining equity: Challenges and opportunities facing South Africa's historically black universities relative to global and national changes. *Journal of Negro*

Education, *66*(4). https://doi.org/10.2307/2668176

Suri, H. (2000). A critique of contemporary methods of research synthesis. *Post-Script*, *1*(1), 49–55.

Suri, H. (2004). Synthesising research for diverse purposes: moving beyond “what works”? *Annual Conference of the Australian Association for Research in Education (AARE), Melbourne*, *28*, 395–430.

Suri, H. (2010). *Cooperative learning in secondary mathematics: A meta-analysis*. VDM Publishing.

Suri, H. (2013). Towards methodologically inclusive research syntheses: Expanding possibilities. *Towards Methodologically Inclusive Research Syntheses: Expanding Possibilities*, 1–191. https://doi.org/10.4324/9780203383193

Suri, Harsh, & Clarke, D. (2009). Advancements in research synthesis methods: From a methodologically inclusive perspective. *Review of Educational Research*, *79*(1), 395–430. https://doi.org/10.3102/0034654308326349/ASSET/IMAGES/LARGE/10.3102_0034654308326349-FIG1.JPEG

Swales, J., & Feak, C.B. (1994). *Academic writing for graduate students.* Ann Arbor: The University of Michigan Press.

Swartz, S., Mahali, A., Moletsane, R., Arogundade, E., Khalema, N. E., Cooper, A., & Groenewald, C. (2018). *Studying while black: Race, education and emancipation in South African universities*.

Taylor, V. J. (2003). Structuration Revisited: A Test Case for an Industrial Archaeology Methodology for Far North Queensland. *Industrial Archaeology Review*, *25*(2). https://doi.org/10.1179/IAR.2003.25.2.129

Taylor, P., Hagen, P., Liljedahl, P., & Moshe, L. (2007). Does a math education PhD program belong in a math department? In P. Liljedahl (ed.) *Proceedings of the Canadian Mathematics Education Study Group*. Calgary, Alberta.

Türk, F., & Cihangiroğlu, Ü. (2018). Thematic and Methodological Investigation of Applied Postgraduate Theses on Psychological Counseling and Guidance. *International Journal Of Eurasia Social Sciences*, *9*, 276–311. Retrieved from https://www.researchgate.net/publication/324223207

University of KwaZulu-Natal. (2006). *University of KwaZulu-Natal language policy*. Available from http://utlo.ukzn.ac.za/Libraries/November_2011_Conferences/APPENDIX_D4_Language_Policy_-_Council_approved_010906.sflb.ashx

University of KwaZulu-Natal. (2013). University of KwaZulu-Natal strategic plan 2007–2016. Available from http://www.ukzn.ac.za/aboutus/strategicplan.pdf

Van Coller, H. P. (2016). Perspectives on Afrikaans as a university language. *Tydskrif Vir*

Geesteswetenskappe, *56*(4–1), 998–1015. https://doi.org/10.17159/2224-7912/2016/V56N4-1A8

Vasara-Hammare, N., Alerby, E., & Hertting, K. (2012). Education, assessment and the construction of the new Swedish school system. *International Journal of Arts and Sciences*, *5*(5), 161–170. Retrieved from https://urn.kb.se/resolve?urn=urn:nbn:se:ltu:diva-8217

Venkat, H., Alder, J., Rollnick, M., Setati, M., & Vhurumuku, E. (2009). Mathematics and science education research, policy and practice in South Africa: What are the relationships? In *African Journal of research in Mathematics, Science and Technology Education*. Special edition 2009.

Venkat, H., Bowie, L., & Graven, M. (2009). Positions and purposes for contextualisation in mathematics education in South Africa. In *African Journal of research in Mathematics, Science and Technology Education*. Special edition 2009.

Vithal, R., Adler, J., & Keitel, C. (2005). *Researching mathematics education in South Africa: perspectives, practices and possibilities*. HSRC Press.

Vithal, R., & Goba, B. (2016). Successful postgraduate mathematics education supervision. In M. Phakeng & S. Lerman (Eds). *Mathematics Education in a Context of Inequity, Poverty and Language Diversity: Giving Direction and Advancing the Field*. Switzerland: Springer.

Waller, P. P., & Maxwell, K. L. H. (2017). Mathematics Teachers' Perceptions of Resources and Curriculum Availability in Post-Apartheid Schooling. *International Journal of Science and Mathematics Education*, *15*(4), 741–757. https://doi.org/10.1007/S10763-016-9713-2/FIGURES/2

Watkins, C. & Mortimore, P. (1999). Pedagogy: What do we know? In P. Mortimore (Ed.), *Understanding pedagogy and its impact on learning*. Thousand Oaks, CA: SAGE

Welman, C., Kruger, S. J., & Mitchell, B. (2005). *Research methodology (3rd edn.). Cape Town*. South Africa: Oxford University Press.

Yitzhaki, M. (2001). *Relation of title length of journal article to length of article*. https://api.semanticscholar.org/CorpusID:31594522.

Zimmer, L. (2006). Qualitative meta-synthesis: a question of dialoguing with texts. *Journal of Advanced Nursing*, *53*(3), 311–318. https://doi.org/10.1111/J.1365-2648.2006.03721.X

Zondo, A. (2021). Exploring learners' cognitive engagement when responding to a Euclidean geometry task. Unpublished masters dissertation, University of KwaZulu-Natal, Pinetown.

APPENDICES

A Pilot study captured on SPSS Code book

B Data captured on ENDNOTE

C Doctoral theses and masters dissertations analysed in this study

D Coded research phenomena from the corpus of mathematics education theses

E Categories of research phenomena

F Theories used in mathematics education postgraduate studies in South Africa (1995-2004)

G Ethical clearance

H Editor’s letter

APPENDIX A

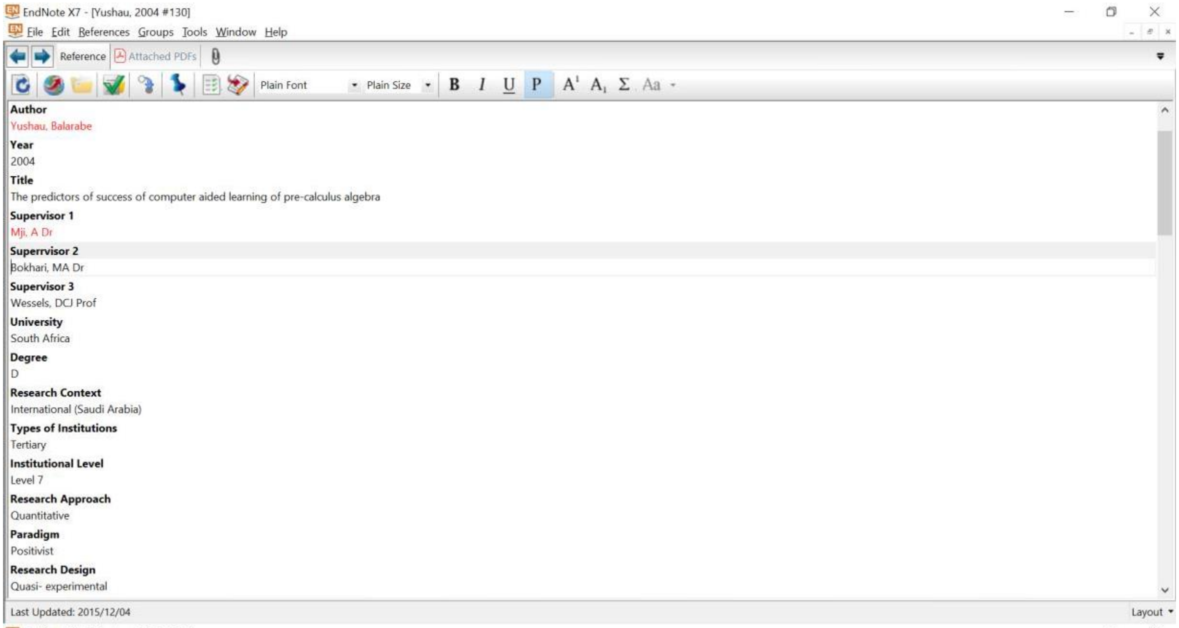
*SPSS try UKZN.sav [DataSet1] - SPSS Data Editor

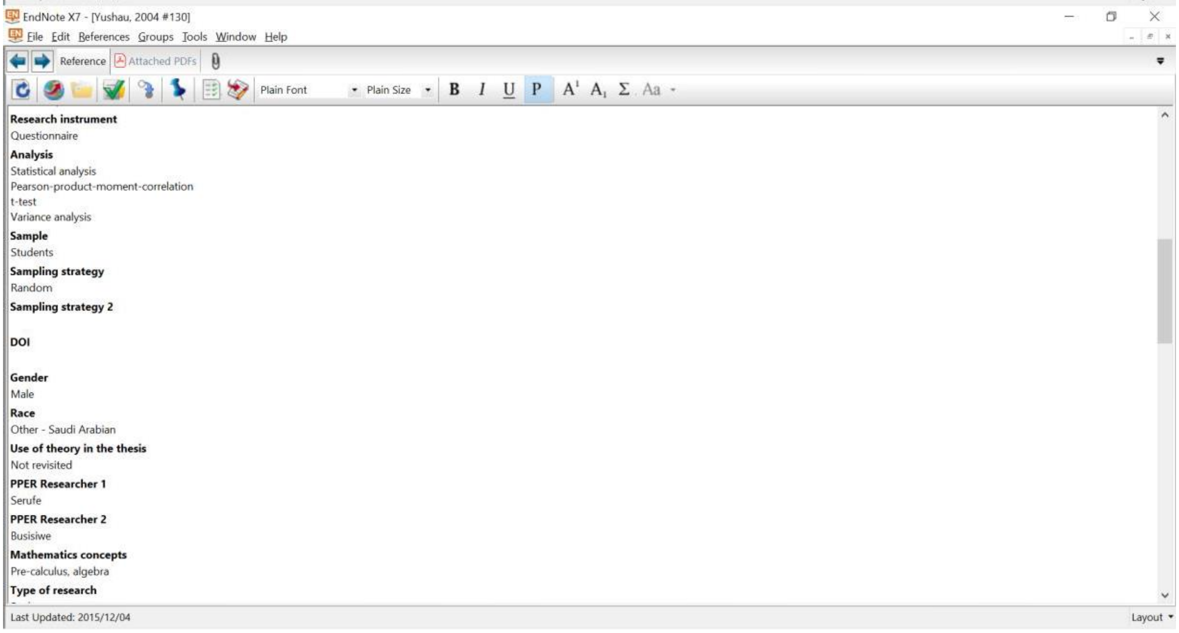
File Edit View Data Transform Analyze Graphs Utilities Window Help

	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure
1	Id_No	Numeric	8	0	Identity of the	None	None	8	Right	Scale
2	Name	String	15	0	Posgraduate's	None	None	11	Left	Nominal
3	Gender	String	8	0	Gender of the	{1, Female}...	None	8	Left	Nominal
4	Race	String	8	0	Race of the po	{1, Black}...	None	8	Left	Nominal
5	Institution	String	8	0	Institution wher	{1, UKZN}...	None	8	Left	Nominal
6	Year	Numeric	8	0	Year in which t	None	None	8	Right	Scale
7	Degree	String	8	0	Degree in whic	{1, PhD}...	None	8	Left	Nominal
8	Sup_1	String	20	0	The first superv	None	None	9	Left	Nominal
9	Discpl_1	String	8	0	The discipline	None	None	8	Left	Nominal
10	Sup_2	String	8	0	The second su	None	None	8	Left	Nominal
11	Discpl_2	String	8	0	The discipline	None	None	8	Left	Nominal
12	Focus	String	8	0	The focus of th	{1, New develo	None	13	Left	Nominal
13	Pardigm	String	8	0	Pardigm used i	{1, Positivist}...	None	10	Left	Nominal
14	Natr_inq	String	8	0	Nature of enqui	{1, Case study	None	8	Left	Nominal
15	Theories_1	String	25	0	Theories used	None	None	10	Left	Nominal
16	Theories_2	String	25	0	Theories used	None	None	8	Left	Nominal
17	Theorist_1	String	25	0	Theorists used	None	None	8	Left	Nominal
18	Theorist_2	String	25	0	Theorists used	None	None	8	Left	Nominal
19	Method	String	8	0	Method used i	{1, Qualitative}.	None	8	Left	Nominal
20	Tool_1	String	8	0	Research tools	{1, Statistics}..	None	8	Left	Nominal
21	Tool_2	String	8	0	Research tool	{1, Statistics}..	None	8	Left	Nominal
22	Tool_3	String	8	0	Research tool	{1, Statistics}..	None	8	Left	Nominal
23	Sample_1	String	8	0	Who is resear	{1, Learners at	None	8	Left	Nominal
24	S_strategy	String	8	0	Sampling strat	{1, Random}...	None	8	Left	Nominal
25	Sample_2	String	8	0	Who/What is r	{1, Learners at	None	8	Left	Nominal
26	S_strategy	String	8	0	Sampling strat	{1, Random}...	None	8	Left	Nominal
27	Level	String	8	0	Level of the stu	{1, Primary}...	None	8	Left	Nominal
28	Geography	String	8	0	Geographical l	{1, Rural}...	None	8	Left	Nominal
29										

APPENDIX B

DATA CAPTURED ON ENDNOTE





EndNote X7 - [Yushau, 2004 #130]
File Edit References Groups Tools Window Help
Reference Attached PDFs
Plain Font Plain Size B I U P A¹ A₁ Σ Aa

Type of research
Explanatory
Date Captured
3 April 2009
Accession Number
11
Thesis Number
3816
Label

