Multiple levels and aspects of language competency in English and Intermediate Phase mathematics teachers: An analysis of case of the Eastern Cape Province

by

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Thesis submitted in fulfilment of the requirements for the degree

Doctor of Philosophy

(Curriculum Studies)

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Stellenbosch University

Supervisor: Prof M. L. A. Le Cordeur

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DECLARATION

I, **Lindiwe Tshuma**, hereby declare that **Multiple levels and aspects of language competency in English and Intermediate Phase mathematics teachers: An analysis of case of the Eastern Cape Province** is submitted by me for the Doctor of Philosophy Degree in Curriculum Studies at Stellenbosch University. The work contained in this thesis is original, and I am the sole author thereof, (save to the extent explicitly otherwise stated) and has not been previously submitted, either in part or in its entirety, for the award of any other degree at any other university. I do further cede copyright of the thesis in favour of Stellenbosch University.

Signature **(L. Tshuma)** **Date: December 2017**

LANGUAGE PRACTITIONER CERTIFICATE

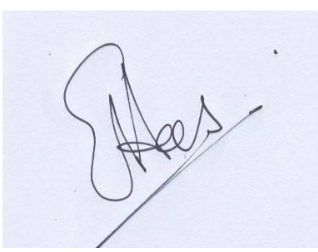
20 August 2017

TO WHOM IT MAY CONCERN

This is to confirm that I assisted Ms **LINDIWE TSHUMA** with the language editing of her thesis submitted for the degree *Doctor Philosophiae* at the Faculty of Education, Stellenbosch University, while she was preparing the manuscript for submission. The title of the thesis: **Multiple levels and aspects of language competency in English and Intermediate Phase mathematics teachers: An analysis of case of the Eastern Cape Province**. Her supervisor was Prof. Michael le Cordeur.

I went through the entire draft making corrections and suggestions with respect predominantly to language usage. Given the nature of the process, I did not see the final version, but made myself available for consultation as long as was necessary.

I may be contacted personally (details below) for further information or confidential confirmation of this certificate.



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ABSTRACT

The South African Language in Education Policy (LiEP) stipulates the use of English or Afrikaans as a language of instruction in the upper primary school, after mother-tongue instruction in the lower primary school. This study is undertaken within the context of many educational research studies which confirm that English is used as the official language of learning and teaching (LoLT) by 90% of the learners in public schools in the country. These learners are multilingual; in other words, they are also English-language learners (ELLs). The aim of the study is to analyse the relationships between IP teachers' language competencies and mathematics instruction at primary school level.

This study is generally informed by Cummins's (2000) work and particularly informed by Gawned's socio-psycho-linguistics theory. The study, which is situated within the interpretivist-constructivist paradigm, is a multi-methods study incorporating language proficiency and mathematics word problem assessments, questionnaires, interviews and classroom observations involving 55 Intermediate Phase (IP) teachers purposefully selected from 16 educational districts in the Eastern Cape Province and 10 IP mathematics teacher educators from different teacher education institutions in the country. Data were quantitatively and qualitatively analysed.

Findings from the study reveal that teacher language competency in English, the language they are supposed to teach in, is significantly low and that IP teachers who are not proficient in the language of instruction compromise the quality of mathematics instruction. The data suggest that while some teachers make an effort to teach in English and promote learner discourse in the prescribed language of instruction, the practice was not consistent.

Inconsistencies varied from teachers attempting to use the stipulated language of instruction with the aid of teaching and learning support material written in English to those who predominantly taught in isiXhosa throughout the lesson in classrooms devoid of text. Overall results of this study illustrate that the lack of consistency stems from the fact that the majority of teacher education institutions do not require or develop mastery in the language of instruction, and provide minimal or no guidance towards systemic use of translanguaging and code switching.

Since the participants in this study are qualified practising teachers, this study concludes that the onus is on teacher education institutions to adequately prepare IP mathematics teachers linguistically. It is not enough to assume that teacher language competency in the language of instruction is up to standard simply because a teacher is qualified to teach. In addition, teacher education curricula should provide knowledge on ELLs, so that teachers are better equipped to serve these learners. It is anticipated that this study will contribute significantly to the current

debate on language use in education and stimulate awareness among teacher education curriculum developers, so that teachers' mastery of the language of instruction is prioritised for the delivery of meaningful content in under-resourced classrooms in South Africa. The study highlights teacher competency in the language of instruction as one of the most significant predictors of mathematics performance; this is particularly significant since the country's indigenous languages are yet to be fully developed to support mathematics instruction.

This study does not seek to enshrine English at the expense of other official languages in South Africa, but endeavours to cater for the ELLs who are in the education system today and are supposed to be taught and assessed in English, as stipulated by the current LiEP. Even if policies change and promote mother-tongue instruction throughout the entire ordinary education system, proficiency in English will remain a prerequisite for ELLs to access the global village.

OPSOMMING

Volgens die Suid-Afrikaanse Taal in Onderrigbeleid (TiOB) is Engels of Afrikaans die Taal van Onderrig in die senior primêre skool of die Intermediêre fase (IF) nadat die leerders moedertaalonderrig in die junior primêre skool ontvang het. Hierdie studie is onderneem teen die agtergrond van talle ander opvoedige navorsing wat bevestig dat Engels die amptelike Taal van Onderrig en Leer (TvOL) is van 90% van alle leerders in openbare skole in Suid-Afrika. Hierdie leerders is meertalig; met ander woorde afgesien van hul moedertaal, is hulle ook Engelse Taalleerders (ETLs). Die doel van hierdie studie is om die verband tussen die IF-onderwyser se taalvaardighede en wiskunde-onderrig in die primêre skool te ondersoek.

Die studie is breedweg gebaseer op Cummins (2000) se werk ten opsigte van die sosio-psigo-linguistiese teorie. Die studie, vind plaas binne die raamwerk van die interpretivistiese-konstruktivistiese paradigma, 'n multi-metode-ondersoek wat insluit taalvaardighede en wiskundige woordsomme-assesserings, vraelyste, onderhoude en klaskamerwaarnemings by 55 onderwysers in die intermediêre fase (IF) doelmatig geselekteer van 16 onderwysdistrikte in die Oos-Kaap asook 10 IF-wiskunde-onderwysdosente van verskillende onderywsinrigtings in die land. Data is kwantitatief sowel as kwalitatief geanaliseer.

Die bevindings van die studie onthul dat onderwysers se taalvermoë in Engels, die taal waarin hulle onderrig moet gee, is beduidend laag en dat IF-onderwysers wat nie vaardig in die taal van onderrig is nie, 'n negatiewe impak het op die kwaliteit van wiskunde-onderrig. Die data dui aan dat alhoewel sommige onderwysers 'n poging aanwend om in Engels te onderrig en leerderdiskoers in die voorgeskrewe taal van onderrig aan te moedig, word dit in die praktyk nie konsekwent toegepas nie.

Inkonsekwenthede wissel van onderwysers wat probeer om die amptelike taal van onderrig te gebruik met behulp van Engelse leer- en onderrig ondersteuningsmateriaal, tot diegene wat hoofsaaklik en regdeur die les in isiXhosa klasgee in klaskamers wat teksarm is. Die finale resultate van hierdie studie illustreer dat die gebrek aan konsekwentheid die gevolg is van die meerderheid van onderwysinstansies wat nie die bemeestering van die taal van onderrig as 'n vereiste stel nie; en slegs minimale en selfs geen leiding gee oor die sistemiese gebruik van transtaligheid en kodewisseling.

Ofskoon die deelnemers aan hierdie studie gekwalifiseerde onderwysers is, kom die studie tot die slotsom dat die onus berus by onderwysinstansies om IF-onderwysers linguisties voldoende op te lei. Dit is nie goed genoeg om net te aanvaar onderwysers se taalbevoegdheid in die taal van onderrig is op standaard net omdat hulle gekwalifiseerde onderwysers is nie. Voorts

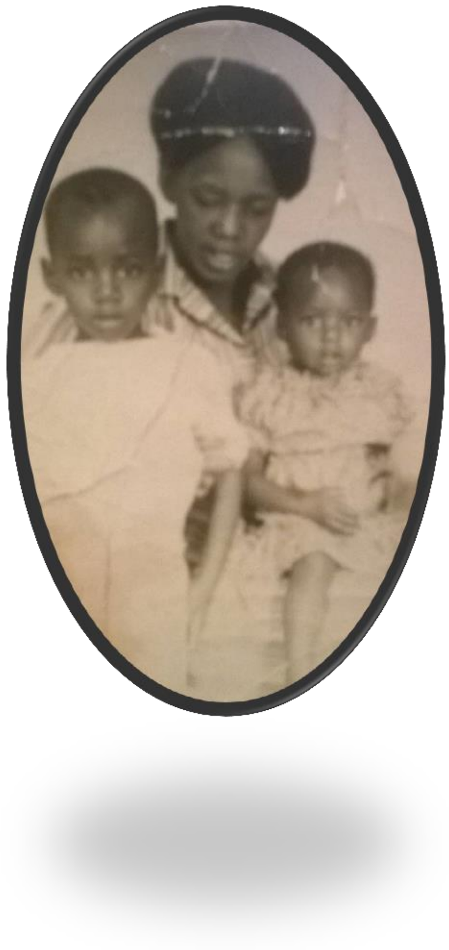
behoort die kurrikulum tydens onderwysopleiding inligting te bevat omtrent ETLs, sodat onderwysers beter toegerus is om hierdie leerders te onderrig.

Daar word gehoop dat hierdie studie ‘n beduidende bydrae sal maak tot die heersende debat oor taalgebruik in die onderwys en dat dit bewusmaking sal stimuleer by kurrikulumadviseurs sodat onderwysers se bekwaamheid in die taal van onderrig ‘n prioriteit sal word ten einde die suksesvolle aflewering van die kurrikuluminhoud te verseker in minder-bevoorregte klaskamers in Suid-Afrika. Hierdie studie beklemtoon dat die taalvaardigheid van onderwysers is een van die belangrikste aanduiders van prestasie in wiskunde. Dit is veral belangrik aangesien ons land se inheemse tale nog nie ten volle ontwikkel is om wiskunde-onderrig te ondersteun nie.

Hierdie studie is nie ‘n poging om Engels ten koste van die inheemse tale in Suid-Afrika te bevorder nie, maar poog slegs om voorsiening te maak vir die ETLs wat tans in die onderwyssisteem is en veronderstel is om in Engels onderrig te word soos voorgeskryf deur die TiOB. Selfs al sou beleid verander om moedertaalonderrig te bevorder deur die hele onderwyssisteem, sal vaardigheid in Engels steeds ‘n voorvereiste wees sodat ETLs toegang tot die globale wêreld kan kry.

DEDICATION

To my dear parents: ***Mr Eustace Justice Tshuma*** *and* ***Mrs Beauty Tshuma****, for raising the philosopher in me; they are philosophers in their own right!*



PEER-REVIEWED PUBLICATIONS AND PRESENTATIONS EMANATING FROM THIS RESEARCH

Research Papers

I. Presented at the Association for Mathematics Education of South Africa (AMESA) Annual National Congress held at Tshwane University of Technology, Nelspruit South Africa from the 27th June – 1st July 2016.

II. Presented with M. L. A. Le Cordeur at the LSSA/SAALA/SAALT Joint Annual Conference held at University of the Western Cape, Cape Town South Africa from the 4 – 7th of July 2016.

III. Presented at the CPUT Language Across the Curriculum Colloquium held at Cape Peninsula University of Technology, Cape Town South Africa on the 21st of July 2016.

IV. Presented at the 13th International Congress on Mathematics Education (ICME13) held at Universität Hamburg, Hamburg Germany from the 24th – 31st of July 2016.

V. Presented at the 25th Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE) Conference held in Bloemfontein, South Africa from the 17th – 21st of January 2017.

VI. Presented at the Association for the Development of Education in Africa (ADEA) Triannale held in Dakar, Senegal from the 14 – 17th of March 2017.

VII. Presented with M. L. A. Le Cordeur at the International Community of Teachers of Mathematical Modelling and Applications (ICTMA) Conference held in Cape Town, South Africa from the 23 – 28th July 2017.

VIII. Presented with M. L. A. Le Cordeur at the Suid-Afrikaanse Akademie vir Wetenskap en Kuns Jaarvergadering en Simposium held in Pretoria, South Africa from the 27 – 29th September 2017.

Journal Paper

IX. Tshuma, L. & Le Cordeur, M. L. A. (2017). Taal as hulpbron in Intermediêre Fase wiskunde-onderrig in die Oos-Kaap: op soek na ’n effektiewe pedagogiek vir wiskunde-onderrig. Language as a resource in intermediate phase Mathematics instruction. Tydskrif vir Geesteswetenskappe/ *Journal of Humanities*. September 2017.

Book Chapters

X. Submitted a chapter for inclusion in the AIMSSEC / Cambridge University Press Mathematical Thinking in the Upper Primary Book Series:

- Language as a resource in mathematics
  NB*: Book to be published in 2018.*

XI. Submitted a chapter for inclusion in the Mapungubwe Institute for Strategic Reflection (MISTRA) Books.

- Language as a resource in Intermediate Phase mathematics Instruction
  NB*: Book to be published in 2017.*

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To Dr Nick Taylor, Ms Annesha Mayet and Mr Double-Hugh Marera at Joint Education Services (JET) for their assistance with the Teacher Language Proficiency and Mathematics Word Problem Assessments and the descriptive analysis of them; and to Professor Dan Nel at Stellenbosch University who advised and handled the statistical analysis component of the study from the design of the quantitative data-capturing templates to the analysis of the voluminous data, I am grateful for your invaluable contribution to the study.

To the Director of AIMS South Africa, Professor Barry Green, the Academic Manager of AIMSSEC, Dr Barrie Barnard, and the Principal Investigator of the AIMSSEC / EU Formative Assessment in Science and Mathematics Education (FASMED) Project, Dr Marie Joubert, who provided funding for fieldwork trips and travel to local, regional and international conferences to share my ideas with fellow researchers in the broader field of language in primary mathematics education; without their generous financial support this study would not have materialised.

Since the study is drawn on my teaching experiences at AIMSSEC, I would like to extend my deepest gratitude to the Eastern Cape Department of Education officials, the IP Mathematics teachers in the province and IP Mathematics teacher educators from different universities in the country who were participants in this research; for sharing your most valuable experience, knowledge, perceptions and insights, without which this study would not have materialised.

To the language practitioner who edited the thesis, Professor Edwin Hees, and to Iain Carson, who read all the chapters of the study, thank you for smoothening the rough edges to make the thesis a coherent piece of work.

To my sisters Nomathemba and Sipho, my brothers Mthulisi, Thabani, Mandla and Vusa and the wider Tshuma family, thank you for the consistent love and support. As with all successes in life, this study would not have materialised without the concern and encouragement of those dearest to me, including friends like Sikhumbuzo Dube.

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LIST OF ABBREVIATIONS and ACRONYMS

AIMS	African Institute for Mathematical Sciences
AIMSSEC	African Institute for Mathematical Sciences Schools Enrichment Centre
AMESA	Association of Mathematics Educators of South Africa
ANA	Annual National Assessment
BICS	Basic Interpersonal Communication Skills
CALP	Cognitive Academic Language Proficiency
CAPS	Curriculum and Assessment Policy Statements
CPTD	Continuing Professional Teacher Development
CSC	Centre for Statistical Consultation
CUP	Common Underlying Proficiency
DBE	Department of Basic Education
DHET	Department of Higher Education and Training
DoE	Department of Education
ECDoE	Eastern Cape Department of Education
ELL	English Language Learners
FET	Further Education and Training
FP	Foundation Phase
INSET	In-service Education and Training
IP	Intermediate Phase
ITE	Initial Teacher Education
JET	Joint Education Trust
LiEP	Language in Education Policy
LoLT	Language of Learning and Teaching
MRTEQ	Minimum Requirements for Teacher Education Qualifications
NEEDU	National Education Evaluation and Development Unit
NCS	National Curriculum Statement
NCTM	National Council of Teachers of Mathematics
SACE	South African Council for Educators
SACMEQ	Southern and Eastern African Consortium for Monitoring Educational Quality
SAQA	South African Qualifications Authority
SASL	South African Sign Language
SGB	School Governing Board
SP	Senior Phase
STEM	Science, Technology, Engineering and Mathematics
SUP	Separate Underlying Proficiency
TLDCIP	Teaching and Learning Development Capacity Improvement Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation

LIST OF ACRONYMS: Teacher Education Qualifications in South Africa

ABET	Adult Basic Education and Training
ACE[1]	Advanced Certificate in Education
ACT	Advanced Certificate in Teaching
ADE	Advanced Diploma in Education
BEd	Bachelor's Degree in Education
MEd	Master's Degree in Education
NPDE	National Professional Diploma in Education
PGCE	Postgraduate Certificate in Education
PTD	Primary Teacher's Diploma
STD	Secondary Teacher's Diploma

LIST OF ACRONYMS: Universities in South Africa

CPUT	Cape Peninsula University of Technology
CUT	Central University of Technology
DUT	Durban University of Technology
MEDUNSA	Medical University of Southern Africa
MUT	Mangosuthu University of Technology
NMMU	Nelson Mandela Metropolitan University
NWU	North-West University
RU	Rhodes University
SPU	Sol Plaatje University
SU	Stellenbosch University
TUT	Tshwane University of Technology
UCT	University of Cape Town
UFH	University of Fort Hare
UFS	University of the Free State
UJ	University of Johannesburg
UKZN	University of KwaZulu-Natal
UL	University of Limpopo
UMP	University of Mpumalanga
UNISA	University of South Africa
Univen	University of Venda
UP	University of Pretoria
UWC	University of the Western Cape
UZ	University of Zululand
VUT	Vaal University of Technology
Wits	University of the Witwatersrand
WSU	Walter Sisulu University

[1] The Advanced Certificate in Education (ACE) was phased out in 2014.

CHAPTER 1

GENERAL INTRODUCTION

1.1 Introduction

This chapter provides the background and context of the current study, which focuses on teacher language competencies in English, the language prescribed for teaching at upper primary school level. The goal of the study was to explore existing relationships between teacher English language competency and mathematics instruction in under-resourced communities in the Eastern Cape Province of South Africa. The research aims and questions that provide the focus for this study are presented, followed by an overview of the conceptual frameworks guiding the study. The research design is based on the interpretivist-constructivist paradigm. This introduction concludes by providing an outline of all the chapters, before listing a glossary of terms that are repeatedly used in the study.

1.2 Background

The quality of South African mathematics education is significantly low (Global Competitiveness Report for the World Economic Forum 2013/2014; TIMSS, 2013). Reasons cited for the low quality of mathematics education include factors such as misguided foci of assessment, curriculum not being fit for purpose, mathematics being a difficult subject, negative societal attitudes towards mathematics, the quality of teaching being substandard and poor competency in the Language of Learning and Teaching (LoLT). According to van Staden and Bosker (2014: 2), the poor performance of South African learners as shown in international comparative studies stems from, among other things, poor communication between learners and teachers in the LoLT. Of the various reasons cited, this study highlights mathematics teachers' competency in English, specifically in the Intermediate Phase years, as one of the most significant predictors of performance in mathematics in relation to the future development of the quality of the South African education system. The study analyses the relationship between language competency and the delivery of mathematics content; this analysis is intended to inform curriculum design so that primary school mathematics teachers are linguistically equipped with skills to effectively deliver content in the prescribed language of instruction.

The five major components of the South African education system are: early childhood development, ordinary school education, special needs education, further education and training colleges, and universities. Of these, the largest is ordinary school education, which extends from Grade R (reception year) to Grade 12. Between Grade R and Grade 12 there are four phases: Foundation Phase (FP) consisting of Grades R to 3, Intermediate Phase (IP) consisting of Grades 4 to 6, Senior Phase (SP) consisting of Grades 7 to 9, and the Further Education and Training (FET) Band consisting of Grades 10 to 12. Figure 1.1 illustrates the distribution of learners in each of these phases in 2013.

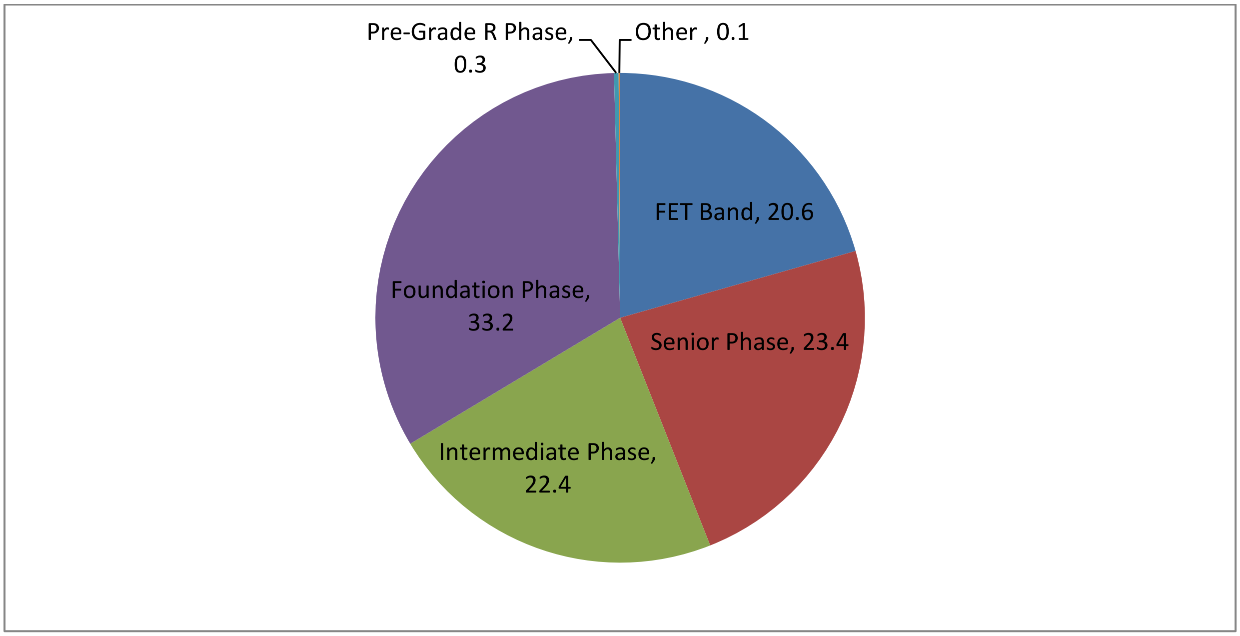
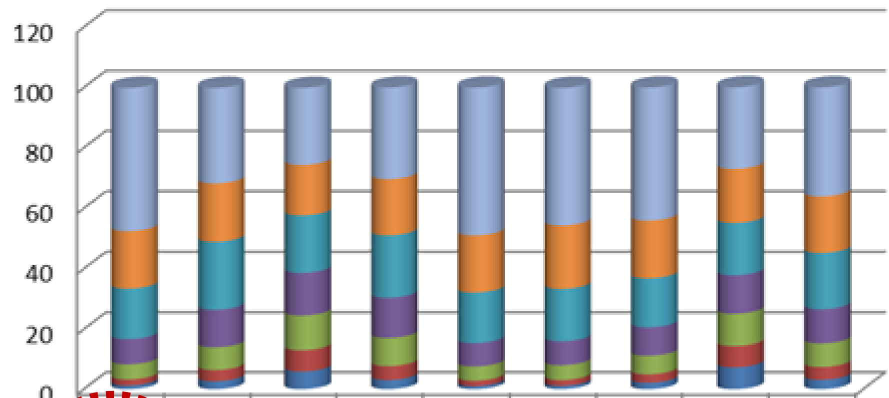


Figure 1.1: Percentage distribution of learners in ordinary schools by phase in 2013 (DBE, 2015)

Since 2000 there have been several initiatives internationally to improve the quality of education, but still education for all has not been achieved yet (Adesina, 2017). Similarly, various stakeholders in the South African education system have made efforts to improve the quality of learning and teaching in the FET and FP years, with little attention being devoted to the IP years, although it is during these years that a number of significant changes take place, the foremost being the change in the LoLT. According to Tshabalala (2012: 22), “The majority of teachers and learners in South African schools are not first language speakers of English, and … many learners and teachers are not fluent in English”. However, from the IP level upwards, the LoLT in 80% of the ordinary schools in all subjects, including mathematics, is English.[2] One of the negative effects of poor mastery of the English language by both learners and teachers is that teaching and learning as well as assessment are compromised.

[2] English- and Afrikaans-speaking learners learn in their home language from Grade 1 to Grade 12 and do not switch in Grade 4.

According to DBE (2015), 22.3% of the nation's ordinary schools are located in the Eastern Cape Province. The Eastern Cape and Limpopo provinces' Departments of Education were placed under administration in 2011 for poor service delivery, with Mount Frere (Eastern Cape Province) being the lowest performing district in the country. Based on the 2013 Annual National Assessment (ANA) results, the bulk of IP learners in the Eastern Cape Department of Education (ECDoE) attained below adequate achievement levels in mathematics as shown in Figure 1.2:



	EC	FS	GP	KZN	LM	MP	NW	WC	SA
Not achieved	47.5	31.7	25.6	30.4	49	45.6	44.1	27.1	36.2
Elementary achievement	19	19.3	16.7	18.6	18.9	21	19.1	17.9	18.7
Moderate achievement	16.7	22.5	19	20.6	16.7	17.3	16.2	17.3	18.6
Adequate achievement	8.5	12.4	14.1	13.3	7.9	8.1	9.4	12.7	11.3
Substantial achievement	5	7.7	11.5	9.5	4.7	4.9	6.3	10.7	8
Meritorious achievement	2	3.7	7.2	4.6	1.8	1.9	2.8	7.2	4.2
Outstanding achievement	1.2	2.6	5.8	3	1	1.1	2.1	7.2	3.1

Figure 1.2: Percentage of learners in various achievement levels for Grade 6 mathematics by province in 2013 (DBE, 2015)

As illustrated in Figure 1.2, if 47.5% and 19% of the learners are rated as *not achieved* and *elementary achievement* respectively; this implies that approximately 70% of the learners from the Eastern Cape (EC) province are rated below *moderate achievement* levels, and this is a cause for concern.

According to Somyo (2015), "… while there has been an improvement in the quality of education in the Eastern Cape, more needs to be done to address other education-related challenges". This study contends that IP teachers' competency in the LoLT is one of the education-related challenges that impact on learner performance. The study acknowledges the voluminous learner performance analyses that have been undertaken before by different educational stakeholders nationally and internationally; however, the focus will be on teacher competency in the LoLT, particularly in relationship to IP mathematics instruction.

1.3 Motivation for the Research

The researcher is a lecturer in the Advanced Certificate in Education (ACE)[3] and Advanced Certificate in Teaching (ACT) IP mathematics modules to in-service teachers at the African Institute for Mathematical Sciences Schools Enrichment Centre (AIMSSEC). Most of the teachers with whom the researcher is in contact are based in the Eastern Cape, Limpopo and KwaZulu-Natal provinces and are out-of-field, non-specialist teachers recruited into IP teaching positions to alleviate the nationwide shortage of mathematics teachers. The majority of the teachers' proficiency in English, as evidenced in their written assignments, is below average and the study contends this as a reflection of the quality of learning and teaching that takes place in the teachers' classrooms. Howie (2001) and Taylor (2008) believe that "teachers cannot teach what they do not know". Research analysing initial teacher education across five South African universities reveals that "the situation with respect to the language of learning and teaching, predominantly English, is of particular concern" (Taylor, 2015: 23).

This study is motivated by the premise that language plays a crucial role in content delivery. In a mathematics classroom, language is used to construct meaning, to express understanding and to develop mathematical thinking skills. However, there is a danger that this role may be interpreted superficially without taking into consideration some underlying linguistic factors that may be associated with the understanding of mathematics. In the IP years these factors include, among others, the teacher's mastery of the LoLT, the switch from mother tongue instruction at FP to the use of English as the LoLT and the teacher's use of code switching. It therefore follows that for improved mathematics instruction; teachers need first to acknowledge and recognise the importance of language in mathematics learning and teaching, as well as be proficient in the LoLT. Only then can the quality of mathematics instruction improve.

1.4 Statement of the Research Problem

To influence mathematics instruction in a positive way, specific initiatives need to focus on the change in the language of instruction at IP level. Initiatives need to target teachers of

[3] At the end of 2014 the Department of Higher Education and Training phased out the ACE programme and replaced it with the ACT programme. Teachers already registered for the programme during this transition were allowed to complete their studies over the following year.

mathematics with a broader view of developing mathematics teachers who are better able to handle the linguistic barriers currently challenging both teachers and learners in the IP years.

1.4.1 Research Problem

Based on the linguistic competency of IP teachers in mathematics assignments and the deterioration in mathematics performance at the General Education and Training (GET) level, the ACE and ACT lecturers at AIMSSEC are concerned about the state of teaching mathematics using English as the LoLT in the under-resourced ECDoE schools.

1.4.2 Research Aim

The aim of the study is to analyse the relationship between IP teachers' linguistic competencies and mathematics instruction.

1.4.3 Research Objectives

i. To investigate the extent to which proficiency in the LoLT relates to IP mathematics teachers' content delivery.

ii. To investigate the aspects of IP mathematics teacher education focusing on the use of English as LoLT.

iii. To determine the extent to which IP mathematics teachers in the ECDoE schools are proficient in English, the prescribed LoLT.

iv. To investigate the teaching methods currently in use in IP classrooms that may overcome language barriers in the delivery of mathematics.

v. To inform decisions about curriculum design at AIMSSEC for purposes of in-service IP mathematics teacher training in order to empower teachers to effectively overcome language barriers in content delivery.

1.4.4 Research Questions

The central research question to be answered by this study is:

How (if at all) does language competency in the LoLT relate to content delivery by IP mathematics teachers?

To shed light on the central research question and to enable the study to reach out for more information and gain greater insight in order to sufficiently answer the central research question, as well as to achieve the objectives of the study, sub-questions have been formulated.

Research sub-questions

i. To what extent does proficiency in the LoLT relate to IP mathematics teachers' content delivery?

ii. What aspects of IP mathematics teacher education focus on the use of English as LoLT?

iii. To what extent are IP mathematics teachers in ECDoE schools proficient in English, the prescribed LoLT?

iv. How do IP mathematics teachers overcome language barriers in the teaching of mathematics?

v. To what extent do teaching methods currently in use effectively overcome the language barriers in the delivery of IP mathematics?