Keywords
Curriculum Mathematics
ICTs
Institutions - HEIs
Pre-Calculus
Abstract
Mathematics achievement has been of great concern to researchers involved in mathematics education. This concern has resulted in research seeking to determine for example, the factors that positively or negatively contribute to student performance in mathematics. Many of the reported studies in the literature have investigated the factors within the context of mathematics teaching and learning in general. Very few studies have investigated the factors contributing to student achievement in mathematics when learning takes place in a computer aided environment. With the pervasiveness of computers in education in general, studies in this direction become imperative. The present study fills this gap in the literature by examining the extent to which selected variables (mathematics attitude, mathematics aptitude, computer attitude, computer prior experience, computer ownership, proficiency in language of instruction, and learning style) contribute to students' achievements in pre-calculus algebra classes that are supplemented with a computer lab program. The participants in the study were 120 students sampled from the population of students enrolled in the second pre-calculus algebra course at the preparatory year program of King Fahd University of Petroleum & Minerals during the 2003/2004 academic session. The instruments used to measure the study constructs were the mathematics attitude scale (Aiken, 1979), the computer attitudes scale (Loyd & Gressard, 1984a), and the learning styles questionnaire (Honey & Mumford, 1992). New instruments to measure computer prior experience and computer ownership were developed for the present study.
Hypotheses formulated for the study were tested using multiple regression and other statistical techniques. The results show that mathematics aptitudes and English language proficiency are the most significant contributors to students' mathematics achievement. No other variables show statistically significant effects on students' achievement. Together, the selected variables explain more than 41 percent of the total variance of students' achievement.
Theoretical and policy-making implications of the results are outlined and discussed.
Research questions/hypotheses
Eight hypotheses stated
Hypothesis 1: There is a significant positive relationship between mathematics aptitudes and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Last Updated: 2015/12/04 Layout

EndNote X7 - [Yushau, 2004 #130]
File Edit References Groups Tools Window Help
Reference Attached PDFs
Plain Font Plain Size B I U P A¹ A₁ Σ Aa

Research questions/hypotheses
Eight hypotheses stated
Hypothesis 1: There is a significant positive relationship between mathematics aptitudes and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Hypothesis 2: There is a significant positive relationship between attitudes towards mathematics and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Hypothesis 3: There is a significant positive relationship between computer attitudes towards mathematics and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Hypothesis 4: There is a significant relationship between computer ownership and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Hypothesis 5: There is a significant relationship between computer prior experience and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Hypothesis 6: There is a significant differential effects of learning styles on achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Hypothesis 7: There is a significant relationship between proficiency in the language of instruction and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Hypothesis 8: The predictor variables (mathematics attitudes, computer attitudes, mathematics aptitudes, computer ownership, proficiency in language of instructions, and learning styles) will contribute a significant portion of variance in the achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.
Research Phenomenon
Assessment
Emotions
Technology
Theory 1
Sociolinguistic - Gawned

EndNote X7 - [Yushau, 2004 #130]
File Edit References Groups Tools Window Help
Reference Attached PDFs
Plain Font Plain Size B I U P A¹ A₁ Σ Aa

Hypothesis 8: The predictor variables (mathematics attitudes, computer attitudes, mathematics aptitudes, computer ownership, proficiency in language of instructions, and learning styles) will contribute a significant portion of variance in the achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.
Research Phenomenon
Assessment
Emotions
Technology
Theory 1
Sociolinguistic - Gawned
File Attachments

Theory 2
Learning Style Inventory- Kolb
Figure

Theory 3

Findings
The results show that mathematics aptitudes and English language proficiency are the most significant contributors to students' mathematics achievement. No other variables show statistically significant effects on students' achievement.
Translated Author

Translated Title

Type of research questions
Hypotheses
Database Provider

Language
English

Last Updated: 2015/12/04 Layout

APPENDIX C

Doctoral theses and masters dissertations analysed in this study

1. Adler, J. B. (1996). *Secondary school teachers' knowledge of the dynamics of teaching and learning mathematics in multilingual classrooms*. Unpublished doctoral thesis, University of Witwatersrand, Johannesburg.

2. Agherdien, G. A. (2004). *Investigating a geometry course for in-service teachers*. Unpublished masters dissertation, University of Cape Town, Cape Town.

3. Appanna, S. (1995). *Pupils' perceptions of study of mathematics as a subject for the Senior Certificate Examination: Two case studies*, Unpublished masters dissertation, University of KwaZulu-Natal, Durban.

4. Arigbabu, A. A. (2003). *The influence of preservice teachers' subject combinations on performance in mathematics in Nigeria*. Unpublished doctoral thesis, University of South Africa, Pretoria.

5. Barnes, H. E. (2004). *A developmental case study: implementing the theory of realistic mathematics education with low attainers*. Unpublished masters dissertation, University of Pretoria, Pretoria.

6. Bedeker, J. C. (1999). *Uitkomsgebaseerde Wiskunde-Onderrig*. Unpublished masters dissertation, University of Johannesburg, Johannesburg.

7. Bennie, C. J. (1999). *Building a model of "spatial ability". An analysis of grade 5 and 6 learners' strategies for solving "spatial" activities*. Unpublished masters dissertation, University of Cape Town, Cape Town.

8. Berger, M. (1996). *The role of the graphical calculator as a mediating sign in the zones of proximal development of students studying a first-year university mathematical course*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

9. Berger, M. (2002). *The appropriation of mathematical objects by undergraduate mathematics students: A study.* Unpublished doctoral thesis. University of Witwatersrand, Johannesburg.

10. Bezuidenhout, J. G. H. (1998). *Universiteitstudente se begryping van basiese begrippe in elementre differensiaalen intergraalrekening*. Unpublished doctoral thesis, Stellenbosch University, Stellenbosch.

11. Bhengu, L. M. B. (2003). *Investigating the use of application tasks in teacher assessment practices: A case study of three Grade 7 mathematics classes in the Durban South Region*. Unpublished masters dissertation, University of KwaZulu-Natal, Durban.

12. Binnendyk, J. M. (1996). *An investigation of the informal mathematical knowledge and competencies of reception class entrants*. Unpublished masters dissertation, University of KwaZulu-Natal, Durban.

13. Boshoff, H. H. (2002). *An action research study focused on improving the mathematical problem solving performance of some learners in Grade 5, for a specific problem-type*. Unpublished doctoral thesis, Nelson Mandela Metropolitan University, Port Elizabeth.

14. Buys, C. (1998). *Koöperatiewe Leer in Wiskunde-Onderrig vir Oriënteringstudente aan 'n Tegniese Kollege*. Unpublished doctoral thesis, North West University, Potchefstroom.

15. Cameron, B. (2003). *Reflections on the introduction of algebra in Grade 8:a teacher's perspective*. Unpublished masters dissertation, University of Cape Town, Cape Town.

16. Campbell, A. B. (1999). *How primary mathematics teachers learn about co-operative learning: Case investigation*. Unpublished masters dissertation, Nelson Mandela Metropolitan University, Port Elizabeth.

17. Carr, B. A. (2002). *Information, knowledge and learning: Is the web effective as a medium for mathematics teaching?* Unpublished doctoral thesis, University of Pretoria, Pretoria.

18. Cassy, B. (1997). *Gender performance and attitudes toward mathematics in BUSCEP students at Universidade Eduardo Mondlane*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

19. Cassy, B. (2002). *Effect of classroom interaction and gender on mathematics performance and attitudes toward mathematics of secondary pupils in Mozambique*. Unpublished doctoral thesis, University of Witwatersrand, Johannesburg.

20. Cherinda, M. (2002). *The use of a cultural activity in the teaching and learning of mathematics: Exploring twill weaving with a weaving board in Mozambican classrooms*. Unpublished doctoral thesis, University of Witwatersrand, Johannesburg.

21. Chetty, M. (2003). *Assessment practices in curriclum 2005: A case study of two senior phase mathematics teachers*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

22. Cilliers, P. S. (1995). *A case study investigation of how assessment practices construct teachers' and pupils' views of mathematics*. Unpublished masters dissertation, University of Cape Town, Cape Town.

23. Collins, H. (2001). *Student mathematical writing, pedagogic practice and quality learning: A comparative analysis of student productions at two schools*. Unpublished masters dissertation, University of Cape Town, Cape Town.

24. Cranfield, C. G. (2001). *An investigation into how Grade 12 students understand and solve geometric problems*. Unpublished masters dissertation, University of Cape Town, Cape Town.

25. Cronje, L. S. (1995). *Euclidean geometry: cognitive gender differences*. Unpublished doctoral thesis, University of Witwatersrand, Johannesburg.

26. Davids, N. A. (1997). *Die Gebruik van Meetkunde - Modelle in Wiskunde - Onderrig*. Unpublished masters dissertation, University of Johannesburg, Johannesburg.

27. Davis, Z. (1995). *The re-contextualizing of pedagogic discourse: A case study drawn from an in-service mathematics education project*. Unpublished masters dissertation, University of Cape Town, Cape Town.

28. de Witt, E. (1998). *Krommepassing as probleemtipe in 'n probleemgesentreerde benadering tot algebra: 'n onderrig-eksperiment met standerd ses en sewe leerlinge*. Unpublished masters dissertation, Stellenbosch University, Stellenbosch.

29. Delport, R. (2003). *Computer-mediated communication in undergraduate mathematics modules*. Unpublished masters dissertation, University of Pretoria, Pretoria.

30. Deonarain, S. (2004). *An investigation into teachers' views of continuous assessment and its implementation in Grade 12 HG mathematics in the Ethekwini Region*. Unpublished masters dissertation, University of KwaZulu-Natal, Durban.

31. Dickson, M. (1999). *Super highway or cul de sac: The internet as a tool for learning school mathematics*. Unpublished master dissertation, University of Witwatersrand, Johannesburg.

32. Dirks, D. (1996). *Mediation and problem solving approach to junior primary mathematics*. Unpublished masters dissertation, University of Western Cape, Cape Town.

33. Dlamini, T. C. (1995). *How teachers use instructional materials in teaching junior primary mathematics, with specific reference to the maths centre for primary teachers*. Unpublished masters dissertation, University of KwaZulu-Natal, Durban.

34. Durandt, R. (2002). *Uitdagings van uitkomsgebaseerde onderwys vir die bestuur van die wiskundeklaskamer*. Unpublished masters dissertation, University of Johannesburg, Johannesburg.

35. Eddy, N. (2003). *Re-cognising teaching and learning in an Ad Mathematics Programme*. Unpublished masters dissertation, University of Cape Town, Cape Town.

36. Els, C. J. (1995). *Leerprobleme van wiskunde- leerlinge in kindersorgskole*. Unpublished masters dissertation, University of Johannesburg, Johannesburg.

37. Erasmus, A. (1995). *Rekenaargesteunde wiskunde programme en die probleemgesentreerde benadering: 'n Instrument om die bruikbaarheid to bepaal*. Unpublished masters dissertation, University of Pretoria, Pretoria.

38. Erasmus, P. (2002). *Die daarstel van 'n remedieringstrategie in wiskunde vir Tswanasprekende leerders.* Unpublished masters dissertation, University of Pretoria, Pretoria.

39. Essack, R. M. (2002). *Trends in participation, performance and career choice, among girls who are successful in mathematics*. Unpublished masters dissertation, University of KwaZulu-Natal, Durban.

40. Fakudze, C. G. (1995). *The influence of institutional biographies on the interpretations of INSET needs an delivery on the part of primary school mathematics teachers an INSET Providers: A case study*. Unpublished masters dissertation, University of Cape Town, Cape Town.

41. Feza, N. N. (2004). *An investigation of Grade Seven learners' understandings of geometry in terms of Van Hiele levels*. Unpublished masters dissertation, Nelson Mandela Metropolitan University, Port Elizabeth.

42. Fourie, M. J. (1997). *Wiskunde-onderrig in n' multikulturele klas*. Unpublished masters dissertation, University of Johannesburg, Johannesburg.

43. Gee, S. (1997). *Enkele metakognitiewe strategiee ter verbetering van 'n groep standerd ses-leerlinge se prestasie in wiskunde*. Unpublished masters dissertation, Stellenbosch University, Cape Town.

44. George, S. (2001). *Pre-service teachers' handling of linear algebra in a problem-centred approach*. Unpublished masters dissertation, Stellenbosch University, Cape Town.

45. Goba, B. B. (2004). *Grade 8 learners' experiences of mathematics in outcome based education*. Unpublished masters dissertation, University of KwaZulu-Natal, Durban.

46. Govender, R. (2002). *An investigation into student teachers' understanding of the nature of definitions and the development of their ability to evaluate and formulate*

definitions in a sketchpad context. Unpublished masters dissertation, University of KwaZulu-Natal, Durban.

47. Graven, M. H. (2002). *Mathematics teacher learning, communities of practice and the centrality of confidence*. Unpublished doctoral thesis, University of Witwatersrand, Johannesburg.

48. Gray, D. J. (1997). *Mathematics and Science in South Africa: an international achievement study at junior secondary level*. Unpublished doctoral thesis, University of Pretoria, Pretoria.

49. Grinker, C. (1998). *The usefulness of everyday mathematics in the senior secondary curriculum: a controlled experiment*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

50. Guambe, R. S. M. (2004). *Language use in algebraic thinking: case study of second language learners in Mozambique*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

51. Gwengo, M. (2000). *An evaluation of the curriculum for the training of mathematics teachers in Zimbabwe*. Unpublished masters dissertation, University of South Africa, Pretoria.

52. Hassan, N. A. (2004). *The mathematics achievement of SYSTEM student teachers in the Northern Cape*. Unpublished doctoral thesis, North West University, Potchefstroom.

53. Hawkey, P. L. (1995). *Mathematics anxiety as a variable in the constructivist approach to the teaching of secondary school mathematics*. Unpublished doctoral thesis, University of South Africa, Pretoria.

54. Heine, M. C. (1997). *Die algemene skolastiese aanlegtoets (ASAT) as voorspeller van wiskundeprestasie in Graad twaalf*. Unpublished masters dissertation, Stellenbosch University, Cape Town.