1.5 Conceptual Framing

Among many frameworks linking the various elements of language and mathematics, the literature describes Gawned 1990's conceptual framework based on a sociolinguistic premise. According to Ellerton and Clarkson (1996: 990), Gawned's framework acknowledges that the LoLT has a particularly important formative effect on the understanding of mathematics and that "mathematical concepts only have meaning within the linguistic and social contexts from which they are derived". Gawned's socio-psycho-linguistic framework will serve as a reference to understand the multifaceted nature of relationships existing between language, mathematics and mathematics education. Other related conceptual frameworks focusing this study are Cummins's (2000) Linguistic Threshold Hypothesis; Ellerton's (1989) Framework for Interpreting Language Factors in Mathematics Learning; Newman's (1983) Approach for Analysing Errors on Written Mathematical Tasks; and Baker's (2011) Pedagogical Translanguaging Theory.

The literature also addresses the challenges faced by teachers who are not fluent in English but use English as a language of instruction. The difficulty of communicating fluently in the prescribed LoLT leads to increased frustration for the teacher, a slow rate of learning, disciplinary problems and teacher-centred instruction (Setati, 1999; Howie, 2003). The prevailing mother-tongue versus second-language instruction debate highlights English as the gateway to global opportunities. Unless policy makers make drastic fundamental decisions, IP teachers will continue to struggle with linguistic barriers in the teaching of mathematics and other subjects. If English is increasingly used as the LoLT, as communities seem to desire, then the necessary support mechanisms – including intensive language training of teachers who will be using English as the LoLT – need to be put in place to facilitate a smooth transition from FP to IP years. The literature will also guide and inform the data collection, analysis and interpretation processes.

1.6 Research Design and Methodology

1.6.1 Research Design

The current study adopts a mixed methods approach situated within the interpretivist-constructivist paradigm, which strategically combines quantitative and qualitative methods, approaches and concepts in order to produce complementary strengths and non-overlapping weaknesses, as suggested by Johnson, Onwuegbuzie and Turner (2007).

1.6.2 Research Methodology

The study uses a convergent parallel model (Creswell & Plano Clark, 2011: 180) in the collection of data in which independent data sets, designed to help answer parallel questions in both the quantitative and qualitative instruments, are collected concurrently, analysed separately and then merged to produce the final findings. The quantitative data collection (questionnaires, language proficiency and mathematics word problem assessments) precedes the collection of the qualitative data (observations and interviews), which seeks to develop an in-depth understanding (Creswell & Plano Clark, 2011; Teddlie & Tashakkori, 2009).

Quantitative data (questionnaires, English language proficiency and mathematics word problem assessments) will be analysed by Stellenbosch University's Centre for Statistical Consultation (CSC). In addition to Stellenbosch University CSC's analyses, data from the English language proficiency and mathematics word problem assessments will be analysed by Joint Education Trust (JET)'s Data Unit Statisticians. Patterns emerging from the two independent analyses of the quantitative data will be merged and compared. Qualitative data (error analysis interviews and classroom observations) will be transcribed by the researcher, and themes emanating from this will be coded using open and axial coding.

1.6.3 Sampling

In order to use the data from the different strands to corroborate, directly compare and relate different sets of findings about the topic, the same respondents are used in both the quantitative and qualitative samples. The quantitative sample is made up of 55 practising IP mathematics teachers from the ECDoE and 10 IP mathematics teacher educators from different university teacher-education departments across South Africa. However, the quantitative sample is much larger than the qualitative sample (10% of the respondents) to enable the researcher to obtain an in-depth qualitative exploration and a rigorous quantitative examination of the topic. All the respondents are a non-probability purposive sample as they are accessible to the researcher, making the recruitment process easy, cost effective and least time consuming.

1.6.4 Validity and Reliability

Administration of JET Education Services assessments used by different universities' education departments will enhance validity, improve reliability and ensure triangulation of results. Using a multi-methods approach will enable corroboration of findings generated from the different data sets and will assist to cross-check the findings of one method with another and thus assist in confirming or challenging the findings with reference to those of other studies, thereby enhancing the integrity and therefore the credibility of the findings.

1.7 Ethical Considerations

Before the study begins, all respondents will be requested to sign a consent form; permission to visit schools and individual teachers for interviews and questionnaires will be sought in advance. An application to carry out the study within the ECDoE will be submitted to the appropriate education authorities as will an application for ethical clearance from the Research Ethics Committee of Stellenbosch University. To ensure that the research is carried out with due consideration of ethical procedures, the rights and identities of all participants in the study will be protected. Personal information of respondents will remain anonymous and all copies of questionnaires and interview audio tapes will be stored in a computer locked by a secret password.

1.8 Chaptering

The study is divided into eight chapters.

Chapter 1: General Introduction

Chapter 2: Theoretical Orientation Regarding Language Competency in Mathematics Instruction

Chapter 3: Language as a Resource in Mathematics Teaching and Learning

Chapter 4: Perspectives on Language Competency and Language of Learning and Teaching Mathematics

Chapter 5: Research Methods

Chapter 6: Quantitative Data Presentation, Analyses and Discussion

Chapter 7: Qualitative Data Presentation, Analyses and Discussion

Chapter 8: General Conclusion, Findings and Recommendations

1.9 Conclusion

The current study intends to broaden and widen the understanding of the relationships between teacher language competency and IP mathematics instruction in under resourced communities of the Eastern Cape Province of South Africa. If in contemporary South Africa there still exists teachers who are not fluent in English but use English as a language of instruction, there is a deficit in the delivery of mathematics content in the IP years; and this study intends to address that deficit. Furthermore, if the linguistic challenges faced by these IP mathematics teachers are not addressed; this too will contribute to far-reaching consequences not only for the education system but also for the calibre of learners produced by these teachers as well as for the general economic growth of the country. The study will inform further research on appropriate interventions to facilitate effective delivery of mathematic content in the prescribed LoLT in the IP years.

1.10 Definitions of Terms

As the terms listed below are used repeatedly in this study, they are explained against the backdrop of the context of this study.

African languages: In this study the term refers to the primary languages spoken by Africans in South Africa. These primary languages are formally called Bantu languages (Adler, 2001: 163 – 166; Essien, 2013).

Bilingual: Refers to one who is proficient in two languages (Adler, 2001: 163 – 166; Essien, 2013; Sibanda, 2014).

Bilingual classroom: Refers to a classroom that includes one or more learners who have varying levels of language proficiency across two languages.

Code switching: Refers to a trait of bilingualism and a form of translanguaging in which there is "juxtaposition within the same speech exchange of passages of speech belonging to two different grammatical systems of subsystems". It refers to the alternating use of two or more languages in the same utterance or conversation (Gumperz, 1982: 59).

Didactician: Refers to teacher educators, including university education lecturers and personnel whose core function is to instruct teachers who may not necessarily be based in university departments of teacher education.

Dual-language education: In South Africa dual-language programmes tend to share the following characteristics: (a) languages are separated during instruction, and (b) both English and non-English speakers are present in nearly balanced numbers (Baker, 2011).

English-language learner (ELL): Refers to a learner who "has sufficient difficulty in the use of English to prevent that individual from learning successfully in classrooms in which the language of instruction is English" (Kindler, 2002: 9). In some cases **second-language learners** (learners who are taught mathematics in a language other than their home or first language) is used instead of English-language learners; in the current study the terms are used interchangeably.

First language: Refers to a language that a child acquires from birth and in which he or she is most proficient. In some cases, *mother tongue* and *home language* are used instead of first language. In the current study the terms are used interchangeably (Adler, 2001: 163 – 166; Essien, 2013).

Foreign language: Refers to any language which learners are unlikely to hear or read outside the classroom in which they are learning it, because it is not in use in the wider community (Adler, 2001: 163 – 166; Essien, 2013).

Indigenous language: Refers to a language that originated and is native to a specified place or region and spoken uniquely by *indigenous* people of that place or region. In some cases **indigenous African language** (IAL) is used in the current study for the sake of clarity.

Language of learning and teaching (LOLT): Refers to the language medium in which learning and teaching, including assessment, take place (DBE, 2010).

Language-minority learners: Refers to learners from homes where the primary language spoken is not English (Menken & Antunez, 2001).

Language competence: Refers to an individual's ability to speak, read, write, interpret and generally use a language well and efficiently. It is the quality of being adequately or well qualified to use a language for both basic communication tasks and academic purposes (DBE, 2010).

Language proficiency: Refers to an individual's level of competence to use a language for both basic communication tasks and academic purposes; proficiency also refers to the quality of great facility and competence (DBE, 2010).

Linguistic competence: Refers to an individual's implicit internalised knowledge of the rules of a language (DBE, 2010). In the current study the terms language competency and linguistic competency are used interchangeably.

Learners: Refers to school children.

Mathematics register: Refers to the meanings of the natural language used in mathematics. A mathematics register is more precise than the natural language itself, because the meanings of the terms are much narrower in scope and hence more precise. Mathematical terms give rise to "an almost totally non-redundant and relatively unambiguous language" (Brunner, 1976: 209).

Multilingual: Refers to a person who is competent in more than two languages. Many South Africans, whose main language is not English or Afrikaans, speak three or more languages. Generally in South Africa the majority of the population is described as multilingual rather than bilingual.

Multilingual classroom: Refers to a situation where learners bring into the class a range of home languages. The term does not imply that all learners are multilingual. The meaning in the current study is that there are more than two languages used in the classroom. Thus, a multilingual class in this context refers to a class where learners (and teachers) come to class with different levels of proficiencies in two or more languages, and where mathematics is taught and learnt in a language other than the first or home language of the majority of learners. This understanding of multilingualism as encompassing bilingualism is adopted in the current study.

Official languages: Refer to the eleven languages which are stipulated and recognised in the South African Language Policy, namely *English, Afrikaans, isiNdebele, isiXhosa, isiZulu, Sepedi, Sesotho, Setswana, siSwati, Tshivenda* and *Xitsonga.*

Psycholinguistics: Refers to the study of psychological states and mental activity associated with the use of language (Psycholinguistics, 2013).

Register: Refers to a "set of meanings that is appropriate to a particular function of language, together with the words and structures which express these meanings. We can refer to a 'mathematics register', in the sense of the meanings that belong to the language of mathematics (the mathematical use of natural language, that is: not mathematics itself), and that a language must express if it is being used for mathematical purposes" (Halliday, 1975: 195).

Sociolinguistics: Refers to an orientation to the study of language that stresses the interrelationship between language and social life rather than focusing narrowly on language structure (Sociolinguistics, 2004).

Translanguaging: Refers to "the process of making meaning, shaping experiences, understandings and knowledge through the use of two languages" (Baker, 2011: 288).

CHAPTER 2

THEORETICAL ORIENTATION REGARDING LANGUAGE COMPETENCY IN MATHEMATICS INSTRUCTION

2.1 Introduction

This chapter provides the conceptual framing that informs the focus on the language competency of IP mathematics teachers. Many studies only outline the characteristics, processes and applications of learner language competency, but very few focus on the language competency of mathematics teachers, who are direct and indirect products of the South African education system. While the literature outlines various theories influencing the relationship between language competency and mathematics instruction, this chapter highlights the key conceptual frameworks employed in this study in order to explore the needs of IP mathematics teachers in terms of language usage and development, which in turn determine the quality of their instruction.

2.2 Conceptual Frameworks relevant to the study

This section describes the conceptual frameworks for investigating language issues in mathematics that can be employed in diverse language contexts, specifically here the South African context; they can help to interpret the findings emerging from a particular context, such as the Eastern Cape Province, hence the significance of this study.

These frameworks are unique in that they draw on and combine a number of different areas such as psycho- and socio-linguistics, mathematics registers, and pedagogical and cultural factors as illustrated in Table 2.1. The conceptual frameworks presented can be employed in order to investigate other bilingual and multilingual learning contexts. Given the increasing number of ELLs receiving education in a dominant language that is not their own first language, these findings are important for mathematics education (Adler, 2001).

The conceptual frameworks grounding the study are Cummins's (2000) *Linguistic Threshold Hypothesis*; Ellerton's (1989) *Framework for Interpreting Language Factors in Mathematics Learning*; Gawned's (1990) *Socio-Psycho-Linguistic Model*; Newman's (1983) *Approach for Analysing Errors on Written Mathematical Tasks*; and Baker's (2011) *Pedagogical Translanguaging Theory*. These conceptual frameworks will be discussed individually and their specific contribution to this study indicated.

2.2.1: Linguistic Threshold Hypothesis: Cummins (2000)

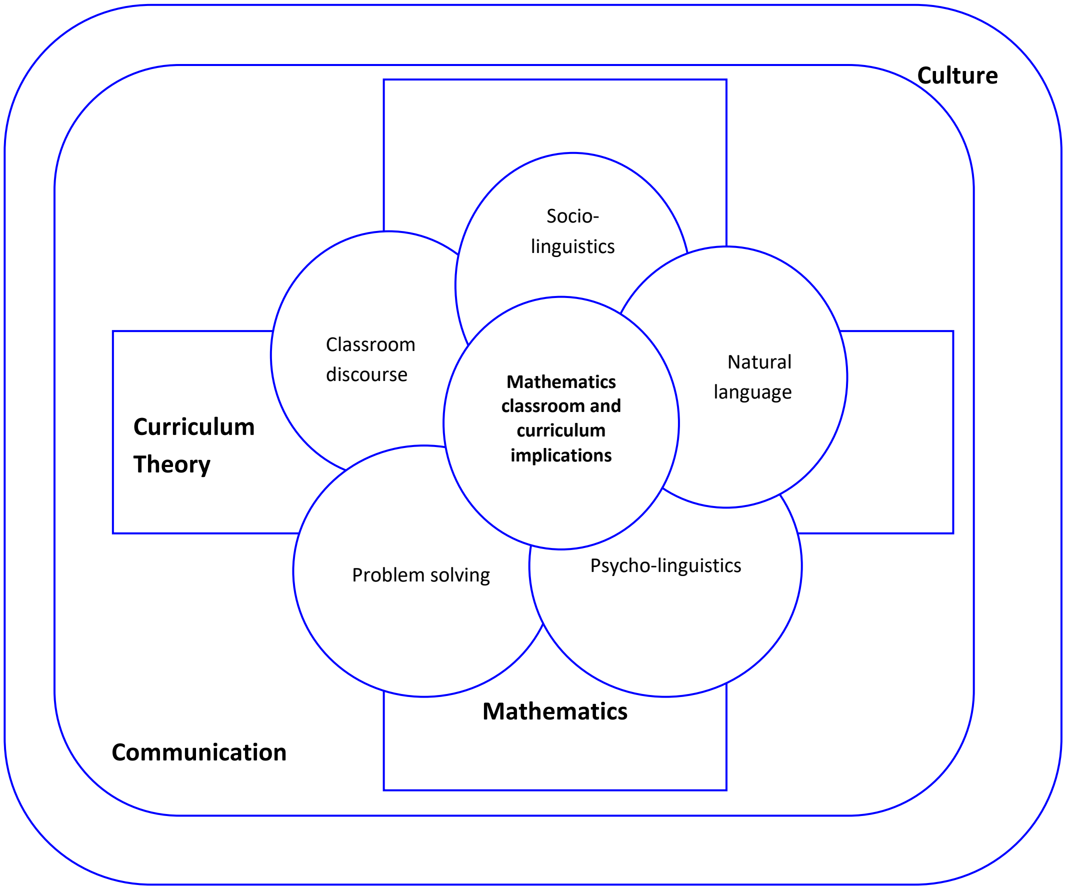
The broad theoretical framework referred to in this study is Cummins's threshold hypothesis (Cummins, 2000), which indicates that a threshold level of second language is necessary for the home-language reading skills and knowledge to transfer to second-language reading. A lack of second-language knowledge 'short circuits' the use of the home-language linguistic skills (Pretorius & Mampuru, 2007: 42; Bernhardt & Kamil, 1995: 17). This hypothesis assumes that language proficiency is the key factor in reading activities and, therefore, for one to be able to read a language, one needs to know the language at a certain level of proficiency. The current study contends that this seemingly obvious aspect of language competency plays an important role in mathematics teaching (and learning) and should not be neglected.

The relevance of the linguistic threshold hypothesis on the research design and methodology employed by this study is that it takes into account that the majority of the IP mathematics teachers referred to in this study are supposedly bilingual. The language they are prescribed to teach in, namely English; is not their home language, and it is also not the home language of the majority of the learners they teach. Cummins's hypothesis recognizes the importance of investigating both languages in which teaching and learning take place and their association to the quality of mathematics learning. Given that the IP mathematics teachers in this study have to manage the transition from mathematics instruction through the medium of isiXhosa to instruction through the medium of English, this hypothesis best reflects the situation present in the Eastern Cape Province of South Africa. The language theories, cultural and pedagogical perspectives, and the mathematics register to be discussed in Chapters 3 and 4 were employed as theoretical tools for the analysis and interpretation of the findings emerging from the current study. Given the diverse nature of these tools, they highlight the complexity of language competency and how it relates to mathematics instruction. However, a number of other key theoretical frameworks have influenced the design of this study and the analysis of the data gathered.

2.2.2: A Framework for Interpreting Language Factors in Mathematics Learning: Ellerton (1989)

Ellerton's framework for interpreting language factors in mathematics learning shows the need to link the various aspects of language factors in mathematics learning; this framework was employed in this study to interpret the outcomes of the data collected from both the IP mathematics teachers and teacher educators within the South African education system (Ellerton, 1989). The framework can be viewed from a 3-dimensional perspective as illustrated in Figure 2.1.

Figure 2.1: A framework for interpreting language factors in mathematics learning (Ellerton, 1989)



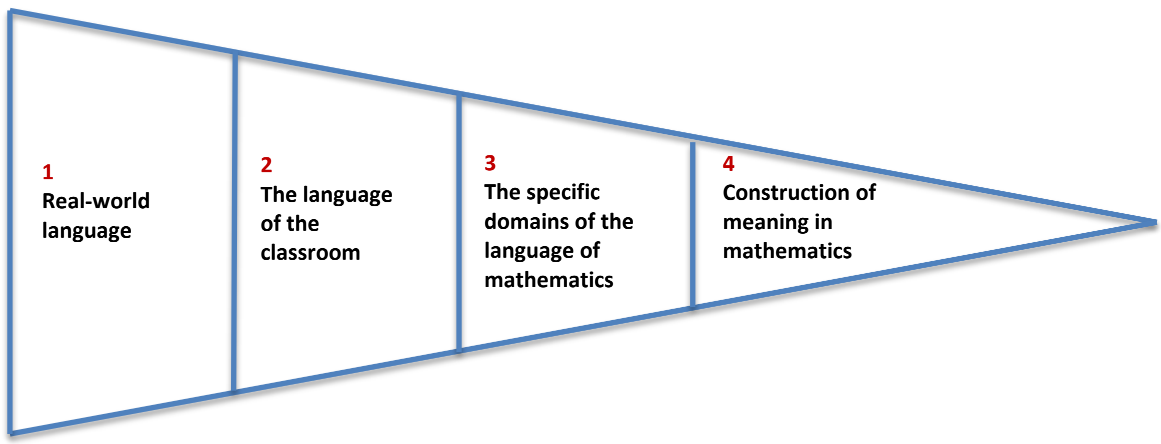
Viewing the framework from a 3-dimensional perspective implies viewing mathematics instruction holistically. When assessing the framework holistically and from an all-encompassing perspective, it can be seen that culture occupies the entire classroom, and that communication within this culture is of key importance. Language, thinking, and mathematics learning and understanding cannot be discussed solely from a cognitive perspective. Cultural and pedagogical influences also need to be explored, given the central role of language in both of these phenomena (Ní Ríordáin, 2011).

Sociolinguistics is defined as an orientation to the study of language that stresses the interrelationship between language and social life, rather than focusing narrowly on language structures (Sociolinguistics, 2004); psycholinguistics is defined as the study of the psychological states and mental activity associated with the use of language (Psycholinguistics, 2013). Communication and language become central factors in matters such as sociolinguistics, natural language, psycholinguistics, problem solving and classroom discourse, all of which intersect with each other, as well as with most parts of the framework. This model indicates the centrality of the teacher, the mathematics classroom and the curriculum in acknowledging the importance of language issues in mathematics education. These were key factors identified by the study in the transition from FP to IP level in the ordinary school system.

2.2.3 A Socio-Psycho-Linguistic Model: Gawned (1990)

Gawned's socio-psycho-linguistic framework is based on a model of language learning (Gawned, 1990; Ellerton & Clarkson, 1996). The current study employs the socio-psycho-linguistic framework as it best reflects the nature of interaction between natural language and the mathematics register, and the way that language can relate to mathematics learning and understanding as illustrated in Figure 2.2.

Figure 2.2: A summary of the socio-psycho-linguistic model (Gawned, 1990)



Particularly important in Gawned's model is its acknowledgement that the language of the classroom has a great effect on learners' understanding of mathematics, and that each classroom has a unique culture of its own (Gawned, 1990). Gawned's model also discusses the discourse patterns found in mathematics classrooms. These discourse patterns tend to be teacher-centred, dominated by rules, and tend to function within strict relationships. Thus, this framework reflects the nature of mathematics classrooms and the way that language plays a key role in learning, particularly the language of the teacher and the textbook, while also highlighting the cultural influences on mathematics education. This framework has facilitated the design of the interview schedule for this study and it will be used to interpret and illustrate the relationships between key findings, in particular the findings emerging from the interviews conducted from the qualitative sample of IP mathematics teachers.

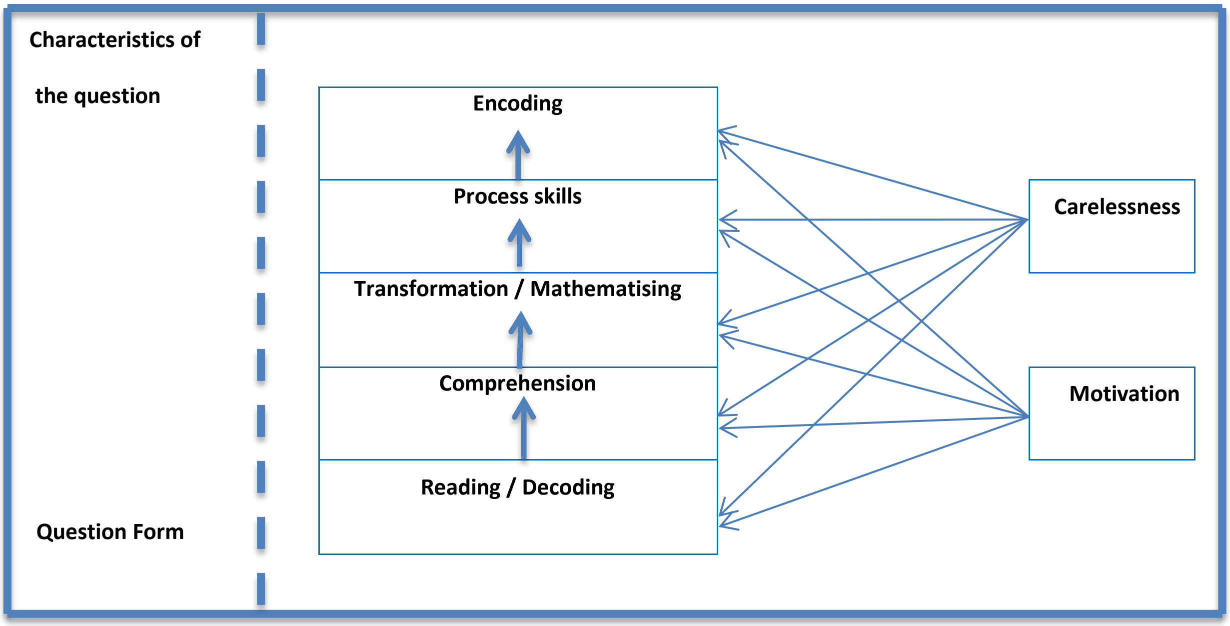
Both Ellerton's (1989) and Gawned's (1990) frameworks provide a theoretical structure for the design methodology and analysis of data collected in relation to language competency and mathematics education in South Africa. These frameworks provide a rationale for this study, as they demonstrate how language and the language of instruction are key areas in the learning and teaching of mathematics. Thus, this has implications for the mathematics learning and teaching process through the medium of a second language, particularly through the use of English as a LoLT.

Viewing mathematics instruction, particularly at the IP level, as a socio-psycho-linguistic process emphasises the construction of meaning and draws upon an individual's unique constellation of prior knowledge, experience, background and social contexts. Thus the socio-psycho-linguistic process is holistic instead of being focused on discrete parts. If teachers understand mathematics instruction as a socio-psycho-linguistic process, then they will be in a better position to incorporate the linguistic elements of mathematics instruction into the classroom practice, while also emphasizing the construction of meaning within the whole mathematics classroom culture. Practice has shown that teachers are inclined to teach the way they were taught mathematics at school and tap into the way they were taught to teach mathematics. Therefore, if mathematics teacher educators model mathematics instruction as a socio-psycho-linguistic process, it becomes easier for mathematics teachers to adopt the same practice in their classrooms. As classroom teachers teach mathematics as a socio-psycho-linguistic process, a component of their learners who will end up in teaching and academic careers will also be inclined to adopt that method. As this approach becomes cumulative and widespread, it could revolutionise the way mathematics is taught and learned.

2.2.4 An Approach to Analysing Errors on Written Mathematical Tasks: Newman 1983

Newman's approach to analysing errors on written mathematical tasks focuses on the written aspects of mathematics and their links with language proficiency (Newman, 1977, 1983). Her framework for interrogating mathematical tasks is of great significance, considering that teachers and their learners continuously encounter written mathematical tasks when dealing with textbooks, exams and other forms of external assessments. She states that when confronted with a written mathematical word problem, a person needs to go through a fixed sequence of events, as illustrated in Figure 2.3, in responding to the problem, namely *reading* or *decoding*; *comprehension*; *transformation* or *mathematising*; *process skills*; and *encoding*.

Figure 2.3: The Newman hierarchy of causes of errors (Newman, 1977, 1983)



Newman's approach draws attention to the importance of language factors in mathematics teaching and learning. Newman's approach is based on her original study conducted with Grade 6 learners and was further developed by Casey (1978), Clements (1980), Clarkson (1980) and Watson (1980), who depicted the hierarchy as a non-prescriptive but useful tool in teaching mathematics problem solving. The approach reveals that 50% of errors made in mathematics tasks occur before the application of process skills. With this in mind, mathematics teachers need to pay particular attention to whether the learners are able to comprehend the mathematics word problems they are tasked to solve; so should mathematics teacher educators in teacher education institutions.

Newman also described an additional category classified as *carelessness* or *imprecision* of errors resulting from unknown factors. In addition to carelessness, a learner who has read, comprehended and worked an appropriate strategy for solving a mathematics problem might be discouraged from proceeding further because of a lack of *motivation*. To identify errors made in written mathematical tasks and to reduce the occurrence of careless mistakes and lack of motivation, the Newman approach recommends that the following steps be implemented:

- Read the question (*Reading / Decoding*);
- What is the question asking you to do? *(Comprehension)*;
- Suggest a method that can be used to find an answer to the question. *(Transformation / Mathematising)*;
- Explain how you worked out the answer, or what you are doing to work out the answer *(Processing)*;

- Write down the answer to the question *(Encoding)*.

Thus the Newman procedure involves an oral question-and-answer session after failing to solve mathematical questions, so as to determine sources of difficulty encountered while answering. Application of the Newman's approach in this study involves interviewing the respondents, asking them questions with the intention of establishing whether they can carry out the following steps: read the question, comprehend what they have read, conduct an appropriate mental transformation from the words of the problem to the choosing of a mathematical strategy, employ the process skills required by the selected strategy, and encode the answer in an appropriate written form. This framework provides justification for employing mathematics word problems as a means of assessing mathematics performance, while addressing potential language issues encountered when confronted with mathematics instruction using English as the LoLT.

2.2.5 Pedagogical Translanguaging: Baker (2011)

The term 'translanguaging' was created by Cen Williams in 1984, drawing on the Welsh word *trawsiethu* to name a pedagogical practice which switches the language mode in bilingual classrooms. This is done by assigning different languages to the lesson's input (reading/listening) and output (speaking/writing), and this is systematically varied. Translanguaging is "the process of making meaning, shaping experiences, understanding and knowledge through the use of two languages" (Baker, 2011: 288). Translanguaging is based on the observation that learners pragmatically use their two languages inside and outside the classroom in order to construct understanding (Probyn, 2015; Baker, 2011; García, 2009).

Translanguaging fits on the spectrum of work on multilingualism. Included in this range of language activity are code switching, translation and translanguaging. Code switching is usually a relatively short move from the LoLT to the home language of learners and then a switch back to the LoLT. Translation usually entails a repetition of an oral or written text in the more accessible home language of learners (Probyn, 2015). Both of these practices are responsive rather than planned strategies, usually regarded as temporary excursions from the monolingual ideal. In some cases, use of the learners' home language instead of the LoLT is viewed as illicit or transgressive (Probyn, 2001, 2009, 2015). Therefore, translanguaging goes beyond code switching and translation, but includes both. It can be used as a pedagogically sensitive tool to systematically promote learning (Heugh, 2015; Lewis, Jones & Baker, 2012; Probyn, 2015). Both languages are used in an organised way to mediate understanding and learning (Baker, 2011; Garcia & Wei, 2015; Heugh, 2015). Thus, the teacher incorporates into their planning which, why, when and how they are going to use each of the two languages for the purposes of assisting the learners to better understand the concepts taught.

García (2009) propounded translanguaging as a hybrid language use that is systematic, strategic, affiliative and sense-making. Thus, translanguaging uses both languages to purposefully complement one another in knowledge transfer. To connect translanguaging to Cummins's bilingual theoretical frameworks, Baker (2011) notes four advantages of translanguaging:

- Promoting a deeper and fuller understanding of the subject matter. In order to read and discuss a topic in one language, and then to write about it in a different language, the subject matter has to be processed and understood, since learners' prior knowledge of, as well as the interdependence of, their two languages is utilized;
- Helping bilingual learners develop oral communication and literacy in their new, weaker language, since they have to work in their two languages;
- Facilitating home-school cooperation – learners are able to ask their minority language parents for help in solving their assignments; and
- Developing English-language learners' competence and content learning at the same time.