55. Hermelin, R. (2004). *The effect of playing chess on the mathematics achievement of primary school learners in two schools in KZN*. Unpublished masters dissertation, University of KwaZulu-Natal, Durban.

56. Hockman, M. (2000). *The development of levels of awareness of senior mathematics students through direct engagement with the mathematical subject and pedagogical matter*. Unpublished doctoral thesis, University of Witwatersrand, Johannesburg.

57. Horn-Botha, R. (1996). *A case study of pupils' and teachers' attitudes to change in the examination structure of standard 7 mathematics in a Boys only high school*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

58. Howie, T. (2004). *Interpreting teachers' mathematical knowledge in the context of learner-centred practice in a selection of Grade nine mathematics classrooms*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

59. Ijeh, S. B. (2003). *The effect of scaling in the understanding of algebraic graphs for grade 9 (Form B) learners*. Unpublished masters dissertation, University of South Africa, Pretoria.

60. Ismael, A. (2001). *An ethnomathematical study of tchadji-about a mancala type boardgame played in Mozambique and possibilities for its use in mathematics education*. Unpublished doctoral thesis, University of Witwatersrand, Johannesburg.

61. Jakovljevic, M. (1995). *The design, development and implementation of computer supported instructional programs for teaching mathematical thinking skills at secondary school level*. Unpublished masters dissertation, University of Pretoria, Pretoria.

62. Janse van Rensburg, H. M. (1999). *Toepassingsmoontlikhede van rekenaargesteunde onderwys met milieubenadeelde leerders in wiskunde in die senior primere fase*. Unpublished doctoral thesis, University of Pretoria, Pretoria.

63. Jordaan, T. (2005). *Misconceptions of the limit concept in a mathematics course for engineering students*. Unpublished masters dissertation, University of South Africa, Pretoria.

64. Jugmohan, J. (2004). *Learners' conceptualization of the sine function, with sketchpad at Grade 10 level*. Unpublished masters dissertation, University of KwaZulu-Natal, Durban.

65. Khan, F. (2000). *Contextual factors associated with mathematics anxiety: Perceptions of teachers and students at a secondary school in Kwa-Zulu Natal*. Unpublished masters dissertation, University of KwaZulu-Natal, Durban.

66. Khechane, N. C. (1998). *Implementation and interpretation of a learner-centred approach: The case of some mathematics teachers in Maseru*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

67. Khumalo, Z. (2000). *Teaching volume to Grade 7 learners in an inclusive classroom: An evaluation of a teaching approach*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

68. kimble, A. E. (2000). *The relationship between learners' attitudes and achievement in mathematics in a multicultural context*. Unpublished masters dissertation, University of Pretoria, Pretoria.

69. Kruger, A. S. (2000). *Begeleide leer vir adolessente met ontoereikende wiskunde-prestasie*. Unpublished doctoral thesis, University of Johannesburg, Johannesburg.

70. Kühne, C. (2004). *Teachers' perceptions of whole number acquisition and associated pedagogy in the foundation phase*. Unpublished masters dissertation, University of Cape Town, Cape Town.

71. Kutama, M. E. (2002). *An investigation into process-based instruction in the teaching of grade 8 and 9 Euclidean geometry*. Unpublished masters dissertation, University of South Africa, Pretoria.

72. Kwakwa, B. P. (1995). *Pupil algebraic manipulative skill and its effects on performance in calculus*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

73. Lampen, C. (2001). *Die ontwikkeling van kinders se geometrisering van drie - dimensionele voorwerpe*. Unpublished masters dissertation, Stellenbosch University, Cape Town.

74. Lebethe, A. L. (2004). *Journeying into the space of possibility*. Unpublished masters dissertation, University of Cape Town, Cape Town.

75. Long, C. (1995). *A small-scale investigation into teachers' access to the regulating principles underlying 'new mathematics' curriculum in the junior primary phase.* Unpublished masters dissertation, University of Cape Town, Cape Town.

76. Loubser, A. (1997). *Kognitiewe Kartering as strategie in wiskunde-onderrig*. Unpublished masters dissertation, University of Johannesburg, Johannesburg.

77. Louw, C. J. (2003). *Die impak van tutoriale op die wiskundeprestasie van studente in eerstejaarswiskunde*. Unpublished masters dissertation, University of Pretoria, Pretoria.

78. Lungu, F. C. S. T. (1996). *The impact of in-service workshops: A case study of senior mathematics and science school teachers drawn from Katlehong, South Africa*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

79. Mahlomaholo, M. G. (1998). *Signification of African cultural identity, individual African identity and performance in mathematics among some standard nine African pupils in Mangaung high schools*. Unpublished doctoral thesis, University of Western Cape, Cape Town.

80. Makara, M. C. (2004). *Teaching practices in mathematics of teachers trained at Lesotho Colllege of Education in Maseru Secondary schools*. Unpublished masters dissertation, University of Free State, Bloemfontein.

81. Maree, J. G. (1997). *The development and evaluation of a study orientation questionnaire in mathematics.* Unpublished doctoral thesis, University of Pretoria, Pretoria.

82. Maseko, J. S. (2002). *Factorisation of quadratics using a web-based spreadsheet for Grade 10 mathematics learners*. Unpublished masters dissertation, University of Johannesburg, Johannesburg.

83. Mashaba, M. D. (1998). *Self confidence and mathematics achievement: A study on second year college of education students*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

84. Mathe, M. M. (1997). *Attitudes and achievement in mathematics in Soweto senior secondary schools*. Unpublished doctoral thesis, University of Johannesburg, Johannesburg.

85. Matlhaga, L. F. (1995). *A diagnostic and remedial programme in elementary mathematics for disadvantaged children with special reference to Standard 8 pupils in the Batswana High Schools*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

86. Matlou, J. M. (2003). *The evaluation of mathematics teaching methods: With specific reference to the Winterveldt North circuit high schools*. Unpublished masters dissertation, Tshwane University of Technology, Pretoria.

87. Matthee, M. C. (1998). *Supporting the teaching of mathematics by information technology in a co-operative learning environment*. Unpublished doctoral thesis, University of Pretoria, Pretoria.

88. McAuliffe, S. M. (1999). *An analysis of the impact of a geometry course on pre-service teachers understanding of geometry*. Unpublished masters dissertation, University of Cape Town, Cape Town.

89. Mdluli, F. (2001). *An analysis of Swazi mathematics teachers' practices in teaching algebra*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

90. Mdluli, M. A. (2004). *Perceptions of primary school principals about the assessment of learner performance in mathematics within Outcomes Based Education.* Unpublished masters dissertation, University of Johannesburg, Johannesburg.

91. Mhakure, D. (2003). *Information technology as an instruction tool in the teaching of mathematics in secondary school: Perceptions of educators and learners in the North West Province*. Unpublished masters dissertation, North West University, Potchefstroom.

92. Mhlanga, S. S. (2004). *An investigation of Form III learners' conceptual understanding of area of quadrilaterals*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

93. Michael, V. J. (2001). *A phenomenological study of leadership in the Rhodes University Mathematics Education Project (RUMEP).* Unpublished masters dissertation, Rhodes University, Grahamstown.

94. Mnisi, P. M. (1996). *Fostering a reflective stance during pedagogical change in the mathematics classroom*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

95. Mofolo, B. L. K. (2003). *Grade 8 learners' interpretations of consolidation activities in an outcomes-based styled mathematics textbook.* Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

96. Mohlala, B. S. (1996). *The influence of arithmetic operations on the learning of algebra in a bridging programme in mathematics*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

97. Mokapi, C. M. (2001). *Form C's conceptions about fractions*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

98. Mokoena, K. J. (1998). *The effect of the self-instructional lesson in mathematics*. Unpublished masters dissertation, University of Johannesburg, Johannesburg.

99. Mokoka, M., Christinah (1998). *The use of South African computer-assisted Mathematics programs in the Brits District of the North West Province*. Unpublished masters dissertation, University of Pretoria, Pretoria.

100. Molefe, S. M. (2001). *The teaching of mathematics in the Kagiso Area*. Unpublished masters dissertation, University of Johannesburg, Johannesburg.

101. Molepo, M. J. (1997). *The role of mathematics in developing rural and tribal communities in South Africa*. Unpublished doctoral thesis, University of Pretoria, Pretoria.

102. Monareng, N. C. (2003). *Primary school teachers understanding of the quadratic function concept through using a graphics calculator.* Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

103. Moodley, D. J. (2002). *Developing alternative assessment practices for outcomes-based mathematics education in South African schools: a case study.* Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

104. Moolman, H. B. (1996). *Die gebruik van 'n sigblad in wiskundeonderwys vir milieugestremde leerlinge in die senior primere fase: 'n verkennende studie*. Unpublished masters dissertation, University of Pretoria, Pretoria.

105. Mosala, M.-A. S. (1997). *Algebraic equations and their applications in a teaching/learning situation at secondary level of school mathematics in a college of*

education context. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

106. Moyana, H. J. (1996). *Factors related to mathematics achievement of secondary school pupils*. Unpublished masters dissertation, University of South Africa, Pretoria.

107. Moyana, H. J. (2000). *An intervention programme to improve the self-concept and attitudes of prospective mathematics teachers*. Unpublished doctoral thesis, University of South Africa, Pretoria.

108. Mphunyane, Z. M. (1997). *Teaching mathematics in ESL classrooms: A study of mathematics teachers' beliefs about language and mathematics teachers' roles*. Unpublished masters dissertation, University of Wits, Johannesburg.

109. Mpofana, T. W. (1996). *The relationship between teaching methods and achievement in mathematics.* Unpublished masters dissertation, University of Johannesburg, Johannesburg.

110. Msomi, D. D. (1995). *The pre-service preparation of secondary school mathematics teachers - A case study of curriculum effectiveness.* Unpublished masters dissertation, Rhodes University, Grahamstown.

111. Mudaheranwa, G. (2002). *Improving mathematics teaching and learning through generating and solving algebra problems*. Unpublished masters dissertation, Stellenbosch University, Stellenbosch.

112. Mudaly, V. (2004). *The role and use of sketchpad as a modelling tool in secondary schools*. Unpublished doctoral thesis, University of KwaZulu-Natal, Durban.

113. Mulcahy, D. (1995). *A case study investigation of the use of a textbook in a secondary mathematics classroom: issues of regulation and control*. Unpublished masters dissertation, University of Cape Town, Cape Town.

114. Mutemba, B. J. D. C. (2001). *The Mozambican students' understanding of the concept limit of a function: a case study*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

115. Naidoo, R. (2003). *The in-service education and training (INSET) needs of educators of primary school mathematics.* Unpublished masters dissertation, University of Pretoria, Pretoria.

116. Nakajima, M. (2002). *Intervening in Schools - An evaluability assessment of the secondary schools partnership project in Western Cape*. Unpublished masters dissertation, University of Cape Town, Cape Town.

117. Nakidien, M. T. (2004). *The recruitment of the 'everyday' in fourteen Grade 7 mathematics classrooms*. Unpublished masters dissertation, University of Cape Town, Cape Town.

118. Nakin, J. B. N. (2003). *The influence of creativity and divergent thinking on the performance of grade 7 geometry learners*. Unpublished doctoral thesis, University of South Africa, Pretoria.

119. Narainsamy, S. (1998). *The use of logo in the teaching of the concept of a variable in the pre-algebra stage.* Unpublished masters dissertation, University of South Africa, Pretoria.

120. Ndhambi, D. A. (2002). *Addition strategies: Use of derived fact strategies*. Unpublished masters dissertation, Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

121. Ndlovu, H. C. M. (2003). *Learners' conceptions of decimal fractions.* Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

122. Netshapala, F. S. (2001). *Classification and analysis of some computer software packages for teaching Mathematics.* Unpublished masters dissertation, University of Pretoria, Pretoria.

123. Ngubane, E. M. (2000). *What are the links between a teacher's views of mathematics and his/her classroom practices?* Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

124. Nieuwoudt, H. D. (1998). *Beskouings oor onderrig: implikasies vir die didaktiese skoling van wiskundeonderwyser.* Unpublished doctoral thesis, North West University, Potchefstroom.

125. Nieuwoudt, S. M. (2003). *Strategiese onderrig en leer van skoolwiskunde in 'n videoklasstelsel*. Unpublished doctoral thesis, North West University, Potchefstroom.

126. Nkotoe, T. C. (1996). *Prejudice reduction in multicultural mathematics education.* Unpublished masters dissertation, University of Johannesburg, Johannesburg.

127. Nyabanyaba, T. (1998). *Whither relevance? Mathematics teachers' espoused meaning(s) of 'relevance' to students' everyday experiences*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

128. Nyabanyaba, T. (2002). *Examining examination: The ordinary level (O level) mathematics examination in Lesotho and the impact of recent trends on Basotho students' epistemological access*. Unpublished doctoral thesis, University of Witwatersrand, Johannesburg.

129. Oliphant, V. G. (1996). *An investigation into the extent and nature of the understanding first year college of education students have of aspects of arithmetic and elementary number theory*. Unpublished masters dissertation, Rhodes University, Grahamstown.

130. Oosthuizen, R. M. (1996). *Anifarm: 'n RGO- wiskundeprogram vir miliegestremde leerlinge in die senior primere fase*. Unpublished masters dissertation, University of Pretoria, Pretoria.

131. Oosthuizen, S. G. (1999). *Die gebruik van sigblaaie om die effektiewe leer van wiskunde te bevorder*. Unpublished masters dissertation, University of Johannesburg, Johannesburg.

132. Osei, C. M. (1995). *Attitudes towards mathematics and mathematics achievements: A case study of the first year students of Junior Primary Teachers Diploma (JPTD) colleges in Transkei*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

133. Padayachee, P. (2000). *Students' perceptions of the mathematics foundation course on the Port Elizabeth campus of Vista University*. Unpublished masters dissertation, Nelson Mandela Metropolitan University, Port Elizabeth.