Thus, translanguaging allows the integration of learners with different levels of second-language competency, and consequently their cognitive academic language proficiency (CALP) and basic interpersonal communication skills (BICS) can develop jointly. Thus, translanguaging can occur in any educational setting: bilingual, English Second Language or mainstream. It can serve as a scaffold for learning English (Baker, 2011). It can also be a powerful way for learners to use their languages as a resource for their learning.

2.3 Relevance of key conceptual frameworks to the current study

The relationship between the research questions, the theoretical frameworks supporting the investigation of these questions, and the significant analytical lenses employed in the analysis of the data and the interpretation of findings is summarised in Table 2.1.

Table 2.1: Relevance of key conceptual frameworks to the study

Research Question	Key Conceptual Framework (CF)	Influence of CF on Research Design	Influence of CF on Analysis	Significant Tool Employed
1	Cummins (2000) Newman (1983)	Language proficiency assessments Mathematics word problem assessments Questionnaires Interviews	• Investigates if there is a relationship between mathematics performance and language proficiency. • Investigates where IP mathematics teachers encounter difficulties with mathematics through the medium of English and the language use they employed in mathematical problem solving.	○ Cummins's Developmental Interdependence Hypothesis (Cummins, 2000) ○ Basic Interpersonal Communication skills (BICS) vs Cognitive Academic Language Proficiency (CALP) ○ Psycholinguistic theories
2	Cummins (2000)	Language proficiency assessments	• Investigates the English language proficiencies of IP mathematics teachers. • Identification of	○ Second language acquisition ○ Cummins's Developmental Interdependence Hypothesis.

	Gawned (1990)		potential sources of difficulty associated with mathematics word problems in relation to Standard English language and mathematics register.	○ Psycholinguistic theories
3	Newman (1983) Gawned (1990)	Mathematics word problem assessments Interviews	• Assesses the mathematics word problems they experience most difficulty with and the potential sources of difficulty within these problems. • Investigates where IP mathematics teachers understanding breaks down when engaged in mathematics word problem solving.	○ The mathematics register ○ Language features that impede learning ○ Newman hierarchy of causes of errors (Newman, 1977)
4	Ellerton (1989)	Questionnaire Interviews	• Examines pedagogical and cultural influences on IP mathematics teachers' conceptions of mathematics and how they influence the transition to English-medium	○ Understanding and culture ○ Cultural issues ○ Types of mathematical understanding

	Gawned (1990)	Questionnaire Interviews	education.	○ Language and understanding
5	Ellerton (1989) Gawned (1990) Baker (2011)	Classroom observations	• Examines teaching methods in use and how teacher's English linguistic practices influence content delivery	○ Pedagogical aspects

The different theoretical lenses and intellectual tools referred to in Table 2.1 are further discussed in the literature reviewed in Chapters 3 and 4 of the study.

2.4 Conclusion

The conceptual theories reviewed in this chapter foreground the discussion on how second-language learning may be integrated with mathematics learning in order to assist ELLs to achieve their academic goals (Cummins, 2000; Ellerton, 1989; Gawned, 1990; Newman, 1983; Baker, 2011). Emerging from the conceptual frameworks discussed in this chapter is the urgent requirement for a transition in language from traditional to innovative forms, in order to motivate IP mathematics teachers and maintain their interest in developing communicative competences for the improvement of their quality of instruction.

Although the theories referred to in this chapter have been widely applied on learners, this study draws upon the application of these theories for guiding the development of teacher language competencies for the purposes of improving their mathematics instruction. Thus, didacticians, teacher educators, educational linguists and teacher education curriculum developers are hereby challenged to provide adequate linguistic preparation and support to pre-service as well as in-service mathematics teachers for the cultivation of language skills that can be used to improve mathematics instruction. Teachers who are confident and proficient in the LoLT are better able to deal with the linguistic needs of IP learners in the South African education system whose language of instruction has just changed from home language to second language, and these teachers are therefore most likely to produce better results.

CHAPTER 3

LANGUAGE AS A RESOURCE IN MATHEMATICS TEACHING AND LEARNING

3.1 Introduction

The current study seeks to reveal the relationships between language competency and mathematics instruction. Some of these relationships may be identified in the role of language in mathematics teaching and learning. This chapter thus presents specific background knowledge on how language can be used as a resource in mathematics instruction to enhance an understanding of the connection between language and mathematics for the purpose of meeting the needs of English Language Learners (ELLs) more effectively. The chapter briefly describes mathematics as a language, the mathematics register and the linguistic features associated with mathematics teaching and learning. The chapter also outlines different strategies that can be used to teach the mathematics register in a multilingual setting and concludes by presenting other common factors that relate to mathematics teaching and learning in a second language, including the use of code switching.

3.2 Mathematics as a language

Durkin and Shire (1991: 3) state that mathematics education begins and proceeds in a language, it advances and stumbles because of language, and its outcomes are often assessed in language. Although this observation can be applied to most of the ordinary school curricula, the interweaving of language and mathematics is particularly intricate and this chapter accounts for some aspects of this complex interrelationship as a way of addressing one of the many challenges posed by mathematics to learners and their teachers.

Language and communication are essential elements of teaching and learning mathematics, and this is evident from research carried out in bi/multilingual settings (Gorgorió & Planas, 2001). Language is employed as a communication tool and facilitates the transmission of (mathematical) knowledge, values and beliefs, as well as cultural practices. Language is also the channel of communication in a mathematics classroom as language provides the tool for teacher-learner interaction (Smith & Ennis, 1961). Competence in the language of communication/interaction is a prerequisite for engagement in the learning process. In South Africa the English language plays a significant role in the transition from mother tongue to English-medium mathematics instruction. For learners of mathematics, this has two dimensions in that they are required to have competence in the language of instruction and in the language of mathematics (specifically the mathematics register). The development of mathematical learning and understanding is therefore interrelated with language capability.

Language is defined as the formal organisation of symbols, sounds and gestures used to communicate ideas, thoughts and feelings to create meaning (Ellerton & Wallace, 2004: 1). Thus mathematics appears to be a type of formal language as it too consists of symbols, sounds and gestures that are used to communicate and formulate mathematical concepts. Sternberg (2004) identifies six distinctive properties of language:

1. **Communicative**: language permits us to communicate with one or more people who share our language;
2. **Arbitrarily symbolic**: language creates an arbitrary relationship between a symbol and its referent: an idea, a thing, a process, a relationship, or a description;
3. **Regularly structured**: language has a structure; only particularly patterned arrangements of symbols have meaning, and different arrangements yield different meanings;
4. **Structured at multiple levels**: the structure of language can be analysed at more than one level (such as in sound, in meaning units, in words or in phrases);
5. **Generative, productive**: within the limits of a linguistic structure, language users can produce novel utterances, and the possibilities for creating new utterances are virtually limitless;
6. **Dynamic**: languages constantly evolve.

The above properties are applicable to mathematics as well and to the concept of mathematics as a language, because mathematics allows people to communicate, it uses symbols; it is structured, generative and dynamic.

3.2.1 But is mathematics truly a language?

Perhaps because mathematics is associated with written work, involves symbols as opposed to words and is communicated on paper rather than orally, it is difficult to perceive it as a language (Pimm, 1987). Pimm (1987: 75) argues that it is not, since there is no one group of people for whom mathematics is their first language. Moschkovich (2012) defines the language of mathematics as the communicative competence necessary and sufficient for competent participation in mathematical discourse practices.

One way of describing the relationship between a natural language like English and mathematics is in terms of the linguistic notion of register (Durkin & Shire, 1991: 17). Therefore mathematical language is considered a distinct ‘register’ within a natural language like English, which is described as "a set of meanings that is appropriate to a particular function of language, together with the words and structures which express these meanings" (Halliday, 1975: 65). Therefore, one function of mathematics as a language can be described as the expression of mathematical ideas and meanings leading to the development of a mathematical register.

3.3 The mathematics register

Mathematics has a particular way of using language and its own particular way of expressing ideas, which is termed the mathematics register (Lee, 2006; Pimm, 1987).

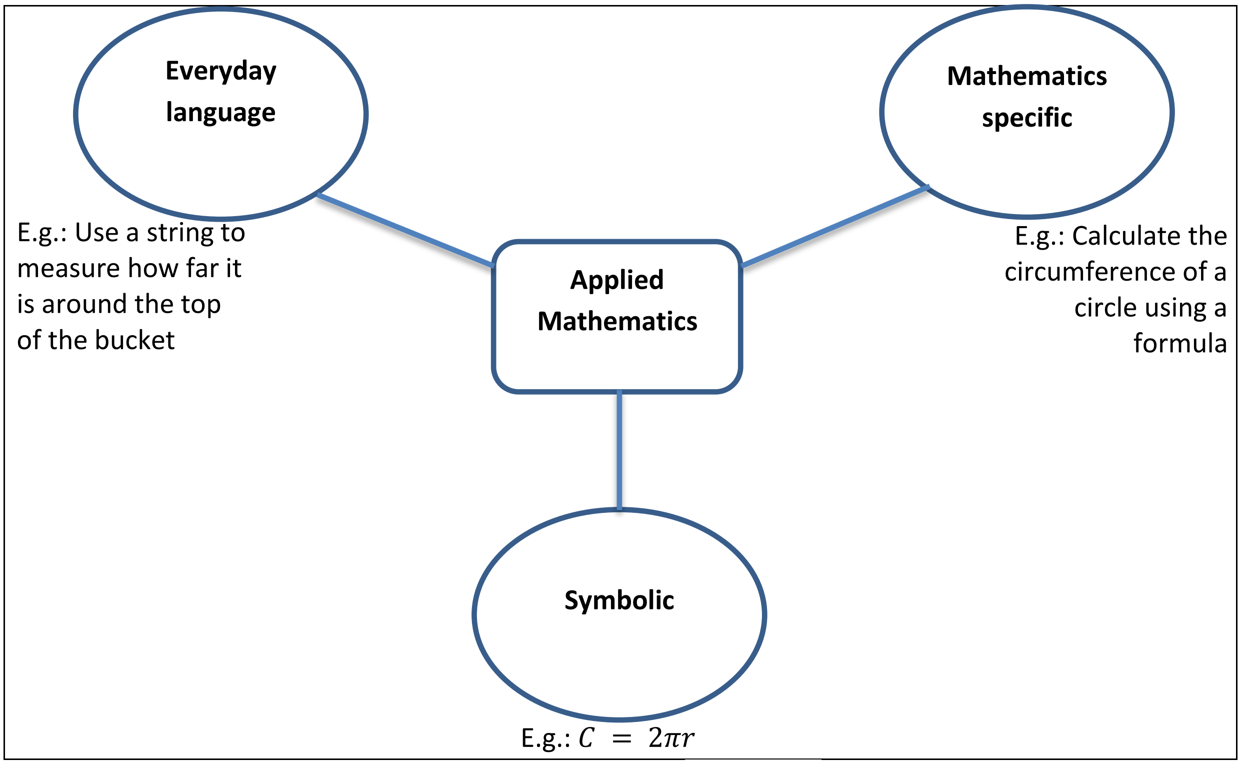
The development of the mathematics register in English has been taking place since the sixteenth century, when Robert Record's mathematical textbooks were among the first to be printed in English rather than in the prevailing languages of that time, Latin or Greek. Similarly, democratic countries on the African continent that have been changing their language of instruction from English, French or Portuguese to indigenous languages are still in the process of developing mathematical meanings in those languages so that the new registers developed are not merely compilations of newly introduced words.

One aspect of the mathematics register consists of the special vocabulary used in mathematics (Gibbs & Orton, 1994) and it is the language specific to a particular type of situation (Lemke, 1989). But it is more than just vocabulary and technical terms. It also contains words, phrases and methods of arguing within a given situation, conveyed through the use of natural language (Pimm, 1987). The grammar and vocabulary of the specialist language are not a matter of style, but rather methods for expressing very diverse things (Ellerton & Wallace, 2004). Each language will have its own distinct mathematics register and ways in which mathematical meaning is expressed in that language. For example, the English language mathematics register includes:

> "the use of common words with specialised meanings; syntax characteristics include increased use of logical connectives, while discourse characteristics include increased density of meaning, increased use of passive voice, and the need for multidirectional reading."
>
> Barton & Neville-Barton, (2003: 4)

Within the mathematics register different forms of mathematical language can be found as illustrated in Figure 3.1.

Figure 3.1: Types of mathematical language



Adapted from Ní Ríordáin (2011); Meaney (2005); Bubb (1994)

As is evident, the complex register of mathematics is similar to a language and requires skills of learning similar to those used in learning a language. This adds another dimension to mathematics learning and reinforces the view that the content of mathematics cannot be taught without language. The process of learning mathematics involves mastery of the mathematics register (Setati, 2005). This allows learners to communicate their mathematical findings in a suitable manner, but "without this fluency, learners are restricted in the ways that they can develop or redefine their mathematical understandings" (Meaney, 2005: 129). By developing a learner's mathematical register, the process provides them with analytical, descriptive and problem-solving skills within a language and a structure so that they can explain a wide range of experiences. Once the register is mastered, learners will have the ability to listen, question and discuss, together with an ability to read and record.

Similarly, classroom discourse has an intricate structure, consisting of units of language such as those used in conversations, lectures, stories, essays and textbooks (Sternberg, 2003). Sentences are structured according to systematic syntactical guidelines – episodes of a discourse are also systematically structured. The context of learning is multidimensional, as understanding discourse does not rest solely on the interpretation of words written in textbooks and spoken by the teacher, but also on the knowledge of the physical, social or cultural context within which the discourse takes place (Sternberg, 2003). For example, the functions assigned to learners and teachers in the given environment, modes of communication, intentions, linguistic choices, and contexts of communication/learning are all influential in the interpretation of meaning (Georgakopoulou & Goutsos, 1997). By taking into consideration the speaker who is producing the spoken or written mathematical text, the context within which it is being produced, and the medium through which it is expressed, it becomes possible to evaluate the learners' mathematical understanding and the relationship between mathematics and language. However, mathematics learning/understanding and its relationship with language is an extremely complex and diverse area of research, which will be examined in the subsequent sections.

3.3.1 Linguistic features associated with mathematics teaching and learning

Mathematics is not language free, in other terms; language is only one component of mathematics. Furthermore, as has been exposed in preceding sections, mathematics *is* a language with its particular vocabulary, syntax and discourse, which can cause problems for learners learning it in a second language (Barton & Neville-Barton, 2003). While many learners who learn mathematics in their mother tongue have difficulty in acquiring the mathematics register, this problem is heightened for those who must learn it in a second language, such as English. Learners have to cope not only with the new mathematics register, but also the new language in which the mathematics is being taught (Setati & Adler, 2000). Some of the language features that may impede mathematical learning are discussed in the following paragraphs.

3.3.1.1 Mathematical vocabulary

The National Numeracy Project (2000) defines mathematical vocabulary as a collection of words and phrases that make up the mathematical register. Teachers and learners need to understand these words and phrases in order to make good progress in mathematics. There are two main ways in which a ELLs' failure to understand mathematical vocabulary manifests itself, namely an inability to perform a task as instructed by the teacher, or an inability to respond to questions during a lesson or in a test. Lack of response may occur for the following reasons:

- Lack of understanding of the spoken or written instructions, (such as draw a line between..., or find two different ways to ...);
- unfamiliarity with the mathematical vocabulary (words such as ***difference***, ***subtract***, ***divide*** or ***product***);
- confusion about mathematical terms (such as ***odd*** or ***table*,** which have different meanings in everyday English; or
- confusion about other words (like ***area*** or ***divide*,** which are used in everyday English and have similar though more precise meanings in mathematics).

National Numeracy Project (2000)

It is therefore essential that teachers assist learners to acquire the appropriate vocabulary in order to increase participation in activities, lessons and assessment that are part of classroom life. An even more important reason for teaching mathematical vocabulary is that mathematical language is crucial to the development of learners' mathematical thinking skills. If a learner does not have the vocabulary to talk about division, perimeter or numerical difference, the learner's progress in understanding these areas of mathematics is impeded.

3.3.1.1.1 Developing mathematical vocabulary in the classroom

Direct teaching of vocabulary builds essential knowledge and when effective vocabulary instruction is built into a mathematics curriculum, learner achievement is likely to improve in mathematics assessments (Gunning, 2003; Vacca, Cove, Burkey, Lenhart & McKeon, 2008). Opportunities for the development of mathematical vocabulary must be regular and planned (National Numeracy Project, 2000). Thus, it must not be assumed that mathematical vocabulary development will occur unplanned or naturally, but opportunities for the development of the vocabulary should be systematically built into the teaching and learning content. Developing a better understanding of mathematical vocabulary can be done systematically by first introducing the new words, then creating opportunities for listening to the teacher using the words, followed by prompting the learners to respond to questions using the new words, followed by fluently reading written texts that include the new word, and finally writing the mathematical vocabulary in a range of contexts. Such focused and strategic development of mathematics vocabulary may benefit the ELLs (who are taught by the majority of the teachers participating in this study) better than when the development is not systematic.

- **Introducing new mathematical vocabulary**
  Although teachers often use informal language in mathematics lessons before or alongside specialised mathematical vocabulary to help learners to grasp the meaning of different words and phrases, the teacher also needs to adopt a more structured approach to the introduction of new vocabulary. Such a structured approach encourages learners to begin using the correct mathematical terminology as soon as possible (Lee, 2006; National Numeracy Project, 2000; Pimm, 1987).

- **Listening**
  Learners of all ages develop an understanding of new mathematical vocabulary by listening to the teacher or peers using the words in a suitable context, before they can copy the practice and use the words themselves. Initially learners listen to the teacher using, repeating and emphasizing important words during practical activities with real objects, when playing games or when discussing pictures or diagrams. The teacher can also make

use of listening comprehension exercises (comprising of pre-listening, while-listening and post-listening activities) to expand the learners' vocabulary. Listening activities guide the ELLs to listen for specific works and discover how they are used in the comprehension passage. In time, the learners pick up the words and their meanings and try them out too, particularly if the teacher, by means of probing and questioning, encourages the learners to use the new mathematical vocabulary (Lee, 2006; National Numeracy Project, 2000; Pimm, 1987)

- **Speaking**

  Initially, speaking opportunities can be combined with practical work so that learners have visual images and tactile experiences of what mathematical language means in a variety of meaningful contexts. At a later stage, using new mathematical vocabulary in oral work alone helps the learners to become less dependent on real objects and begin to visualise and work mentally. The teacher can develop the learners' understanding of terminology as well as assist the learners in understanding ambiguities and misconceptions through a range of open and closed questions. Oral work alone provides opportunities to:

  - Acquire confidence and fluency in speaking by being encouraged to use single words and phrases, then compose complete meaningful sentences that include the new mathematical words;
  - Describe, define and compare mathematical properties, positions, methods, patterns, relationships or rules;
  - Discuss ways of solving a mathematical problem, collecting data or organising the work;
  - Make predictions or hypothesize about possible results;
  - Present, explain and justify their methods, results, solutions or reasoning in pairs or small groups to the whole class; and
  - Generalise or describe examples that match a general statement.

  (Lee, 2006; National Numeracy Project, 2000; Pimm, 1987)

- **Reading**

  The teacher can provide a variety of texts with new mathematical vocabulary to be read aloud or silently. The teacher can ask learners to bring relevant texts such as newspaper and magazine extracts (with some bearing on the mathematical concepts to be taught) to be read in class. The texts can be read individually, as a whole class or through chorus reading. The teacher can provide reading opportunities in form of:

  - Numbers, signs and symbols, expressions and equations written on the chalk board;
  - Instructions and explanations in work books, text books or eBooks;
  - Prose in library books, including reference books, story books or books of rhymes;
  - Labels and captions on classroom displays, on diagrams, graphs, pictographs, charts or tables; or

- Definitions in illustrated dictionaries, ready-made dictionaries or dictionaries made by the learners in order to discover synonyms, origins of words or words beginning with the same prefix such as triangle and trisect.

(Lee, 2006; National Numeracy Project, 2000; Pimm, 1987)

Just like the variety of listening activities listed above, the teacher can incorporate pre-reading, while-reading and post-reading activities that improve the learners' awareness of mathematical vocabulary within the text.

- **Writing**

  The teacher can provide writing and recording opportunities in a variety of ways progressing from words, phrases and short sentences to poems, paragraphs and longer pieces of writing such as:

  - Writing prose in order to describe, compare predict, interpret explain or justify;
  - Writing formulae, first using words, then symbols;
  - Sketching and labelling diagrams in order to clarify their meaning; and
  - Drawing and labelling graphs, charts or tables or interpreting and making predictions from the data in graphical presentations.

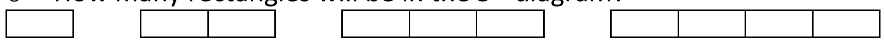
(Lee, 2006; National Numeracy Project, 2000; Pimm, 1987)

3.3.1.1.2 Questioning techniques for developing mathematical vocabulary

Since the meaning of words cannot be learnt in isolation, the teacher's use of questions is crucial in helping learners to understand mathematical ideas and use mathematical terms correctly. According to the National Numeracy Project, (2000), teachers often find it easy to ask simple recall questions – those that require learners to recall facts rather than asking questions that require learners to engage higher levels of thinking. Therefore teachers are encouraged to use the full spectrum of question types to allow learners to respond with more complex answers in which they explain their thinking. Six types of questions that can be used by teachers to improve vocabulary learning are indicated in Table 3.1.

Table 3.1: Types of questions for developing mathematical vocabulary

Types of questions	Examples
Recalling facts	○ What is 3 add 7? ○ How many days are there in a week? ○ How many centimetres are there in a metre? ○ Is 31 a prime number?
Applying facts	○ List two numbers that have a difference of 12. ○ What unit would you choose to measure the width of a table? ○ What are the factors of 42?

Hypothesising / predicting	○ Estimate the number of counters in the jar. ○ If the survey is conducted again on Friday, how likely is it that the graph would be the same? ○ Roughly, what is 51 times 47? ○ How many rectangles will be in the 5th diagram? 
Designing and comparing procedures	○ How might we count this pile of sticks? ○ How can you subtract 37 from 82? ○ How can you test if a number is divisible be 6? ○ How can we find the 20th triangular number? ○ Are there other ways of solving the problem?
Interpreting results	○ So what does that tell us about numbers that end in five or zero? ○ What does the graph tell us about the most common shoe size? ○ So, what can we say about the sum of the angles in a triangle?
Applying reasoning	○ The seven coins in my purse total 23 cents, what could they be? ○ In how many different ways can four children sit at a round table? ○ Why is the sum of two odd numbers always even?

Adapted from National Numeracy Project (2000: 4)

Different types of questions can be used by the teacher to promote good dialogue and interaction in a mathematics classroom. Questions can either be closed, with only one correct answer, e.g. 'Is 16 an even number?', or open, with a number of different correct answers, e.g. '*List the even numbers between 10 and 20*'. Open questions provide more learners with a chance to respond and they often provide a greater challenge for the most able learners, who can be asked to think of alternative answers, and in suitable cases, to count all the different possibilities. Questions can be used at any point during the lesson to extend the learner's thinking. When learners are in the entry phase of an activity, the teacher may ask the learners a question such as: '*What information do you have?*' To make positive interventions for the purposes of checking progress while learners are working, the teacher may ask: '*Can you explain what you have done so far?*' To assist learners who are stuck, the teacher may ask: '*Can you describe the problem in your own words?'*, and during the feedback session, the teacher may ask, '*How did you get the answer?*' As learners provide answers to the teacher's questions, the teacher needs to encourage the correct use of newly learnt words as well as other relevant mathematical vocabulary, and reward or positively reinforce correct usage of the mathematical terms in the dialogue. Such practices would help to develop the learners' mathematical vocabulary.

A study conducted by Moloi, Morobe and Urwick (2008) in Lesotho primary schools identified three major challenges in teachers' questioning. The first is that most questions asked simply require learners to recall what the teacher has said; these are closed questions with one correct answer. Learners are therefore restricted in their thinking skills. Probing, analytical, general interpretation and open-ended questions are rarely asked. While there is some element of multiple representations of mathematical concepts in the primary classrooms, generally questions used in exercises only require recall, with no room for critical thinking. Learners are not afforded the opportunity to imagine or to interpret. Similar observations were made by Ntoi and Lefoka (2002: 280), who noted that teacher education lecturers' questions "do not lead to much discussion because of their restrictive nature". Thus the answers called for are safe and simple for the student-teacher.

Secondly, questions are not always distributed around the whole class, especially in large classes. The majority of the learners get an opportunity to respond to a question only through chorus answers; otherwise they may go through the whole lesson without getting the opportunity to demonstrate their understanding or lack thereof. The learners who get a chance to respond to questions feel involved in the lesson.

The third challenge is lack of feedback. Generally, teachers correct learners' inaccurate answers and redirect or rephrase questions, but they do not reinforce the correct answer. Either they underestimate the importance of reinforcement for learners' motivation, or they are not very interested in the matter. This practice of providing inadequate feedback defeats the whole purpose of using questioning techniques to improve language competency in the classroom.

3.3.1.2 Ambiguous terms

A key issue that creates significant hurdles for ELLs (as well as monolingual learners) is the number of words *borrowed* from everyday English (Pimm, 1987). These words tend to be ambiguous as they have one very specific meaning in the mathematics register and a range of possible other meanings in their everyday uses (Yushau & Bokhari, 2005). Table 3.2 is a compilation of the more common ambiguous words found in mathematics education. The non-mathematical meanings of these terms can interfere with mathematical understanding, as well as being a source of confusion.

Table 3.2: Some ambiguous words used commonly in school mathematics

above, altogether, angle, as great as, average, base, below, between, big, bottom, change, circular, collection, common, complete, coordinates, degree, difference, different, differentiation, divide, down, element, even, expand, face, figure, form, grid, high, improper, integration, leaves, left, little, low, make, match, mean, model, moment, natural, odd, one, operation, overall, parallel, path, place, point, power, product, proper, property, radical, rational, real, record, reflection, relation, remainder, right, root, row, same, sign, significance, similar, small, square, table, tangent, times, top, union, unit, up, value, volume, vulgar

Durkin and Shire, (1991: 74)

Furthermore, Rudner (1978) found that the following are sources of difficulty and hinder learners' interpretation and understanding of mathematical word problems:

- conditions (if, when);
- comparatives (greater than, the most);
- negatives (not, without);
- inferentials (should, could, because, since);
- low-information pronouns (it, something); and
- lengthy passages.

Lexical ambiguity in mathematics can be classified under homonymy, polysemy, homophony, and shift in application or imprecision (Durkin & Shire, 1991: 71 – 75). Table 3.3 summarises vocabulary misconceptions commonly found in mathematics classrooms.

Table 3.3: Summary of vocabulary misconceptions

Misconception	Examples
Homonyms: words shared by mathematics and standard English but have different meanings	○ *Right* angle *Right* answer ○ *Reflection*: flipping over a line *Reflection*: thinking about something ○ *Table*: organising information *Table*: piece of furniture
Polysemy: mathematical words shared with standard English and have comparable meanings, but with a more precise mathematical meaning	○ *Difference*: answer to a subtraction problem *Difference*: general comparison ○ *Even*: divisible by 2 *Even*: smooth
Mathematical words **shared with other disciplines** and have different technical meanings in the two disciplines	○ *Divide* in mathematics means to separate into parts, but the continental *divide* is a geographical term referring to a ridge that separates eastward/westward flowing waters. ○ *Variable* in mathematics is a letter that represents possible numerical values, but *variable* clouds in science describes a weather condition.
Shift of application: words with more than one mathematical meaning	○ *Round*: a circle ○ *Round*: a number rounds off… **243** rounds off to **240** ○ *Square*: a shape □ *Square*: a number times itself $\mathbf{2^2} = \mathbf{4}$ ○ *Second*: a measure of time ○ *Second*: a location in a set of ordered items 1^{st} $\mathbf{2^{nd}}$ 3^{rd} 4^{th} …
Homophones: mathematical terms sharing the same pronunciation with standard English terms	○ *Sum* / some ○ *Arc* / ark ○ *Pi* / pie
Irregularities found in English spelling and usage	○ *Four* has a 'u' ○ *Forty* does not

Specialist terms: mathematical terms only found in mathematical contexts	○ *quotient* ○ *decimal* ○ *denominator* ○ *isosceles*
The same mathematical concepts **expressed in more than one way**	○ *One quarter / one fourth /* $\frac{1}{4}$
Related mathematical words whose distinct meanings may be confused	○ *factors* and *multiples* ○ *hundreds* and *hundredths* ○ *numerator* and *denominator* ○ *mode, mean* and *median*
Imprecision: adapting an informal term and using it as if it is a mathematical term	○ *Diamond* for rhombus ○ *Corner* for vertex ○ *Cross* for intersection ○ *Turn* for rotate

Adapted from National Numeracy Project (2000)

Homonymy denotes the property of some words that share the same form but have distinct meanings. A standard example is *bank* – meaning a financial institution, and *bank* meaning the area of land beside a river. An example relevant to mathematic is *leaves* which in everyday use refers to the outgrowths of a tree, but has a different meaning when referring to the process of subtraction (3 from 7 *leaves* 4).

Polysemy refers to the property of some words that they can have two or more different but related meanings. A standard example is *mouth*, which can refer to a facial aperture or the place where a river meets an ocean. These are different but related meanings, which may be apparent to the native speaker of English in that they contain some shared sense of an opening. A mathematical example is *product*, which in everyday use refers to an item which has been made, whereas in mathematics it refers to a quantity obtained by multiplication. Again, there is a shared sense of that which is produced in both the everyday and specialised meanings; however, this shared sense may not be so obvious to a second-language learner of English.

Homophony refers to the phenomenon wherein two distinct words have the same pronunciation. Standard examples include *bare* / *bear*; *flour* / *flower*. These are linguistic coincidences which may lead to misconceptions. Mathematically relevant examples include *two* / *too* / *to; sum* / *some; pi* / *pie*.