134. Padoa, N. E. (1995). *Constructivism and the creative teaching and learning of algebra in South Africa*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

135. Penlington, T. H. (2004). *Exploring learners' mathematical understanding through an analysis of their solution strategies*. Unpublished masters dissertation, Rhodes University, Grahamstown.

136. Pereira, C. A. (1995). *A mathematics competency test for the placement of students at a Technical College*. Unpublished doctoral thesis, University of Johannesburg, Johannesburg.

137. Pfeiffer, C. R. (2003). *Deurlopende assesseiring in die wiskunde-klaskamer*. Unpublished masters dissertation, Stellenbosch University, Stellenbosch.

138. Phiri, P. (2003). *Investigating learners problem solving strategies involving algebraic thinking*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg..

139. Pomario, W. L. (1996). *The effect of after school mathematics tuition on standard 9 pupils mathematics ability*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

140. Poni, T. (2000). *"Grade 10 English second language pupils' difficulties with paradoxical jargon and technical terms commonly used in their mathematics curriculum"*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

141. Potgieter, S. (2003). *The influence of a cooperative learning strategy on mathematics test results of pre-technikon students at the Port Elizabeth Technikon.* Unpublished masters dissertation, Nelson Mandela Metropolitan University, Port Elizabeth.

142. Press, K. (1999). *The school mathematics textbook as an instantiation of the pedagogic discourse of school mathematics*. Unpublished masters dissertation, University of Cape Town, Cape Town.

143. Prins, E. D. (1995). *The influence of readability of examination questions on achievement in senior secondary school mathematics (A study on verbal problems with special reference to second language readers).* Unpublished doctoral thesis, Stellenbosch University, Stellenbosch.

144. Pylman, J. N. (2001). *Die verband tussen angs kognisies en die invloed daarvan op die wiskundeprestasies van 'n groep plattelandse adolessente.* Unpublished masters dissertation, Nelson Mandela Metropolitan University, Port Elizabeth.

145. Rademeyer, A. (1997). *The impact of mathematical expertise on the ability of facilitators to mediate level 2 numeracy skills: An exploratory investigation.* Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

146. Rakumako, A. M. (2003). *Demographic profile and perceived in-service education and training needs of secondary mathematics in Limpopo.* Unpublished masters dissertation, university of Cape Town, Cape Town.

147. Rambehari, H. (1996). *An evaluation of the efficacy of the aims and objectives of the senior certificate mathematics curriculum.* Unpublished masters dissertation, University of South Africa, Pretoria.

148. Ramnarian, U. D. (1999). *An investigation of the processes of mathematical thinking of Grade 8 learners and its effects on problem-solving performance.* Unpublished masters dissertation, University of South Africa, Pretoria.

149. Rampa, S. H. (1996). *Teaching of mathematics in Soshanguve schools: A situation analysis.* Unpublished masters dissertation, University of Johannesburg, Johannesburg.

150. Ramsingh, A. V. (1999). *The effectiveness of NGO-Sponsored INSET on the classroom practices of primary school mathematics educators: A case study of MCPT.* Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

151. Rankwana, H. (2003). *Die evaluering van 'n rekenaargesteunde leerpakket vir graad 8 wiskunde-leerders.* Unpublished masters dissertation, University of Johannesburg, Johannesburg.

152.1` Roos, J. E. (1996). *Junior-Primêre onderwysers se konsepsie van probleemgesentreede wiskunde-onderrig.* Unpublished masters dissertation, University of Johannesburg, Johannesburg.

153. Rootman, C. H. (1996). *Die gebruik van 'n RGO-program in wiskundeonderwys vir milieugestremde leerlinge in die senior primere fase.* Unpublished masters dissertation, University of Pretoria, Pretoria.

154. Rowney, S. (2002). *Factors that impact on the attraction and retention of Science and Mathematics teachers in public secondary schools in Gauteng.* Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

155. Rughubar, S. (2003). *The mathematics education of youth at-risk: Nellie and Wiseman.* Unpublished masters dissertation, University of KwaZulu-Natal, Durban.

156. Sambo, R. P. (2003). *An ethnomathematical approach to learner-centred classroom mathematics.* Unpublished doctoral thesis, University of Witwatersrand, Johannesburg.

157. Scholtz, S. M. P. (1996). *Die invloed van houding op die wiskundeprestasie van 'n groep Standerd 8-Leerlinge.* Unpublished masters dissertation, North West University, Potchefstroom.

158. Scott, G. B. (1996). *Applicability of mathematics in technical college. An inquiry into lecturers' beliefs.* Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

159. Sebela, M. P. (1997). *The use of investigative methods in teaching and learning primary mathematics in Lebowa schools: A case study*. Unpublished masters dissertation, Rhodes University, Grahamstown.

160. Sedibe, G. K. (2003). *A comparison of isiXhosa-speaking learners' responses to word problems given in English and isiXhosa.* Unpublished masters dissertation, Stellenbosch University, Stellenbosch.

161. Sekao, R. D. (2004). *The influence of an Hour-glass model of co-operative learning on the learning and achievement of grade 8 mathematics learners in crowded classrooms*. Unpublished masters dissertation, North West University, Potchefstroom.

162. Semata, T. F. (2004). *Perspectives on girls' performance in mathematics in Lesotho: A case study.* Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

163. Seopo-Sengwe, M. E. (2001). *Media integration in the teaching of mathematics in the pre-primary and primary schools*. Unpublished doctoral thesis, University of South Africa, Pretoria.

164. Setati, M. (1996). *Code switching and mathematical meaning in a senior primary class of second language learners.* Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

165. Setati, M. (2002). *Language practices in multilingual classrooms in South Africa*. Unpublished doctoral thesis, University of Witwatersrand, Johannesburg.

166. Sibaya, D. C. (1995). *A study of the responses of culturally different pupils to mathematics vocabulary.* Unpublished masters dissertation, University of Zululand, Empangeni.

167. Sibaya, D. C. (1999). *Learners with learning difficulties in mathematics: Attitudes, curriculum and methods of teaching mathematics*. Unpublished doctoral thesis, University of Johannesburg, Johannesburg.

168. Singh, T. (2004). *School-based assessment: the interface between Continuous Assessment (CASS) and the external summative assessment at Grade 12 level with special focus on Mathematics and Science.* Unpublished masters dissertation, University of Pretoria, Pretoria.

169. Sitole, K. E. S. (1997). *An integrated approach to technology education as a means of enhancing achievement in mathematics and science*. Unpublished doctoral thesis, University of South Africa, Pretoria.

170. Steyn, T. M. (1998). *Graphical exploration as an aid to mastering fundamental mathematical concepts: an instructional model for mathematics practicals.* Unpublished masters dissertation, University of Pretoria, Pretoria.

171. Swanepoel, E. (1999). *Creating a computer-assisted learning programme in mathematical relationships for learners in the senior phase.* Unpublished masters dissertation, University of Pretoria, Pretoria.

172. Tawodzera, G. (2001). *An investigation of mathematical misconceptions through an analysis of Grade 7 learners' responses to test items on decimals, percentages and measurement.* Unpublished masters dissertation, University of Cape Town, Cape Town.

173. Temba, N. (1998). *Perceptions and beliefs in grade one mathematics: The teachers' perspective.* Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

174. Thabane, J. L. (1998). *Students' understanding of the limit concept in a first year calculus course*. Unpublished masters dissertation, University of Witwatersrand, Johannesburg.

175. Theron, G. C. (1997). *Hipnose as terapeutiese hulpmiddel by wiskunde-angs.* Unpublished masters dissertation, University of South Africa, Pretoria.

176. Thijsse, L. J. (2002). *The effects of structured teaching method on mathematics anxiety and achievement of grade eight learners*. Unpublished masters dissertation, University of South Africa, Pretoria.

177. Thusi, Z. E. (2004). *Are we developing self-regulated learners in Grade 8 mathematics classrooms: A case study conducted at a high school in KwaZulu-Natal.* Unpublished masters dissertation, University of KwaZulu-Natal, Durban.

178. Van der Spuy, J. (1997). *Kognitiewe kartering as strategie van wiskunde-onderrig aan leerders met n' gesiggestremheid.* Unpublished masters dissertation, University of Johannesburg, Johannesburg.

179. van Laren, L. (2001). *A case study of mathematics teaching and learning at a rural school in KwaZulu-Natal.* Unpublished masters dissertation, University of KwaZulu-Natal, Durban.

180. van Rooyen Barnard, S. (2004). *An investigation into the impact of the use of an integrated learning system on mathematics Standard Grade Paper 2 marks of Grade 12 learners of one high school in the Nelson Mandela Metropolitan area.* Unpublished doctoral thesis, Nelson Mandela Metropolitan University, Port Elizabeth.

181. Van Staden, P. S. (1999). *Onderrig van Wiskunde met formele bewystegnieke*. Unpublished doctoral thesis, University of South Africa, Pretoria.

182. van Tonder, J. (2000). *'n Reflekterende leerondersteuningstrategie vir graad sewe leerders met wiskunde-probleme, ontwikkel in die opvoedkundige sielkunde*. Unpublished masters dissertation, University of Pretoria, Pretoria.

183. Viljoen, K. J. (1995). *An investigation into small group problem solving in geometry*. Unpublished masters dissertation, University of Witswatersrand, Johannesburg.

184. Volschenk, D. E. (2004). *Die integrering van uitkomsgerigte onderwys en kooperatiewe leer as ondersteuningsmeganisme vir wiskunde-inderring by kolleges.* Unpublished masters dissertation, North West University, Potchefstroom.

185. Walters, B. (1996). *An ethnographic study of a black South African High School with special reference to its mathematics classrooms.* Unpublished masters dissertation, University of Cape Town, Cape Town.

186. Webb, M. L. (2003). *Teachers' Understanding of the nature of mathematics.* Unpublished masters dissertation, Nelson Mandela Metropolitan University, Port Elizabeth.

187. Wendt, G. E. (1999). *An investigation into learner's perceptions of homework in relation to the learning of mathematics: Case studies in the Northern Townships of Port Elizabeth*. Unpublished doctoral thesis, Rhodes University, Grahamstown.

188. Westaway, L. (2004). *A critical investigation into the processes of negotiating a mathematics education curriculum with pre-service teachers*. Unpublished masters dissertation, Rhodes University, Johannesburg.

189. Wilson, H. (2002). *An action research case study of active learning through dialogue, action and structure in self-study distance education packages*. Unpublished masters dissertation, University of South Africa, Pretoria.

190. Yushau, B. (2004). *The predictors of success of computer aided learning of pre-calculus algebra.* Unpublished doctoral thesis, University of South Africa, Pretoria.

APPENDIX D

Coded research phenomena from the corpus of mathematics education theses

No/ Degree/ HEI	Verbatim research focus area	Key words (KW) of phenomenon studied			Mathematics Content	Cat	Participants	Edu level	Location
		KW 1	KW2	KW 3					
1 D Wits	“This is a study of secondary mathematics teachers' knowledge of the dynamics of learning and teaching mathematics classrooms in South Africa. It probes teachers' articulated and tacit knowledge …[of] teachers drawn from three different multilingual school contexts”.	knowledge	Language			2 7	Teachers	Secondary Grs 8-12	Urban/ township
2 M UCT	“This study focused on Foundation Phase teachers' pedagogical and content knowledge. It investigated the impact that a geometry course (Shape and Space), had on the teachers levels of understanding of shape and space”.	knowledge	PCK	Geometry course	Shape and space	2 10	Teachers	FP Grs 1-3	Urban
3 M UNISA	“The aim of this study was to gain insights into pupil's perceptions of mathematics”.	Perception				2	Learners	Secondary Gr 12	Urban
4 D UNISA	“This study examined pre-service mathematics teachers' examination performance over a period of three years”.	Performance				3	Students	Tertiary 3rd year	International
5 M UP	“The research document in this report had a twofold purpose. Firstly, it was to design and implement an intervention based on the theory of Realistic Mathematics Education (RME) aimed at improving the mathematical understanding of learners …a second purpose was to investigate the viability and emerging characteristics of an intervention based on the theory of RME in such a setting (i.e. with low attainers to revisit key number concepts).	Realistic Mathematics Education	Understanding		Place value, fractions & decimals	2	Learners	Secondary Gr 8	Urban
6 M UJ	“The research conducted for the purpose of this study clearly showed that outcomes-based education (OBE) potentially offers a remedy for this country's ineffective education system”	Outcomes Based Education				9	Documents/ Literature	Combined Grs 1-12	Urban & rural

7 M UCT	“This study explores the notion of 'spatial ability" from the perspective of mathematics education”.	‘Spatial ability’			Space and shape	2	Teachers Learners	I F Grs 5-6	Urban
8 M Wits	“This study explores the ways in which first-year Mathematics students use the graphic calculator as a tool of semiotic mediation”.	Graphic calculator	semiotic mediation		Mathematics problem	4 7	Students	Tertiary 1st year	Urban
9 D Wits	“In this thesis I consider how mathematics students in a traditional first-year Calculus course at a South African university appropriate mathematical objects which are new to them but which are already part of the official mathematics discourse”.	Appropriation of mathematical objects	Calculus course		Calculus	1 10	Students	Tertiary 1st year	Urban
10 D SU	“This study investigates first-year university students' understanding of fundamental concepts of the calculus”.	Understanding			limit, derivative, integral	2	Students	Tertiary 1st year	Urban
11 M UKZN	“The purpose of this study was to investigate teachers' perceptions and the extent to which application tasks are used by three teachers in mathematics classrooms, also their perception and approaches towards mathematics assessment	Perception	Application tasks	Assessment practices		1 2 3	Teachers	Primary Gr 7	Combined Urban & Rural
12 M UKZN	“This study investigates the mathematical knowledge and competencies of 40 reception class children from English speaking, working class homes in Pietermaritzburg, KwaZulu-Natal.	Knowledge	competencies of young children		Rote counting, cardinality rule, numeral recognition, ordering numbers, addition and subtraction, social sharing and multiplication, estimation, pattering, shape& space, measurement, time and ordinal numbers.	2	Learners	ECE Gr R	Suburban

13 D NMMU	"The objective of this research is to design and implement a problem solving action-plan, which will enable learners to improve their problem solving skills with regard to a specific problem type	Problem solving				1	Learners Teachers	Primary Gr 5	Combined urban & rural
14 D NWU	"This study concentrates on co-operative learning"	Co-operative learning				1	Students	Tertiary 1st year	Urban
15 M UCT	"This dissertation looks at the early learning of algebra from a classroom teacher's perspective".	Early learning			Algebra	1	Textbook Teachers Learners	Secondary Gr 8	Suburban
16 M NMMU	"This case study examines qualitatively how primary mathematics teachers learn about cooperative learning in their classrooms.	Teacher learning	Cooperative learning			1	Teachers	Primary Gr 4-7	Township
17 D UP	"This document is a report on an experiment in which mathematical skills were taught to first year university students using the Web as a method of instructional delivery".	Web as a method of instructional delivery				4	Students	Tertiary 1st year	Urban
18 M Wits	"the purpose of this study was, to explore possible gender differences in performance and attitudes toward mathematics among 1996 BUSCEP students".	Gender-differences	Performance	Attitude		3 5	Students	Tertiary 1st year	International
19 D Wits	"explored possible gender differences in patterns of mathematics classroom interactions, pupils' performance and attitudes toward mathematics".	Gender-interactions	Performance	Attitudes		3 5 6	Learners Teachers	Secondary Gr 9-10	International
20 D Wits	"This thesis is about a study of the use of plain and twill weaving in teaching and learning of mathematics".	Plain and twill weaving	teaching and learning of mathematics			1 6	Learners Teachers	Secondary Gr 11	International
21 M Wits	"This research report investigated the assessment strategies that two senior phase mathematics teachers used to assess mathematical performance in contextualised settings in Curriculum 2005".	Assessment strategies	performance	Curriculum 2005		3 9	Teachers	Secondary Grs 8-9	Urban
22 M UCT	"This dissertation focuses on two themes-the way in which assessment practices construct school mathematics, and the way in which these constructions of school and the way in which these constructions of school mathematics work dynamically with assessment practices to produce descriptions of students".	Assessment practices	Construction of school mathematics			2 3	Learners Teachers	Secondary Gr 10	Suburban

23 M UCT	“Mathematical texts recorded in notebooks of “achieving” and non-achieving” matric students in each school were examined.	Mathematical texts				7	Learners	Secondary Gr 12	Township
24 M UCT	“This study investigates how Grade 12 students understand and solve geometric problems”.	Understanding	Problem solving		Geometry	1 2	Learners	Secondary Gr 12	Township
25 D Wits	“The present gender investigation involved almost an equal number of males and females from 5 selected secondary schools near Johannesburg in South Africa. Performance in Euclidean geometry was evaluated for possible gender differences were compared.	Gender	Performance		Geometry	3 6	Learners	Secondary Gr 11	Urban
26 M UJ	“The empirical research has shown that models can serve as a medium to unlock the learning content of Geometry to the pupil”.	Models			Geometry	4	Learners Teacher	Secondary Gr 10	Urban
27 M UCT	“The dissertation is concerned with the production of a systematic account of the recontextualising of pedagogic discourse across two contexts: mathematics INSET provision and school mathematics teaching”.	Pedagogic discourse-	INSET	School mathematics teaching		1 8	Teachers	Combined Grs 1-12	Urban
28 M SU	“This study comprises a teaching experiment with std 6 and std 7 pupils, with a view to assess the extent to which pupils can acquire aspects of the gradient concept by doing simple curve-fitting”.	Acquiring aspects of gradient – curve fitting			Gradient	2	Learners	Secondary Gr 8-9	Urban
29 M UP	“A quantitative study was performed based on the results of a questionnaire developed to evaluate the students' experience of web-supported learning”.	Web learning				4	Students	Tertiary Pregradua te	Urban
30 M UKZN	“The proposed research is about the introduction of Continuous Assessment (CA) in Grade 12 Higher Grade Mathematics, as part of the learners’ overall assessment”.	Continuous assessment				3	Teachers	Secondary Gr 12	Township
31 M Wits	“This research report examines the possible contribution, if any, the Internet can make in enabling mathematics learning at junior secondary school level”.	Internet	Mathematics learning			1 4	Learners	Secondary Grs 8-9	Urban
32 M UWC	“The purpose of this study is to investigate how exposure to mediation can improve pupils’ problem solving abilities”.	Mediation	Problem solving		Word sums	1	Learners	Primary Grs 1-3	Urban

33 M UKZN	"This is an empirical study of how teachers in Math Centre for Primary Teachers project use instructional materials in teaching mathematics in junior primary schools".	Instructional Materials	Math Centre for Primary Teachers Project			4 10	Teachers	Primary Grs 4-7	Township
34 M UJ	"The purpose of this investigation was in the first place to determine the influence of OBE on the classroom management of the mathematics educator in the senior phase".	OBE	Classroom management			9 11	Teachers	Secondary Grs 8-9	Urban
35 M UCT	"This dissertation deals with me and my practice as a mathematics teacher in a high school in Cape Town. Through the lens of my teaching in an Ad (advanced, accelerated and enriched) mathematics programme I recognise the teaching and learning opportunities that have presented themselves over a three year period".	Teacher practices				1	Teachers Learners	Secondary Grs 8-12	Urban
36 M UJ	"Learning problems of mathematical pupils in child care schools"	Learning problems	Child care schools			1	Children out of school	Primary Grs 1-3	Urban
37 M UP	"In this study the problem-centered approach was investigated by studying local and international literature. Criteria were identified which were used to develop a paper based as well as a computer based instrument to help the mathematics teacher to evaluate computer assisted mathematical programs and to determine their usefulness in the problem-centered approach".	Computer assisted mathematical programs	Problem-centered approach			1 4	Teachers	Primary Grs 1-6	Urban
38 M UP	"The aim of this study is, inter alia, the exploration of the Tswana learner's inadequate achievement in mathematics in the Mafikeng area… The cognitive and affective facets of the tswana learner's achievement in mathematics was determined through assessment and evaluation".	Achievement	Cognitive	Affective		2 3 5	Learners	Primary Gr 4	Township

39 M UKZN	"The question that this study attempts to answer is 'why do females who usually perform well in mathematics, not choose to study it further? I will attempt to examine this question on multiple levels: First, an examination of the statistical trends in participation and performance in mathematics, by gender".	Gender	Participation	Performance		1 3 6	Learners Records	Secondary Gr 12	Urban
40 M UCT	"Its aim is to explore…how their institutional and /or personal biographies might have shaped their interpretations of the teachers' needs for INSET, and the way in which they thought INSET should be delivered.	Teachers' needs for INSET	Institutional & personal biographies			8	Teachers Facilitators	Primary Grs 1-6	Township
41 M NMMU	"What is the level of grade seven learners' understanding of geometry in historically black primary schools of the Eastern Cape in terms of Van Hiele levels"?	Understanding	van Hiele levels		Geometry	1 2	Learners	Primary Gr 7	Combined urban & rural
42 M UJ	"The primary aim of this study is to conduct a research into the different ways in which a teacher can forge a constructive link with children from diverse ethnic communities, via his/her own perceptions, educational aims and strategies, usage of language in the classroom, as well as classroom skills and techniques".	Diverse ethnic communities	Perceptions	Language		5 6 7	Documents Learners	Combined Grs 1-12	Urban
43 M SU	"The aim of this research was to explore the feasibility of teaching a programme of metacognitive strategies to groups of standard six pupils with the main purpose of improving their results in mathematics".	Metacognitive strategies	Achievement			2 3	Learners	Secondary Gr 8	Urban
44 M SU	"The primary concern of the study is how pre-service teachers perform after they have been exposed to a section of linear algebra course based on the problem-centred approach".	Performance	Problem-centred approach	PRESET	Linear algebra	1 3 8	Students	Tertiary 3rd year	Urban
45 M UKZN	"This research project attempts to understand what happens in a Grade Eight classroom when mathematics is taught in context".	Contextual teaching	OBE			1 9	Learners Teacher	Secondary Gr 8	Urban
46 M UKZN	"This research investigated student teachers' understanding of the nature of definitions and the development of their ability to evaluate and formulate definitions in a Sketchpad context".	Understanding	Nature of definitions	Sketchpad	Geometry	2 4	Students	Tertiary 3rd year	Urban

47 D Wits	"This study investigates mathematics teacher learning in relation to teachers' participation in an… INSET programme, structured to enhance participation in a community of practice, in the context of current South African curriculum change".	Teacher learning	INSET			1 8	Teachers	Service provider Grs 7-9	Township
48 D UP	"this study was designed to investigate and evaluate South Africa's achievements in Mathematics and Science at the Junior Secondary level through the TIMSS testing instruments".	Achievement	TIMSS			3	Learners	Combined Grs 7-8	National
49 M Wits	"The aims of the experiment were to see if teaching through methods related to the use of materials based on everyday mathematics (realistic/ethnomathematics) improved pupils' academic performance in any significant way, and to observe if teaching in this way had any effect on pupil's attitudes to school mathematics".	Everyday/ realistic/ Ethnomathematics	Performance	Attitude		2 3 5 6	Learners	Secondary Grs 10-12	Urban
50 M Wits	"The study explored Grade 8 learners' use of algebraic symbols, learners' understanding of the mathematical language and the role of language in algebraic thinking.	Language	Thinking		Algebra	2 7	Learners	Secondary Gr 8	International
51 M UNISA	"This study sought to evaluate the curriculum for the training of mathematics teachers in Zimbabwe. Two components (objectives and content) of the curriculum were examined".	Curriculum evaluation	Objectives	Content		9	Students Teachers Principals Subject - advisors	Combined	International
52 D NWU	"Within this contextual framework the study made special reference to Study orientation in mathematics, including mathematics anxiety and attitude towards mathematics, as possible causative factors that could inhibit/enhance performance and achievement in mathematics".	Performance/ achievement	Anxiety	Attitudes		3 5	Students Teachers	Tertiary 1^{st} -3^{rd} year	Urban
53 D SU	"Mathematics performance, perceptions, attitudes and levels of anxiety were investigated by means of tests, questionnaires".	Performance;	Perceptions	Attitudes & Anxiety		3 5	Students Learners	Combined Gr 10 – 3^{rd} year	Combined urban & rural

54 M SU	“In this research report the …GSAT as an evaluation scale of academic intelligence was used with a group of Grade 6 learners as a predictor of mathematical achievement in their Grade 12 year”.	Achievement	General Scholastic Aptitude Test (GSAT)	Intelligence		2 3	Learners	Secondary Gr 12	Urban
55 M UKZN	“The effect of playing chess on the mathematics achievement of primary school learners in two schools in KZN”	Achievement	Chess			3 4	Learners Teachers	Primary Grs 4-7	Combined urban & rural
56 D Wits	“This research has as its goals the understanding and improvement of mathematics teacher educator practice. This is accomplished by examining the changes in beliefs, attitudes and performance of the students participating in the MI course in 1998”.	Understanding	Beliefs & attitudes	Performance	Geometry	2 3 5	Students Lecturers	Tertiary 1^{st}- 3^{rd} year	Urban
57 M Wits	“The purpose of this study was to investigate teachers' and pupils' attitudes to a change in the examination structure of std. 7 mathematics in the Gauteng province”.	Attitudes & anxiety	Examination structure	Performance		3 5	Teachers Leaners	Secondary Gr 9	Suburban
58 M Wits	“This study extends some of their subcategories of knowledge, illustrating the complexity of teachers’ use of knowledge”.	Knowledge			Straight line graphs	2	Teachers	Secondary Gr 9	Urban
59 M UNISA	“The objective of the research is to establish the fact that scaling has influence on the understanding of algebraic linear graphs”.	Understanding			Algebra, scalling, linear graphs	2	Learners	Secondary Gr 9	International
60 D Wits	“This research is in the field of ethnomathematics. The study was carried out in three phases with the Tchadji-game being its principal focus”.	Ethnomathematics	Tchadji game			4 6			
61 M UP	“This research describes and presents the findings of a study which aimed to trace the development of pupils' lower/middle and higher order thinking skills within a CSI environment”.	Computer supported instructional program (CSI)	Thinking		Linear function	2 4	Learners	Secondary Gr 10	Urban
62 D UP	“This research served to assess how computer drills, tutorials, games and a spreadsheet could be used in teaching word sums in grade six mathematics for milieu-deprived learners”.	Computer drills-spreadsheet	Tutorials	games	Word sums	1 4	Leaners Subject advisors	Primary Gr 7	Urban
63 M UNISA	“In this investigation an attempt was made to determine the misconceptions that engineering students have of the idea of a limit”.	Misconceptions			Limit	2	Students	Tertiary 1^{st} – 3^{rd} year	Urban