Shifts of application refer to occasions where the same sense can be considered from different perspectives. Pimm (1987) suggests *wall* as a standard example which has different aspects according to whether it is discussed with reference to its composition (brick, stone) or its function (from the perspective of brick layers, architects, residents). A mathematical example is the word *number*, which is subject to shift of application, for example, when used to describe *nominal* (the number 5), *ordinal* (the second number she said) or *visual* (the number 7 is crooked) properties.

Imprecision and use of **informal** terms occurs in any area of vocabulary use; however, it is worth mentioning that these are frequent in mathematical contexts and contribute to ambiguity. Durkin and Shire (1991) explain how the word *share* refers to division satisfactorily for some problems, but is misleading for others. Pimm (1987), Durkin and Shire (1991) and Hanley (1978) provide the following examples: *average* when *mean* is intended; *data* to indicate a singular referent, or *diamond* to refer to a square in a particular orientation. Some words may be used more informally in ways which conflict with their precise meanings in mathematics and logic, for example, the phrase '*Let's move the tables to make more space*' is a description which would fail the conservation of area assessment (Hobart, 1980).

As stated in the earlier section of this chapter, since languages are dynamic, most language use involves shifts of application, otherwise nothing new would be said, and thus even mathematics teachers who pride themselves on the precision of their subject are as capable as any other language users of imprecise and misleading descriptions (Durkin & Shire, 1991). Certain word combinations created in mathematics are intended to represent meanings which are different from the sum of their everyday senses. Such examples include: simple interest, pie chart, square root, closed figure (Shuard & Rothery, 1984: 28). Conversely, some colloquial descriptions of mathematical operations have different everyday meanings, such as *take away* (*takeaway*).

3.3.1.3 Specialist terms

The use of specialist terms can lead to misunderstanding and misinterpretation of mathematical tasks. Learners tend to encounter these terms only within the mathematics classroom (for example, *quadrilateral*, *parallelogram* and *hypotenuse*) and they are unlikely to be reinforced outside of it (Pimm, 1987). If second-language learners do not acquire the correct meaning of these terms, this can lead to difficulties within the mathematics context. Second-language learners have a tendency to translate new mathematical terms/vocabulary into their mother tongue. This translation may not exist and/or it may be done incorrectly, thus resulting in further confusion and misinterpretation (Graham, 1988).

3.3.1.4 Context

Context is also a key aspect in lexical ambiguity. Words can change their meaning depending on their context within the mathematics lesson (Gibbs & Orton, 1994: 98). In terms of language analysis, this is referred to as semantics: establishing meaning in language, or the relationship between and representation of signs and symbols. Because of the multiple meanings that various words can have, the context is vital in determining the correct interpretation. A review of the literature showed that learners experience more difficulties with the semantic structure of word problems than with other contributing factors such as the vocabulary and symbolism of mathematics and standard arithmetic (Ellerton & Clarkson, 1996).

3.3.1.5 Symbolism

Symbolism, the use of symbolic expressions or symbols, is one of the most distinctive features of mathematics. It is crucial for the construction and development of mathematics. Unfortunately symbolism can accordingly cause considerable difficulties to those whose mother language has different structures (Austin & Howson, 1979: 176). One of the requirements for mathematical learning is that learners should be able to interpret the mathematical text and convert it to an appropriate symbolic representation, and perform mathematical operations with these symbols (Brodie, 1989). Thus if learners cannot understand the text because of the language of instruction, they will be unable to convert it to the appropriate mathematical constructions needed to solve the problem. Symbols provide structure, allow manipulation, and provide for reflection on the task completed. Some lexical ambiguities are compounded by the fact that they relate to mathematical symbols which themselves are described by different words in different contexts; for instance, the symbol = can mean *equals*, *means*, *makes*, *leaves*, *the same as*, *gives*, *results in*, any one of which itself has multiple meanings. Although there may be other conceptual factors involved, this linguistic diversity seems likely to be implicated in the findings that learners experience difficulties in interpreting the equals sign as they proceed further with their school years (Baroody & Ginsburg, 1983; Cobb, 1987).

Registers exist in other disciplines such as science or technology, but Standard English language can also be classified as a register. In the teaching and learning process, mathematics and ordinary language registers can interfere with each other. Thus learners need to recognise each of these registers so as to identify which is being used at any given time (Sierpinska, 1994), and this a challenge many IP mathematics teachers face when managing the transition to teaching mathematics through the medium of English.

This study contends that mathematics classrooms are among the *few* places where learners engage with mathematical vocabulary; therefore, teachers *must* create opportunities for learning mathematical vocabulary and its applications; this applies specifically to IP mathematics teachers, for the purposes of facilitating a smooth transition from mother-tongue instruction to instruction using English as the LoLT.

3.3.1.6 Vocabulary teaching and learning strategies and the role of vocabulary

From Schmitt's (1997: 207 – 208) taxonomy of vocabulary learning strategies, some key vocabulary teaching strategies that can be inferred and are relevant for the second-language IP classrooms include:

- Provision of a mother-tongue equivalent;
- Guessing word meaning from contextual use;
- Teaching word lists;
- Using flash cards;
- Use of a new word in a sentence;
- Giving the meaning or synonym of a word;
- Practising word meaning with peers for consolidation;
- Pictorial word representation;
- Making connections between words and their synonyms or antonyms;
- Use of semantic maps;
- Drilling an aspect of a word, for example, pronunciation, spelling;
- Use of physical action e.g. demonstration or gestures;
- Verbal and/or written repetition of word;
- Labelling objects in the classroom.

Long and Richards (2001) found that strategies of drawing attention to words and defining them lead to vocabulary gains. Attention-drawing strategies include activities such as presentation of words to learners prior to the reading of a particular selection and pre-teaching them as well as highlighting them. The manifestation of such strategies in teacher practices would be indicators of the potential for teacher practices to impact on vocabulary learning. Learners can only learn those words that they are exposed to.

Hart and Risley's (1995) study on the discrepancies in vocabulary knowledge of learners according to their different socio-economic statuses attests to the significance of word exposure for word acquisition and knowledge. There is, however, no consensus in the research on the average number of words average learners of an average school age learn per day or per week. Daily word acquisition estimates are extremely varied, ranging from three words a day (Joos, 1964), through seven (Beck, McKeown, & Kucan 2002) to twenty (Miller, 1978). Beck *et al*. (2002) even found that among what they called 'at-risk' learners the figure was as low as one or two words a day.

For first-language speakers of English, Biemiller (2005) found that the lowest quartile learners learnt between 500 and 600 words a year. According to Nagy and Herman (1985: 16), the Vocabulary Learning Hypothesis states that most vocabulary is learned gradually through repeated exposure to new and known words, in various contexts. They note that a single word encounter gives the learner only a 5 to 10% probability of knowing and retaining it. They peg the ideal number of word encounters for the entrenchment of a word in memory in varied contexts at 10 to 12 exposures. More and varied contextualised exposures would be needed to ensure transference of words from passive to active vocabulary. Hinkel (2007: 6) notes that "a large passive vocabulary does not necessarily result in a better active vocabulary. Active vocabulary is one a language user can easily and readily draw on for productive language use, whereas passive vocabulary is somehow distant and slightly hidden". The frequency of word usages required for learners to 'own' a word underscores the importance of strategies that will ensure vocabulary instruction. Sacrificing the contextual usage of words for the number of words learnt is counter-productive. In as much as having a million bricks does not mean having a house, the meaningfulness of the context in which vocabulary is encountered is as important as, if not more important than, mere exposure of the vocabulary, especially for developing active vocabulary.

Lessons focusing on a specific topic or theme allow for the recycling of vocabulary within a meaningful context, which allows for sufficient practice with the related vocabulary. There is also need for multiple exposures to complement such practices for the purposes of developing learners' vocabulary. Mere word repetition or word drills will not achieve much (Stahl, 2005). Possibly the most consistent finding in vocabulary instruction is that varied, multiple and meaningful word exposure is essential for vocabulary development. The more concrete the learners' experiences with new words, the better they will be positioned to comprehend and retain them.

Biemiller (2005) documented the meagre percentage of vocabulary instructional time and the absence of systematic, explicit vocabulary instruction in schools within second-language contexts. Traditionally, word instruction was delegated to the glossary and the dictionary, or took the form of a quick oral definition. This accorded learners an on-the-fly word exposure, which hardly translated to word learning on a long-term basis, seeing that learners needed multiple word exposures in multiple contexts for them to understand, remember and apply new words appropriately (Nagy, 2005).

In the study by Saragi, Nation and Meister (1978) learners learned 93% of the words after six or more exposures to the words, while words presented fewer than six times were learned by only half the learners. The study by Jenkins, Stein and Wysocki (1984) found only 25% of the learners learning a word after 10 encounters. Although such discrepancies characterize research on the amount of exposure that triggers word learning, what is held in common is the idea that the higher the frequency of word exposure, the greater the likelihood of it being internalised. The discrepancies in the estimates emanate from a host of other confounding variables, including the nature of the word exposure and the word testing, and the proficiency levels of the learners, among others.

3.3.1.7 Strategies used to teach the mathematics register in a second language

The previous sections explored the link between language and mathematics achievement, including vocabulary misconceptions prevalent in mathematics classrooms. The literature has revealed that for learners of mathematics, especially in a second language, there are some linguistic constraints that might hinder the mathematics learning and understanding.

This section looks at some strategies that may help in making mathematics meaningful for bilingual learners in spite of their linguistic constraints. A study conducted in Botswana by Kasule and Mapolelo (2005) summarises common teachers' strategies of teaching primary school mathematics in a second language, as illustrated in Table 3: 4.

Table 3.4: A typology of strategies used in teaching mathematics in a second language

Linguistic Strategies	Games and other strategies	Organisational strategies
- Code switching from English to first language	- Using concrete objects	- Group work based on ability so that the weaker learners can be helped
- Inviting questions from learners	- Using flash cards and playing cards	- Giving large amounts of homework daily
- Teaching the language of mathematics	- Using jigsaw puzzles	- Providing variety in teaching methods and classroom activities
- Translating the textbook from mother tongue to English	- Snakes and ladders	- Forming Maths clubs
- Using simpler English words wherever possible	- Using multiple tables	- Asking one learners to solve a problem while others listen
- Doing 'oral' maths	- Role play	- Using the solution to check the meaning of the problem
- Using discussion	- Asking learners to convert number to story / word problems	- Involving the learners when working out a problem on the board
- Encouraging learners to speak English	- Regular participation in mathematics ○ quizzes, ○ fairs, and	- Providing different ways of getting to the answer.
- Relating a new to an		

old topic / concept	○ other competitions	

Kasule and Mapolelo, (2005)

To minimise lexical ambiguity in mathematics classrooms, Durkin and Shire (1991: 74 – 78) propose several strategies that can be adopted by teachers. These strategies include monitoring lexical ambiguity, enriching contextual cues, exploiting ambiguity to the learners' advantage as well as confronting ambiguity. In addition to minimising lexical ambiguity, the literature reveals other pedagogical strategies that may help in making mathematics meaningful for bilingual learners in spite of their linguistic constraints; these are: appraising mathematics ability, employing bilingual approaches, contextualising mathematics, localising mathematics, employing linguistic approaches, removing reading difficulties, monitoring language in the classroom, and using analogy and metaphor.

- **Monitor lexical ambiguity**

In preparing materials for use in mathematics lessons, the teacher must consider whether any words might have a different meaning for the learner from that intended or assumed in the specialist context. If the teacher is aware in advance of potential misconceptions, sensitivity to the learners' needs is increased.

- **Enrich contextual cues**

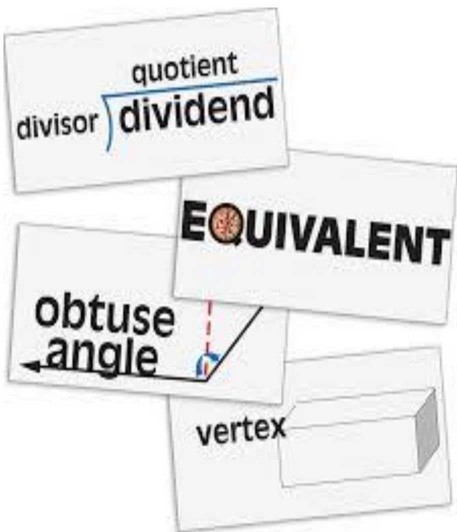
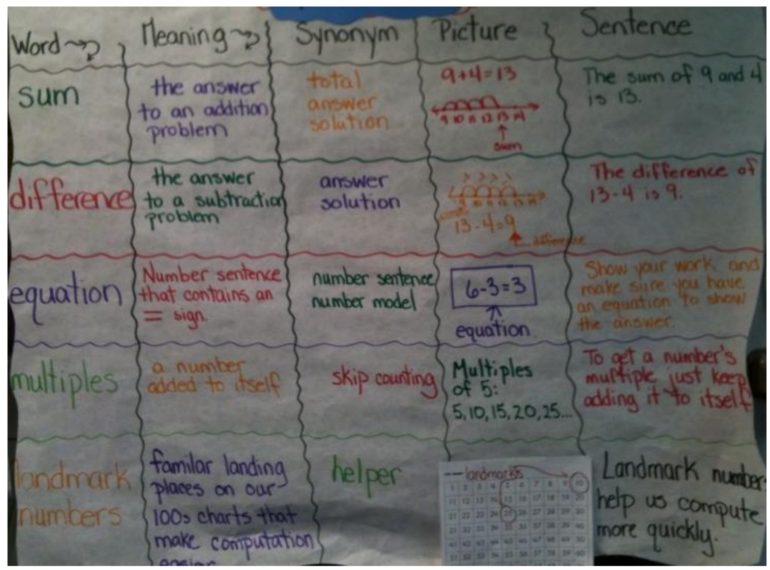
Successful decoding of a specific use of an ambiguous word is dependent upon the context in which it is used. The contexts provided by mathematics lessons may not always be sufficiently familiar or secure for the learner to readily access the appropriate mode of discourse and terminology. For the most able learners in mathematics, this may not be a problem, but for weaker learners misconceptions over the specialist use of terminology can only compound the confusion. Structured and sensitive preparation by the teacher can help guide the learners to the context-specific meaning of the target words. Shire and Durkin (1989) found that providing learners with visual support for judgements about rank ordering facilitated the learners' performance. When mathematical definitions need to be differentiated from every day or scientific meanings, the teacher should allow the learners to discuss the differences and draw pictures or construct meaningful sentences to contrast the two meanings such as:

- The *difference* between my two bags is that one is red and the other is blue.
- The *difference* between 12 and 7 is 5 because *12 – 7 = 5.*

In addition, keeping a plain word wall, or journal entries of new words, or using published dictionaries to search for word meanings might not be as enriching and creative as posting new words alongside their definitions and illustrations to make the new words more meaningful.

Compared to published dictionaries; learner-made dictionaries, also called *vocabulary journals***,** allow learners to draw on their creativity, which could be advantageous in aiding memory. Using illustrative word walls as shown in Figure 3.2 provides visual cues that can help learners with word recognition, automaticity, decoding and spelling (Browne, 2002; Peregoy & Boyle, 2005).

Figure 3.2: Examples of illustrative journal entries

Illustrative Word Wall	Vocabulary Journal
	

Adapted from Virginia Department of Education, (2006)

Barwell et al, (2002) note that it is not enough for learners to hear a few examples of a word being used or to be given a formal definition. Learners need to explore the concepts involved, push at the limits of definitions and most of all, make the meaning their own as they learn to talk mathematically.