64 M UKZN	"This study investigated how Grade 10 learners conceptualize an introductory activity to the sine function with The Geometers' Sketchpad".	Conceptualisation	Geometers' Sketchpad		Sine function	2 4	Teachers Learners	Secondary Gr 10	Suburban
65 M UKZN	"The contextual factors associated with mathematics anxiety were examined from the perspective of ten mathematics students and three teachers of mathematics".	Anxiety				5	Teachers Learners	Secondary Gr 12	Township
66 M Wits	"This is a qualitative research project that attempts to describe and explain how selected mathematics teachers in Lesotho interpret and implement a learner-centred approach to teaching and learning mathematics".	Learner-centred approach				1	Teachers	Secondary Grs 8-12	International
67 M Wits	"The study analyses and interprets effective teaching strategies that develop mathematical concepts of measurement in an inclusive classroom".	Effective teaching strategies	Inclusive classroom		Measurement-volume	1	Learners Teachers	Primary Gr 7	Urban
68 M UP	"The aim of this project is to determine if a relationship exists between a learner's achievement in mathematics and his/her attitude towards the subject".	Achievement	Attitudes			3 5	Learners	Combined Grs 7, 9 & 11	Urban
69 D UJ	"What should be included as part of the content of the guided programme to make it efficient?...The investigation focused on the different strategies that could be applied in problem-solving".	Problem solving	Guided programme			1	Learners	Secondary Grs11 -12	Urban
70 M UCT	"This dissertation is interested in the systematic analysis of teachers' comments regarding the ways in which young children learn number concepts…The purpose of this investigation is to analyse the discourse that teachers use when describing their knowledge and understanding of number acquisition.	Knowledge & understanding	Whole Number acquisition		Whole numbers	1 2	Teachers	Primary Gr1	Rural
71 M UNISA	"the study investigated the extent to which learners perform in Process-Based Instruction".	Performance	Process based instruction		Geometry	1 3	Learners	Secondary Grs 8-9	Township
72 M Wits	"Special attention was given to pupils' algebraic manipulative skills and its influence on their performance in calculus".	Performance	Algebraic manipulative skills		Algebra Calculus	1 3	Teachers Learners	Secondary Gr 12	Combined urban & rural

73 M SU	"The study of three-dimensional boxes is widely regarded as a suitable topic for entry-level geometry… this study takes children's intuitive knowledge of boxes as point of departure to research…".	Knowledge - intuitive			Geometry	2	Learners	Primary Grs 1-3	Urban
74 M UCT	"This thesis stories the journey of a teacher who teaches teachers. On this journey, this teacher sets out to examine a mathematics in-service course that she teaches on at the University of Cape Town".	INSET				8	Teachers	Tertiary ACE	Township
75 M UCT	"This research project focuses on the 'new primary mathematics' curriculum that has been implemented in the schools…What access do teachers have to the regulating principles underpinning the 'new primary mathematics' curriculum"?	Curriculum- New Primary Mathematics;	Regulating principles			1 9	Students	Tertiary Bridging	Urban
76 M UJ	"This study researches an alternative lesson/study strategy which can be implemented in the classroom. Cognitive mapping are able to change each learner's learning process into an active, independent thought process.	Lesson strategies	Cognitive mapping			1	Learners	Secondary Gr 10	Urban
77 M UP	"An investigation into the reasons for underachievement in mathematics prompted the researcher to launch a study through which she wanted to remediate some of these identified problems. The research project … comprised of the implementation of tutorial sessions".	Achievement	Tutorial			1 3	Students	Tertiary 1st year	Urban
78 M Wits	"This study investigated the impact of an in-service programme on teacher knowledge of selected concepts and the teachers' attitudes towards science and mathematics".	INSET	Knowledge	Attitude		2 5 8	Teachers	Secondary Grs 11 -12	Township

79 D UWC	"This study investigates how two groups of African pupils, namely the low and high performers in standard 9 mathematics classes…, construct meaning of their African cultural, individual African identity and performance in mathematics respectively. The observation underpinning this investigation is that social structural factors have not gained much attention in research as bases for explaining differentiated performance in mathematics, hence this study".	Culture	African identity	Performance		3 6	Learners	Secondary Gr 11	Urban
80 M UFS	"This study concentrates on teaching methods that are used by teachers trained at LCE, particularly in teaching a success, and how improvements can be made regarding the training of teachers so that the training of mathematics teachers keeps abreast of new developments in teaching".	Teaching methods	Teacher education			1 10	Teachers Learners Principals	Secondary Grs 8-12	International
81 D UP	"The primary aim of this thesis was the development and evaluation of a study orientation questionnaire (SOM) in mathematics".	Study orientation Questionnaire				1	Learners	Secondary Grs 8-12	Combined urban & rural
82 M UJ	"How can a web-based spreadsheet be developed for grade ten learners and how can their experiences assist in developing guidelines for web-based mathematics teaching?	Web-based spreadsheet			Factorization Quadratics	4	Learners	Secondary Gr 10	Combined urban & rural
83 M Wits	"Self-confidence and mathematics achievement… Are students' success in mathematics and their attitude depend upon the method cooperative task employed"?	Achievement	Attitude	Cooperative task		1 3 5	Students	Tertiary 2^{nd} year	Urban
84 D UJ	"Is there any relationship between the students' attitudes toward and achievement in mathematics in the Soweto senior secondary schools"?	Attitude	Achievement			3 5	Learners	Secondary Grs 10-12	Township
85 M Wits	"The present study sought primarily to know what would happen to achievement in mathematics if a diagnostic and remedial approach was used to teach mathematics to disadvantaged children in Batswana schools. The study further investigated whether achievement had an effect on attitude of the disadvantaged children in their study of mathematics".	Achievement	Diagnostic & remedial approach	Attitude	Algebra & geometry	1 3 5	Learners	Secondary Gr 10	Rural

86 M TUT	"…teachers' methods of teaching mathematics were the focal point of this investigation".	Teaching methods				1	Teachers	Secondary Grs 8-12	Rural
87 D UP	"This study presents the computer-supported co-operative mathematics learning environment (CSCML) as a catalyst for change of an inappropriate educational system".	Computer CSCML				4	Teachers	Secondary Grs 8-12	Rural
88 M UCT	"This dissertation examines the impact of a geometry course on pre-service teachers' levels of understanding of geometry".	Understanding	Pre-service teachers' course		Geometry	2 10	Students	Tertiary 2nd year	Urban
89 M Wits	"This study,… analyses… teachers' practices in teaching algebra. The crucial point of the study concerns teachers' classroom activities and their reflections on teaching algebra".	Teachers' practices	Activities	Reflections	Algebra	1	Teachers	Secondary Grs 10-12	International
90 M UJ	"Perceptions of primary school principals about the assessment of learner performance in mathematics within Outcomes Based Education"	Assessment	Performance			3	Principals	Primary Grs 1-6	Township
91 M NWU	"This research study was intended to study the role played by information technology as an instructional tool in high schools and the challenges associated with the integration of information technology in the teaching and learning of mathematics in high schools.	Information technology	Instructional tool			4	Teachers Learners	Secondary Grs 8-12	Combined Township & rural
92 M Wits	"This research project describes Form 3 learners' conceptual understanding of area of quadrilaterals in one high school in Swaziland.	Conceptual understanding			Area-quadrilaterals	2	Learners	Secondary Gr 10	International
93 M RU	"I have chosen to use phenomenological enquiry as an avenue for examining how…, the leader of the Rhodes University Mathematics Education Project (RUMEP), experiences being a leader.	Leadership	RUMEP project			8 11	Leader	Tertiary Research project	Urban
94 M Wits	"The purpose of this study was to investigate whether and how the Change-Agent in the Primary Mathematics Education (CAPME) programme as change -agents themselves think about and act in relation to children constructing their own mathematical understanding.	Understanding	CAPME programme;	Change-agents		2 8	Teachers	Primary Grs 1-6	Township

95 M Wits	"This study investigates how Grade 8 learners interpreted consolidation activities from an OBE-styled mathematics textbook Math For All Grade 8".	Activities	Textbook	OBE		1 4 9	Learners	Secondary Gr 8	Township
96 M Wits	"The study investigated the use of the basic arithmetic operations in the solution of arithmetic and related algebraic fractions and expressions".	Solution to problems			Algebraic fractions & expressions; Arithmetic operations	2	Students	Tertiary Bridging	Urban
97 M Wits	"It investigates some Lesotho students' fractional concepts and whether and how students draw on Sesotho in articulating their conceptions. It is a case study involving clinical interviews with six Form C students from one school in Lesotho".	Conceptualisation	Language-Sesotho		Fractions	2 7	Learners	Secondary Gr 10	International
98 M UJ	"Is there any relationship between the self-instructional lesson and achievement in mathematics in QwaQwa secondary schools"?	Self-instructional lesson	Achievement			1 3	Learners	Secondary Gr 10	Rural
99 M UP	"This research project aimed to establish what extent computer-assisted Mathematics programs are used in schools… and how useful programs can be for teachers and learners".	Computer assisted math programme				4	Teachers Principals DoE Vendors	Primary Grs 1-7	Urban
100 M UJ	"1. What are the teaching strategies and methods that are applied by most of the teachers in the learning and teaching of mathematics in secondary schools in the Kagiso area? 2. Do the methods being applied in classrooms foster thinking skills relevant to problem solving, critical and creative thinking in the learners? 3. Which strategy and approach can encourage learners to think rather than to complete with paper and pencil, encourage learners to invent, explore, participate and cosntruct their own meaning?"	Teaching strategy	Thinking			1 2	Learners Teachers	Secondary Grs 10-12	Township
101 D UP	"Hypothesis: The present mathematics that is being taught in the rural high schools does not play an important role in developing rural and tribal communities in South Africa".	Rural tribal communities	rural mathematics curriculum development			6 9	Learners Teachers Youth-out-of school Parents	Combined Grs 1-12	Rural

102 M Wits	"This research report … looks at the benefits of using electronic teaching and learning resources, i.e, graphics calculators, as learners construct their knowledge. The research also considers the question as to whether the group of student teachers who used the calculators developed positive opinions towards their use in learning mathematics".	Graphics calculator	knowledge construction	Opinions	Quadratic function	2 4 5	Students	Tertiary 3rd year	Township
103 M Wits	"The focus was on the perceptions these educators had of tools used to assess mathematical investigations, the mathematical content and processes "	Assessing	Perceptions	Mathematical investigations		1 3 5	Teachers Learners	Secondary Gr 9	Urban
104 M UP	"This study investigated the effect of spreadsheets on mathematics lessons to standard 4 pupils in under-developed communities".	Spreadsheets			Statistics	4	Learners Teachers Principals DoE	Primary Gr 6	Combined urban & rural
105 M Wits	"This study was undertaken to shed light on students' performance and errors in solving linear and quadratic equations at secondary level of school mathematics".	Performance	Errors		Linear & quadratic equations	2 3	Students	Tertiary 1st – 3rd year	Urban
106 M UNISA	"This study investigated the relationship between diverse variables and secondary school pupil's mathematics achievement. It also dealt with the relative contribution of each variable to mathematics achievement and the significance of differences in mathematics achievements when pupils' gender and home background as well as teachers' experience, gender, education, in-service education, homework assignment and testing frequency are taken into account".	Achievement	Gender	home background		3 6	Students	Tertiary 1st -3rd year	Rural
107 D UNISA	"This study attempted to design and implement an intervention programme to improve the self-concepts and attitudes of prospective primary school teachers".	Intervention programme	Self-concept	Attitude		1 5	Learners	Secondary Gr 10	Rural
108 M Wits	"This is a study of mathematics teachers' beliefs about language in teaching mathematics to ESL pupils and the roles mathematics teachers assume".	Beliefs –	Language	ESL		5 7	Teachers	Secondary Gr 8 -12	International

109 M UJ	"The aim of the study is to expose the causes of the high failure rate of mathematics in the formerly black Kwa-Zulu/Natal schools… The study will, therefore, examine the teaching methods that are mostly applied by the teachers in the region".	Achievement	Teaching methods			1 3	Teachers Learners	Secondary Gr 12	Township
110 M RU	"To analyse mathematics curriculum of the College…To establish the teacher educators' and student teachers' perceptions of the … curriculum in general... content and processes. To establish the quality of available materials used at the College for realization of the curriculum goals".	Curriculum	Perception	Materials		4 5 9	Students Lecturers	Tertiary 1st – 3rd year	Township
111 M SU	"this study aims to investigate innovative and appropriate teaching strategies to introduce in the Rwandan educational system in order to foster students' mathematical thinking and problem solving skills".	Teaching strategies	Thinking	Problem solving skills	Algebra	1 2	Learners Teachers	Secondary Gr 9	International
112 D UKZN	"It attempted to determine whether learners were able to use modeling to solve a given real world problem. It also attempted to establish whether learners developed a better understanding when using Sketchpad".	Modeling	Understandin g	Sketchpad software	Geometry	1 2 4	Learners Teachers	Secondary Gr 10	Urban
113 M UCT	"This dissertation is concerned with aspects of the role of the textbook in school mathematics".	Textbook	Regulation & control			1 4	Teachers Textbook	Secondary Gr 10	Urban
114 M Wits	"The present study scrutinizes the students' understanding of the concept of limit of a function".	Understanding			limit function	 2	Learners Teachers	Secondary Gr 12	International
115 M UP	"This investigation is primarily concerned with the In-Service Education and Training (INSET) needs of primary school mathematics educators".	INSET				 8	Teachers	Primary Grs 1-6	Combined urban & rural
116 M UCT	"This study aims to discuss the issue of the evaluability of educational projects through a case study of the SSPP. In addition, the research raises the importance of programme theory for credible evaluation to take place".	Evaluation of projects (SSPP)-	Programme theory			 8	Teachers Principals Programme-coordinator DoE	Secondary Grs 8-12	Township
117 M UCT	"This dissertation is concerned with how, if at all, the 'everyday' is employed in fourteen Grade 7 mathematics classrooms".	'Everyday' knowledge				 2	Teachers Learners	Primary Gr 7	Township

118 D UNISA	"The research aimed at establishing the extent to which creativity and divergent thinking enhance the internalisation of geometry concepts using the problem-based approach ".	Thinking	Problem based approach		Geometry	1 2	Learners	Primary Gr 7	Urban
119 M UNISA	"determine the influence of Logo programming on children's understanding of a variable concept before they were taught any algebra".	Understanding	Logo programming		Algebra- variables	2 4	Learners	Primary Gr 7	Urban
120 M Wits	"This study explores how…children … solve a range of addition problems with known and unknown facts. Data was gathered … to gain access to the quality of children's thinking as they solved problems in addition.	Thinking	Problem solving		Addition problems	1 2	Learners	Primary Gr 2	Rural
121 M Wits	"This is a qualitative case study that investigates learners' conceptions of decimal fractions".	Conception			Decimal fractions	2	Learners	Secondary Gr 8	International
122 M UP	"In this dissertation, the advantages and disadvantages of using software packages are developed and a number of the software packages are listed and described".	Software packages				4	Computer software	Combined Grs 1-12	Nil
123 M Wits	"This study investigates whether there is a link between teachers' views of mathematics and their teaching styles".	Views of mathematics-	Teaching styles			1 2	Teachers	Secondary Grs 8-12	Township
124 D NWU	"this study focused on the development of a grounded teaching-theoretical framework for school mathematics teaching".	Grounded teaching				1	Students Teachers Lecturers Subject- advisor	Tertiary 1st – 3rd year	Urban
125 D NWU	"This research was undertaken to determine the influence of a video class system on strategic teaching and learning of school mathematics".	video class system	Strategic teaching and learning-			1 4	Teachers Learners	Secondary Grs 8-9	Urban
126 M UJ	"How can racial mathematical stereotypes and multicultural education in the post-apartheid dispensation could be reduced or totally eradicated"?	Racial mathematical stereotypes	Multicultural education-			6	Teachers HOD DoE NGO	Primary Grs 1-3	Urban
127 M Wits	"This is a study of teachers' espoused meaning(s) of 'relevance" as it refers to relating school mathematics tasks and activities to students' everyday contexts".	'Everyday' contexts	Relevance	Tasks & activity		1 2	Teachers Learners	Secondary Gr 12	International

128 D Wits	"This is a study of the trends to embed mathematics examination items in 'realistic' contexts and Basotho students' access to the resultant 'realistic' items".	Examination	'Realistic' contexts			2 3	Students	Tertiary ACE	International
129 M RU	"…this study uses alternative and more direct means of assessing the level and nature of the understanding such students have of basic arithmetic and number theory".	Understanding			Arithmetic, number theory	2	Students	Tertiary 1st year	Urban
130 M UP	"The project investigated the implications of …CAE in the mathematics on milieu handicapped pupils in the senior primary phase".	Computer assisted education (CAE)-			Word sums	4	Learners	Primary Gr 6	Township
131 M UJ	"The objective of this study was to explore the possibilities of applying and using the computer in the Mathematics classroom".	Computer- use & application				4	Learners Teachers	Secondary Gr 9	Urban
132 M Wits	"This research was concerned with the relationship between attitudes towards mathematics and mathematics achievement".	Attitudes	Achievement			3 5	Students	Tertiary 1st year	Rural
133 M NMMU	"This dissertation investigates students' perception of the Mathematics Foundation Coarse on the Port Elizabeth campus of Vista University".	Perceptions	Mathematics foundation course			2 10	Students	Tertiary Bridging	Urban
134 M Wits	"This research report compares the effect that the absolutist and constructivist pedagogies have on the creative teaching and learning of algebra".	Creative teaching and learning	Absolutist and constructivist pedagogies		Algebra	1	Learners	Secondary Gr 8	Urban
135 M RU	"The purpose of this study is to investigate various solution strategies employed …when solving a given set of mathematical tasks".	Solution strategies	Problem solving		Word problems, number sense	1	Learners Teachers	Primary Gr 7	Township
136 D UJ	"A mathematics competency test for the placement of students at a Technical College"	Competency test	Placement of students			3	Students Lecturers	Post-secondary Gr 12, N4-N5	Urban
137 M SU	"The research is…an empirical investigation of the perceptions of teachers … o[f] continuous assessment.	Perceptions	Continuous assessment			3 5	Teachers	Secondary Grs 10-12	Township
138 M Wits	"Investigating learners problem solving strategies involving algebraic thinking"	Problem solving strategies	Thinking		Algebra; expression, equations	1 2	Learners Teachers	Secondary Gr 11	Combined urban & rural

139 M Wits	"This research report studies the effects that extra mathematics tuition has on the mathematics ability of the pupils that attend this tuition".	Extra tuition	Mathematics ability			1 2	Learners	Secondary Gr 11	Suburban
140 M Wits	"This study investigates the extent of the difficulty that Grade 10 English second language learners have with some of the mathematics terms which are commonly used in their curriculum".	ESL	Mathematics terms			7	Learners	Secondary Gr 10	Urban
141 M NMMU	"This study investigates the possibility that the introduction of a cooperative learning strategy may help to improve the written mathematics test results of Pre-Technician students".	Cooperative learning strategy	Written mathematics test results			1 3	Students	Tertiary Bridging	Urban
142 M UCT	"The research focus of this dissertation is the manner in which textual strategies present in school mathematics textbook contribute to the production of the pedagogic discourse of school mathematics".	Textual strategies	Textbook	pedagogic discourse		1 4 7	Textbook	Primary Gr 7	National
143 D SU	"This study investigates the influence of readability of mathematics examination questions on achievement".	Readability	Examination questions	Achievement		3 7	Learners	Secondary Gr 12	Urban
144 M NMMU	"This research was primarily aimed at determining the relationship between anxiety, cognitions and achievements in mathematics of rural adolescents".	Anxiety	cognition	Achievement		2 3 5	Learners	Secondary Gr 9-10	Rural
145 M Wits	"This research report investigates the impact of mathematical expertise of Adult Basic education and Training numeracy facilitators on their facilitation… and mediation…of level 2 numeracy to adult learners of numeracy..."	Mathematical expertise	ABET	Facilitation & mediation	Numeracy-fractions	1 12	Facilitators	ABET Gr 4-7	Urban
146 M UCT	"determine the demographic profile of secondary mathematics teachers in Limpopo Province,… to establish the perceived INSET needs of these teachers, and… to examine possible associations between demographic profiles and perceived INSET needs of secondary mathematics teachers in the Limpopo Province".	INSET needs	Demographic profile of teachers			6 8	Teachers	Secondary Grs 8-12	Rural
147 M UNISA	"In this study, senior certificate…pupils' attainment of the cognitive and affective aims and objectives of the senior certificate mathematics curriculum was investigated".	Attainment	Cognitive	Affective		2 3 5	Teachers Learners	Secondary Gr 12	Urban

148 M UNISA	"In the study, the cognitive and metacognitive processes of mathematical thinking are examined".	Thinking	cognitive	metacognitive		2	Learners	Secondary Gr 8	Township
149 M UJ	"What is the cause of the problems in the teaching and learning of mathematics …? Can the teaching and learning problems in…school's mathematics be overcome?	Teaching & learning problems				1	Learners Teachers HOD	Secondary Gr 8	Township
150 M Wits	"In this research report, the effectiveness of NGO-sponsored mathematics INSET on the classroom practices of primary school educators is investigated.	INSET	Classroom practices			1 8	Teachers	Service-provider MCPT	Urban
151 M UJ	"The aim of this study was to assess the extent to which a computer-based learning package for mathematics can be utilized effectively to address the lack of mathematical skills in South Africa".	Computer-based learning package				4	Learners Teachers	Secondary Gr 8	Urban
152 M UJ	"This study investigates junior primary teachers' conception of problem-centred mathematics teaching with the view to describe and also explain their conception".	Problem-centred teaching	Conception			1 2	Teachers	Primary Gr 1-3	Urban
153 M UP	"The purpose of this case study was to determine the effect of a Cairoo program to improve the mathematics skills of milieu-handicapped primary children, when it is supplemented by traditional lessons	Cairoo computer program	Learners from disadvantage backgrounds			4 6	Teachers Learners	Primary Gr 6	Urban
154 M Wits	"The challenge for the DoE is to understand which factors will attract and retain math and science graduates. This research is aimed at determining those factors in the public school system".	Attraction of mathematics graduates	Retention			13	Teachers Students Ex teachers	Private Sector	Urban
155 M UKZN	"This study examines the mathematics education of youth at-risk in South Africa. It explores how two learners at the margin understand and perform in mathematics in two radically different educational environments".	Understanding	Performance	Youth-at-risk		2 3 6	Youth out of school	Combined Primary & Secondary Grs 7-8	Urban

156 D Wits	"The purpose of the study was to investigate the following: what mathematics knowledge and beliefs embedded in cultural practice/activities learners bring to school… how teachers facilitate the development of academic mathematics using the mathematics knowledge embedded in cultural practices/activities has on learners".	Knowledge	Beliefs	Cultural practice/ activities		2 5 6	Learners Teachers	Secondary Grs 8-12	Rural
157 M NWU	"The purpose of this study was to determine: What the influence of attitude is on the mathematical achievement".	Attitude	Achievement			3 5	Learners	Secondary Gr 10	Suburban
158 M Wits	"This is an enquiry into the beliefs of mathematics lecturers at technical colleges regarding the teaching and learning of mathematics, its nature, and particularly, its applicability to technology".	Beliefs	nature of mathematics	Applicability to technology		2 4 5	Lecturers	Post-Secondary Gr 12, N4 – N5	Urban
159 M RU	"A research study was made of constructivist and investigative teaching and learning methods as employed by teachers in a number of primary schools in the area".	Teaching & learning methods	Constructivist methods	Investigative methods		1	Learners Parents DoE Teachers	Primary Grs 1-6	Combined urban & rural
160 M SU	"this study sought to investigate whether there are any difference in the quality of interpretation and choice of algo-heuristic methods when isiXhosa-speaking learners respond to mathematical word problems set in English and isiXhosa".	Algo-heuristic methods	ESL		Word problems	1 7	Learners Teachers	Secondary Gr 8-10	Township
161 M NWU	"This study, therefore, aims at affording mathematics teachers and learners of crowded classes an opportunity to effectively use cooperative learning, namely the Hour-glass model in mathematics lessons".	Crowded classes	Cooperative learning	Hour-glass model		1	Learners Teachers	Secondary Gr 8	Township
162 M Wits	"This study investigated the social factors that influence girls' performance in comparison to boys' in mathematics in early secondary schooling in Lesotho".	Performance	Social factors	Girls & boys		3 6	Learners	Secondary Gr 8-9	International
163 D UNISA	"The…purpose of this research is to establish whether mathematics can be taught effectively with the use of appropriate media to further establish the possible effects of media in the teaching of mathematics".	Media				4	Learners Teachers	Primary Grs R-4	Combined Urban & rural

164 M Wits	"This study investigates ways in which code-switching shapes possibilities for mathematical meaning-making in a primary class of second language learners".	Code-switching	Mathematical meaning	ESL		2 7	Teachers Learners	Primary Gr 5	Township
165 D Wits	"This is a study of language practices of intermediate phase mathematics teachers in multilingual classrooms in South Africa".	Language practices	Multilingual classroom			 7	Teachers Learners	Primary Grs 4-7	Township
166 M UZUL	"The first aim was to investigate pupils' understanding of the meaning of words found in their text books. The second aim was to determine the level of difficulty experienced by pupils in learning the meaning of mathematical terms. The third aim was to find out whether mathematics performance is influenced by any particular respondents' characteristics".	Understanding of meaning of words	ESL	Performance		2 3 7	Learners	Secondary Grs 11- 12	Combined Township & rural
167 D UJ	"Is there any relationship between attitude, curriculum, and methods of teaching and learning difficulties in mathematics"?	Attitude	Learning difficulties	Curriculum		1 5 9	Teachers	Secondary Grs 11-12	Township
168 M UP	"This study focuses on the implementation of CASS in Mathematics and Science".	Continuous assessment				 31	Teachers DoE	Secondary Gr 12	Combined urban & rural
169 D UNISA	"Does the performance in Mathematics and Science of standard 8 students in the pilot study receive tuition in Technology Education improve or not"?	Performance	Technology education			3 4	Learners	Secondary Gr 10	Urban
170 M UP	"What are the requirements for graphing technology to ensure meaningful visualisation of two-dimensional functions to promote better understanding of the mathematical concepts involved"	Understanding	Visualisation	Technology	Calculus Graphs	2 4	Lecturers Students	Tertiary 1st year	Urban
171 M UP	"Creating a computer-assisted learning programme in mathematical relationships for learners in the senior phase".	Computer-assisted learning programme	Combined subjects			1 4	Learners Teachers HOD	Combined Grs 7-9	Urban
172 M UCT	"The present study aims to… investigate whether these patterns suggest underlying misconceptions held by the learners … the study also set out to evaluate the test instrument as a measure of achievement and of potential misconceptions".	Misconceptions	Test instruments	Achievement	Decimals, percentage, measurement	2 3	Learners	Primary Gr 7	Township

173 M Wits	"The purpose of this project is to look at the beliefs and perceptions of Grade One teachers in mathematics".	Beliefs	Perception			5	Teachers	Primary Gr 1	Township
174 M Wits	"This research focuses on students' understandings of the limit concept in a first year Calculus course".	Understanding			Calculus Limit	2	Students	Tertiary 1st year	Urban
175 M UNISA	"The aim of this study was to determine whether hyponotherapy can be used to lower Mathematics anxiety levels to such an extent that pupils can optimally achieve in Mathematics".	Hypnotherapy	Anxiety	Achievement		3 5	Learners	Secondary Grs 8-12	Urban
176 M UNISA	"The general aim of the empirical investigation is to investigate the relationship between maths anxiety, maths achievement and different teaching methods".	Teaching methods	Anxiety	Achievement		1 3 5	Learners	Secondary Gr 8	Urban
177 M UKZN	"The aim of the study was to investigate whether self-regulated learners are developed in Grade 8 mathematics classrooms".	Self-regulated				5	Learners Teacher	Secondary Gr 8	Rural
178 M UJ	"This study is an investigation into cognitive mapping as strategy in the constructivist approach to mathematics education to learners with a visual disability with the view to describe the change in pupils' thoughts on mathematical concepts, as well as their experiences during the process of cognitive mapping".	Cognitive mapping-	Visual disability	Thinking		1 2	Learners	Secondary Gr 9	Urban
179 M UKZN	"The purpose of this study was … to examine the teaching strategies that a teacher at a rural school … used in a Grade 8 mathematics classroom …also to examine the learning outcomes and to explore possible links between teacher strategies and learning outcomes".	Teaching strategies	Learning outcomes			1	Learners Teacher	Secondary Gr 8	Rural
180 D NMMU	"The aim of this study was an exploration of the relationship between the use of an Integrated Learning System (ILS), …, and mathematics achievement".	Integrated learning system	Achievement	Technology		1 3 4	Learners	Secondary Gr 12	Township
181 D UNISA	"The aim of this study is to determine to which extent pupils taking Mathematics at school level and student teachers of Mathematics receive instruction in logic as grounding for rigorous proof".	Logic	Proof		Geometry-theorems	1 2	Documents Literature	Combined Secondary & Tertiary Gr 10 – 3rd year	Urban

182 M UP	"In this study a technique of reflection was developed as a learning strategy for learners in Grade seven who experience problems in Mathematics".	Reflection technique	Learning strategy		Number system	1	Learners	Primary Gr 7	Urban
183 M Wits	"This study was aimed at investigating the way in which pupils in small groups solve Geometry problems".	Small groups	Problem solving		Geometry	1	Learners	Secondary Gr 11	Urban
184 M NWU	"The central focus of the study is the development of guidelines and the creation of an implementation model for the integration of… OBE and cooperative learning".	Implementation model	OBE	Cooperative learning strategy		1 9	Lecturers	Tertiary 1st -3rd year	Urban
185 M UCT	"the research undertaken provides the education community with a detailed description of life in an urban black South African high school in general, and of its mathematics classrooms in particular".	Black South African high school	Mathematics classrooms			1 6	Teachers Learners	Secondary Grs 8-11	Township
186 M NMMU	"What are the beliefs held by in-service teachers registered for mathematics education degrees at the university of Port Elizabeth in the Eastern Cape about the nature of mathematics"?	Beliefs	Nature of mathematics	Teaching practices		1 2 5	Teachers	Combined Grs 1-12	Combined urban & rural
187 D RU	"In order to discover how Port Elizabeth learners from ex-DET schools perceived and experienced Mathematics homework, and the nature of such homework, ten case studies of Grade 11 learners were done".	Homework	Nature of homework			1	Teachers Learners	Secondary Gr 11	Township
188 M RU	"A critical investigation into the processes of negotiating a mathematics education curriculum with pre-service teachers".	Curriculum negotiation-	Teacher education			9 10	Students	Tertiary 3rd year	Urban
189 M UNISA	"This study investigates the terms, dialogue, structure and active learning in Open Distance Learning texts in a constructivist and problem-solving approach".	Open Distance Learning Texts (Materials)	Constructivist	Problem solving approach		1 4 7	Lecturers Students	Tertiary 1st – 3rd year	Urban

190 D UNISA	“The present study fills this gap in the literature by examining the extent to which selected variables (mathematics attitude, mathematics aptitude, computer attitude, computer prior experience, computer ownership, proficiency in language of instruction, and learning style) contribute to students’ achievements in pre-calculus algebra classes that are supplemented with a computer lab program”.	Achievement	Computer lab program	Attitude	Pre-calculus algebra	3 4 5	Students	Tertiary Bridging	International

APPENDIX E
Categories of research phenomena

Category number	Actual phenomenon studied in mathematics education theses (1995-2004)	Category coding
1	Absolutist & Constructivists pedagogies; Activities; Algebraic manipulative skills; Algo-heuristic; Application tasks; Appropriation of mathematical objects; Child care; Classroom practices; Cognitive mapping; Combined subjects; Constructivist methods; Contextual teaching; Cooperative learning; Cooperative task; Creative teaching & learning; Crowded classes; Diagnostic & remedial approach; Early learning; Extra tuition; Facilitation & mediation; Guided programme; Grounded teaching; Homework; Hour-glass model; Inclusive classroom; Investigative methods; Learner-centred approach; Learning; Lesson strategy; Learning problems; Learning difficulties; Logic; Mathematics classrooms; Mediation; Methods; Modelling; Participation; Pedagogic discourse; Pedagogic Content Knowledge; Problem-centred approach; Problem solving; Process-based instruction; Reflection technique; Regulation & control; Regulating principles; Self-instructional lesson; Small groups; Solution strategies; Strategic teaching and learning; Study orientation questionnaire; Teaching & learning problems; Teacher practices; Teaching styles; Teaching strategy; Teacher learning; Tutorials; van Hiele levels; Visual disability; Whole number acquisition	Pedagogy
2	Ability; Acquiring; Cognitive; Cognition; Competencies; Conceptualization; Conceptual understanding; Concept development; Construction; Errors; Intelligence; Intuitive; Knowledge; Mathematics meaning; Misconceptions; Special abilities; Thinking; Understanding; Visualization, Visual disability; Nature of mathematics; views of mathematics; construction of school mathematics; nature of definitions; PCK; Spatial ability; Metacognitive strategies; Solution to problems; Everyday; Everyday knowledge; Realistic; Realistic Mathematics Education; Relevance; proof	Knowledge, Cognition & Epistemologies
3	Achievement; Assessment instruments; Assessment practices; Assessing Mathematical Investigations; Attainment; Competency test; Continuous assessment; Examination Structure; Examination questions; General Scholatics Aptitude Test (GSAT); Performance; Placement of students; Test instruments; TIMSS; Written mathematics test results	Assessment
4	Applicability to technology; Cairoo computer program; Computers; Computer software; Computer programmes; Computer supported Instructional program; Computer drills; spreadsheet; Computer use & application; Computer Lab program; Geometers' Sketchpad; Graphic calculators; Information Technology; Integrated Learning system; Internet; Logo programming; Media; Technology Education; Web; Instructional tools; Chess; instructional materials; Tchadji game; Teaching resources; textbook; video class system; Models	Technology & Resources
5	Affective; Anxiety; Attitudes; Beliefs; Hypnotherapy; Opinion; Perceptions; Self-concept; Self-regulated	Affective domain
6	African identity; Black; Black South African High School; Culture; Cultural practices & activities; Demographic profile of teachers; Diverse Ethnic Communities; Ethno-mathematics; Gender; Girls & Boys; Home background; Learners from disadvantaged backgrounds; Multicultural; Plain & twill weaving; Racial mathematics stereotypes; Rural tribal communities; Social factors; Social practice; Youth-at-risk	Socio-cultural political perspective
7	Code-switching; English Second Language; Language; Language practices; Mathematics terms; Meaning of words; Multilingualism; Multilingual classroom; Open Distance Learning Texts; Readability; Semiotic Mediation; Texts; Textual strategies; Writing	Language
8	Change-agent; Change-Agent in the Primary Mathematics Education programme (CAPME); Demographic profile of teachers; Evaluation of SSPP project; Geometry course; In-Service Courses; INSET needs; Institutional & personal biographies; Math Centre for Primary Teachers Project; Programme theory; Rhodes University Mathematics Education Project (RUMEP); Workshops	INSET
9	Curriculum 2005; Curriculum Content; Curriculum Evaluation; Curriculum negotiation; Curriculum Objectives; Implementation model; New Primary Mathematics; Outcomes Based Education; Programme evaluation; Rural Mathematics Curriculum development	Curriculum Policy & implementation
10	Calculus course; Geometry course; Intervention programme; Mathematics Foundation Course; Pre-service teachers' course; Teacher education	PRESET
11	Classroom management; Leadership	Leadership
12	Adult Basic Education and Training (ABET)	ABET
13	Attraction; Recruitment; Retention	Attrition rate

APPENDIX F

Theories used in mathematics education postgraduate studies in South Africa (1995-2004)

Theories	*F*	Theories	*F*	Theories	*F*
Abstraction	1	Cognitive cartography	1	Diagnostic instrument	1
Achievement	1	Cognitive development	8	Discourse and procedure	1
Action theory	1	Cognitive inherent	1	Discourse structure	1
Activity theory	3	Cognitive mapping	1	Domains of mathematics practice	1
Affective schema	1	Cognitive schema	1	Educational ideologies	1
Approaches to teaching algebra	1	Cognitive taxonomy	1	Enactivism	1
A prior synthetic	1	Cognitive theory of reading process	1	Enculturation	1
Areas of thinking	1	Collectivism	1	Ethno mathematics	3
Assessment in the pedagogy	1	Communities of practice	2	Evaluability assessment	1
Attentional Model for learning math	1	Computer application	2	Experiential learning	1
Attitude	3	Concept definition, image & development	6	Factor analysis	1
Bantu education	1	Conceptions of learning	1	Feminism	1
Beginning situation	1	Connectionist theory of reading	1	Functional model	1
Behavioural oriented theory	1	Constructivism/ Constructivist	66	Games	2
Bilingualism	1	Cooperative learning	11	Gendered learning styles	1
Biography Transformation Model	1	Critical Mathematics Education	4	Gender and mathematics	2
Bloom's taxonomy	1	Critical theory	1	Gender stereotyping	1
Chaos theory	1	Culture of learning and teaching	1	Generic technology	1
Classification & framing of knowledge	7	Cultural models	2	Geometry learning / schema	2
Classical test theory	1	Cultural schemata for readability	1	Group process model	1
Classroom management	1	Cumulative learning model	1	Guided discovery	2

Theories	*F*	Theories	*F*	Theories	*F*
Code theory	1	Curriculum	1	Habitus	**1**
Cognitive conflict	**1**	Cyclic models	**1**	Heuristic	1
Hierarchy of needs	1	Levels of geometric thought	14	Primitive intuitive model	1
Hour-glass model	1	Marxism	1	Problem based learning	36
Ideology in mathematics	1	Mathematics anxiety	8	Proficiency	1
Ideological foundations of curriculum	1	Mathematical understanding	5	Psychological development	1
Induction	1	Mathematics and context	1	Quasi-empirical	1
Information processing memory	2	Mathematics learning/ object appropriation	2	Radical constructivism	1
Input-Process-Output	1	Mathematics register	1	Rationale for using computers	1
Inquiry model	1	Mathematising /cycle	2	Readability	1
INSET provisioning	6	Mastery learning	1	Readiness-for-action	1
Instrumentalism/ instrumental learning	2	Mediation Learning Experience	2	Realistic Mathematics Education	6
Intellectual ability	1	Mentoring	1	Recognition of rules	1
Interactive instruction	1	Metacognition	3	Reflection-in-action	1
Investigative process	1	Misconceptions	8	Reflection-on-action	1
Item response theory	1	Modes of identification	1	Reflective practice	4
Knowledge transmission and acquisition	1	Multicultural education/ Multilingualism	2	Regulation principles	1
Language and mathematics	3	Multiple embodiment	2	Relational understanding	1
Language development	2	Multiple intelligence	1	Renumeration packages	1
Language dilemma	1	New environmental theories	1	Representations	1
Language, culture and thought	2	Number theory	1	Representations	1
Learner-centered approaches	2	Object process	1	Scale drawing	1
Learning event	1	Ontological contextual view of teaching	1	Self-confidence	1
Learning organisation	1	Outcomes Based Education	1	Self-concept	2

Theories	*F*	Theories	*F*	Theories	*F*
Learning style inventory	**1**	Pedagogical content knowledge	**1**	Self-efficacy	**1**
Learning theories	1	Pedagogic discourse	1	Self-regulation	1
Learning transfer theory	**2**	Planning theory	**2**	Semiotic theory /mediation	**2**
Legitimate peripheral participation	1	Platonism	2	Signification	1
Situated cognition/ learning	5	Subject matter knowledge	**1**	Tornado effect	1
Six-stage collaborative INSET model	1	Symbolic control	1	Transformational leadership	1
Social practical theory	2	Symbolic interactionism	1	Transitional stages	1
Socio linguistics	2	Taxonomy of educational objectives	3	Typology of knowledge	1
Socio-cultural learning theory	15	Teacher centred /role	2	Tutorials/ tutoring program	3
Spatial ability	1	Teacher knowledges	5	Understanding	2
Strategies of teaching calculus	1	Technology Acceptance Model	1	Visual literacy/ Visualisation	2
Structuration theory	1	Theory of cultural transmission pedagogy	1	Word problem	1
Study orientation	1	Theory of social practice	1	Zone of proximal development	13

APPENDIX G

ETHICAL CLEARANCE

UNIVERSITY OF KWAZULU-NATAL

RESEARCH OFFICE (GOVAN MBEKI CENTRE)
WESTVILLE CAMPUS
TELEPHONE NO.: 031 – 2603587
EMAIL : ximbap@ukzn.ac.za

1 NOVEMBER 2007

PROF. R BALFOUR (1059421)
LANGAUGE, LITERACIES, MEDIA & DRAMA EDUCATION

Dear Prof. Balfour

ETHICAL CLEARANCE APPROVAL NUMBER: HSS/0603/07

I wish to confirm that ethical clearance has been granted for the following project:

"An exploratory study of research priorities, methodologies, trends and developments in educational research in M. E. D. and PhD students' theses in ten South African Higher Educational Institutions (HEI) from 1995 to 2004"

PLEASE NOTE: **Research data should be securely stored in the school/department for a period of 5 years**

Yours faithfully

[redacted]

MS. PHUMELELE XIMBA
RESEARCH OFFICE

APPENDIX H
Editor's letter

Thabisile Nkambule

[redacted]

[redacted]

[redacted]

Cell Number: [redacted]

To Whom It May Concern

I certify that I have edited

"Critical analysis of knowledge produced through postgraduate mathematics education research in post-apartheid South Africa: the first decade".

By Barbara Busisiwe Goba

However, the correction of all errors/missing information remains the responsibility of the author.

[redacted]