- **Exploit ambiguity to advantage**

In many cases, particularly with polysemous words, purposeful use of the contexts in which the everyday and specialist meanings of the terms coincide can provide learners with a secure base from which to familiarise themselves with the new extensions of their vocabulary before venturing into more demanding uses. For the most able learners as well as in the upper levels of the IP, teachers may use strategies that include analyses of word origins as a way of exploiting ambiguity to advantage. Analysing word origins allows teachers to share with learners the '**words behind the words**', so that learners connect terms that sound foreign to the words they already know:

- *Parallel* comes from '*alongside'* … (*para*-) as in a paramedic who works alongside medical professionals.
- *Percent* comes from *'for each hundred'* (*per* dozen – for each dozen) from which the term *divided by 100* is derived.

Word origins can also be used to clarify distinct meanings of mathematics word pairs that are commonly confused such as (numerator / denominator). The root *nom* means to name, hence the *denominator* names the fraction, while the *numerator* tells the *number* of parts of interest. Thus $\frac{3}{5}$ means that something is divided into *five* equal parts, and we are referring to *three* of those parts.

- **Confront ambiguity**

In terms of linguistic economy and organisation, there are good reasons why homonymy and polysemy exist and learners' appreciation of the varieties of meanings can be promoted by developing teaching materials which bring potential conflicts into focus. This calls for careful monitoring of learners' responses by the teacher, and learners can only benefit from such encounters, particularly from middle childhood, approximately at the IP level of the South African education system, the period during which learners generally become more sensitive to linguistic ambiguities. Shultz and Horibe (1974) describe this period as characterised by an increasing interest in word play, jokes, puns and riddles. To this effect, activities such as quizzes, word searches, crossword puzzles and creative writing (discussed later in this section) in mathematics become relevant.

While providing learners with opportunities to gain access to the resources implicit in natural language can be viewed as a common aim of all teachers, Durkin and Shire (1991) view a particular aim of mathematics teachers as providing their learners with a means to make use of the mathematics register for their own purposes. As such, this study values IP mathematics teachers' knowledge of the language forms and structures that comprise aspects of that register, so that part of learning mathematics reinforces gaining control over the mathematics register, which in turn means that learners are able to talk like mathematicians and express their understanding of mathematics coherently.

- **Appraise mathematics ability**

Individual learner strengths and needs vary, bilingual learners may have high ability in maths and yet not be able to communicate that ability, due to lack of English proficiency, or a lack of communication skills in either language. Therefore it is crucial to appraise mathematics ability as early as possible, and on the basis of cognitive ability and not assumed on the basis of learner proficiency in English

- **Bilingual instructional approach**

The level of bilingual language proficiency should be measured to ascertain the level of language proficiency in both languages. If the learner is stronger in their mother tongue than English, then instruction should continue in the mother tongue before transition to English (Cuevas & Beech, 1983; Setati, 2003).

> If it is determined that the native language will be used for instruction, then a teacher who is fluent at the academic level of that language should provide instruction. Just as the language proficiency of bilingual learners can range dramatically, so can the language proficiency of bilingual teachers. If the teacher is highly proficient in the academic language of mathematics, then the learner will be more likely to learn that higher level of their native language. A teacher who is only fluent in the social aspects of the native language may struggle to communicate precisely with mathematical terms and expressions in that language, and may not be able to take their native language learners to a higher level of learning.
>
> Raborn, (1995)

However, if the language of instruction is the learners' second language, a translation of key words into the learners' first language can help (Yashau & Bokhari, 2005; Secada & Cruz, 2000; Setati & Adler, 2001). The teacher may also request a strongly bilingual / multilingual learner to translate for the weaker bilinguals and multilinguals, so that the rest of the class may have an opportunity to participate in the classroom discussions. Teachers might request having some of their teaching materials translated into the learners' native language, or to have the material rewritten in simplified language to make it more accessible to the learners.

- **Contextualisation of mathematics**

One of the major constraints faced by learners is that mathematics has remained inaccessible to teachers and hence to the learners.

> If the young learner receives only a quick and abstract initial encounter with variables followed by practice in the essentially syntactic skills of manipulating algebraic expressions, the semantics component of the new language may never be realised.
>
> Burton, (1988: 6)

In this case the learner will have difficulties in making sense of the problem; therefore teachers should always try to use a context or theme that learners are familiar with to serve as a matrix out of which they generate mathematical activities and problems. Since mathematical language, like language in general, develops in context to support communication, the best way to increase learners use of precise language is to use contexts that require such precision (Secada & Cruz, 2000).

- **Localizing mathematics**

Effective bilingual teachers use their learners' home cultures to support classroom management and learning. All indigenous societies have their own forms of mathematics, which are different from the internationalised mathematics (Ellerton & Clarkson, 1996: 1014). Localising educational theories and practices allows the curriculum to be directed to those for whom it is being developed. Such a curriculum can be built upon the natural cognitive modes of the learners in question, which are determined by their language (Brodie, 1989: 51).

> The cultural perspective requires us to culturalise the curriculum at each of the levels, and demonstrate that no aspect of mathematics teaching can be culturally neutral.
>
> Ellerton & Clarkson, (1996: 1017)

- **Linguistic approach**

Two linguistic strategies are suggested. The first strategy should be to aim at improving the linguistic skills and fluency in the language of instruction, while at the same time developing the skills and support for the mother tongue. Thus, developing proficiency in the language of instruction, should not be at the expense of the development of the mother tongue, but should be in such a way proficiency in both the languages is developed. The second strategy is to involve language teachers who would spend a substantial portion of their teaching time concentrating on linguistic skills that are relevant to mathematics (Broadie, 1989: 49).

- **Removing reading difficulties**

> Whether the text is written in the learner's first or second language, an important factor is readability.
>
> Broadie, (1989: 50)

To make mathematics accessible to the majority of the learners, it is imperative to develop the reading skills of the learners and to make mathematics textbooks simple and directly to the point. Thus, teachers should avoid using dense stylised mathematical writing, which tends to redirect the reader's attention to the correctness of what is written instead of concentrating on the richness of the meaning (Austin & Howson, 1979: 174).

- **Language in the classroom**

The classroom conversational language between teachers and learners, and amongst the learners themselves, has a great impact on mathematics learning. The language of the classroom should be simple and straightforward to avoid communication gaps. ELLs usually receive little encouragement to talk about their ideas, in part because of the belief that they will find it too difficult to express themselves (Secada & Cruz, 2000). Therefore teachers should initiate discussion in the class and should encourage weak language learners to participate in classroom discussions. Such practices will enable the teachers to identify the learners struggling with new vocabulary in mathematics and thereby provide the necessary support and guidance.

> In addition to simplifying oral language, teachers should expand on learner responses and build on those when posing their next question. Some learners pass through a 'silent period' when learning a second language, during this time, they focus on listening and trying to make sense of the rules for conversation in the classroom as well as in the larger world. Teachers will need to give learners time and look for nonverbal cues as to whether they understand the gist of the lesson.
>
> Secada and Cruz, (2000)

It is important to learn both vocabulary and the way that vocabulary is used. Thus, learners need to use the mathematical language themselves in order to get used to the way that the expressions are used, and to begin to use the mathematical terms to express the web of concepts and ideas that are encompassed by those terms (Lee, 2006: 36).

- **Analogy and metaphor**

> Other texts, especially literally ones, convey ideas through imagery and metaphor, and often restate them in different ways in order to present a more complete picture.
>
> Brodie, (1989: 49)

The use of analogy and metaphor is also suggested and shown to be a useful instructional tool in mathematics. The use of analogy and metaphor in mathematics can address the language constraints of ELLS by simplifying contextualised mathematical concepts and by strengthening vocabulary learning. Analogy and metaphor can also be incorporated into creative writing activities (Newby & Stepich, 1987; Dickmeyer, 1989; Wessels, 1990).

Creative writing strategies appropriate for mathematics teaching and learning include short stories, songs and poems. A poem based on a mathematical concept can easily be composed by learners of varying abilities. Once learners formulate the first two sentences, they build up more impressive lines and they begin to play with the rhythms created by the lengthening of the sentences. Poetry sessions can be done impromptu, within specified times and without warning, or they can be done over a longer period of time to allow learners to find out more information on a mathematical concept. The poem below by Baartman (2015) is an example of creative writing composed by a completing two given statements:

- *If I were a shape, I would be a .... because ....*
- *If I were a shape I would **not** want to be a .... because ....*

If I were a shape, I would like to be a *circle*
I would have neither end nor beginning
I would be *infinite*
You would see me everywhere
You would see me every day
On your watch, the shape of the Sun
Even when you eat
My *circumference* loves *pi diameter*
But my *radius* loves *pi half* as much as my *circumference*

If I were a shape I would *not* want to be a *square*,
Everything would always be the same
Everyone would know me wherever I go
Even when I am stretched,
I would still just be a *special square*
You would find me in any *area*... how boring!

Althea Baartman (2015) SP Mathematics Teacher at Aloe Junior High School, Cape Town[4]

Writing about mathematics allows learners to understand mathematical vocabulary, provides them with the means to make use of the mathematics register for their own purposes, and gives teachers the opportunity to assess learners' understanding of the terms they use. Thus creative writing enforces control over the mathematics register, so that learners are able to talk like mathematicians and express their understanding of mathematics coherently (Durkin & Shire, 1991).

> While teachers may consider mathematics to be universal, there are factors related to language, culture and cognition that must be taken into consideration in mathematics education. With careful assessment planning and implementation, learners with diverse learning characteristics can be successful in mathematics.
>
> Raborn, (1995)

To achieve this, the following recommendations of the National Council of Teachers of Mathematics (NCTM) are imperative to address mathematics teaching and learning using a second language holistically, including other stakeholders involved in the teaching and learning process, other than just the teacher and the learner.

[4] Ms Baartman composed the poem during an activity conducted in one of the researcher's lectures with in-service mathematics teachers.

- Schools should provide second-language learners with support in their home language and in English language while learning mathematics.
- Teachers, curriculum advisors and other professionals who have the necessary expertise should carefully assess the language and mathematics proficiencies of each learner in order to make curricular decisions and recommendations.
- Mathematics teaching, curriculum and assessment strategies should be based on best practices and build on the prior knowledge and experiences of learners and their cultural heritage.
- To verify that barriers have been removed, teachers should monitor enrolment and achievement statistics to determine whether second-language learners have gained access to and are succeeding in mathematics courses. Reviews should be conducted at school, district, provincial and national levels.

It is worth pointing out that mastering the mathematical register alone or accumulating a collection of mathematical vocabulary does not constitute better performance in mathematics. There are other factors that are associated with mathematical learning and teaching. The section below details a number of key factors that need to be considered when using language as a resource in mathematics teaching and learning.

3.4 Mathematics teaching and learning in a second language

There is growing recognition that language, bilingualism and multilingualism play a key role in mathematics teaching and learning (Barwell, 2009). Given the increase in international migration, and the dominance of English as a language for learning and teaching mathematics, many learners face a transition to learning mathematics through the medium of English (Barwell, Barton & Setati, 2007). Much diverse research has been undertaken on the effect of second-language teaching in mathematics instruction (Adler, 1998; Barwell, 2009), but this research is specifically concerned with addressing the teachers' English-language competency association with mathematics instruction and investigating the difficulties encountered with the English mathematics register when English is the learners' second language of learning. A collection of studies investigating the teaching and learning of mathematics using English as the LoLT is detailed in Chapter 4.

3.4.1 Code switching in mathematics classrooms

The process of language switching appears to be unconscious and unplanned behaviour, but there has been a move towards using the primary language of instruction in the classroom (Clarkson, 2007: 212). However, Clarkson (2007) places an emphasis on the role that the mathematics teacher can play, given their knowledge of language use, in order to enhance their learners' mathematical ability. Code switching is often associated with terms such as code mixing and borrowing (Chikiwa, 2016), which are described below.

- **Code switching**

Cook (2001) defines code switching as a natural phenomenon in settings where speakers share two languages. It refers to the alternate use of two or more languages in the same utterance or conversation. It is a trait of bilingualism and a form of translanguaging in which there is juxtaposition within the same speech exchange of passages of speech belonging to two different grammatical systems or subsystems (Gumperz, 1982). With most of the world becoming multilingual (Jegede, 2012), as a result of globalisation and migration of people within and beyond countries and continents, the use of more than one language in daily speech is becoming more prevalent than it was. Code switching occurs when one substitutes a word or phrase in one language with a phrase or word in a second language (Heredia & Altarriba, 2001). It is the use of elements from two languages in the same utterance or in the same stretch of conversation (Genesee, Paradis, & Crago, 2004). It is the use of two or more linguistic varieties or elements from other languages within the same utterance or conversation. This occurs naturally in day-to-day conversations especially in multilingual societies (Martin, 2007; Metila, 2009; Mahadhir & Then, 2007). Code switching can thus be regarded as a diverse linguistic resource from which teachers can choose to draw in order for them to communicate mathematical concepts effectively and successfully (Mati, 2004).

- **Code mixing**

Bokamba (1989) defines code mixing as the embedding of various linguistic units such as affixes, words, phrases and clauses from a cooperative activity, where the participants must reconcile what they hear with what they understand. This resonates with Ncoko, Osman and Cockcroft's (2000) notion that code mixing involves the mixing of affixes, words, phrases and clauses from more than one language within the same sentence and speech situation. Thus code switching and code mixing are in some cases used interchangeably (Mahootian, 2006), even though code mixing often refers to intra-sentential code switching only. In language studies and other literature, there is no widespread consensus on the precise meaning of code mixing and its theoretical distinction from code switching (Myslìn & Levy, 2014). Code switching and code mixing are usually used complementarily (Chikiwa, 2016), with code switching for alternation between sentences and code mixing for alternation of two languages within a sentence (Winford, 2003).

- **Borrowing**

Borrowing is defined by Bokamba (1989) as the introduction of single words or short, frozen, idiomatic phrases from one variety of language into the other. Treffers-Daller (2007) describes borrowing as the incorporation of features of one language into another. Such borrowing may include integrating and assimilating structural features (phonics, semantics), figurative language, metaphor, verbs, nouns, adjectives connectives, simile and many others from one language into another, since any linguistic feature can be transferred from any language to any other language (Thomason & Kaufman, 1988). It is also explained by Hughes, Shaunessy and Brice (2006) as a means of using one primary language, but mixing in words or ideas from another.

Chikiwa (2016) declares that, in borrowing, code mixing and code switching the speaker actively using both languages, alternating between them or incorporating features from one into another to achieve predetermined goals.

3.4.1.1 Teacher code switching in the classroom

Teacher code switching is a common phenomenon in many multilingual mathematics classes, where the LoLT is neither the teacher's nor the pupils' first language (Chikiwa, 2016). Code switching is a reality in multilingual classroom (Halai, 2009) and teachers' code switching in such classrooms arises for various reasons. Zevenbergen (2001) posits that even if there is an official policy about this, teachers make individual spontaneous decisions about language choices, and these are mostly determined by the need to communicate effectively. Being entrusted to implement the school curriculum, teachers do so through the best pedagogical options available to them (Chikiwa, 2016). This study seeks to highlight that these assumptions often lead to linguistic malpractices in IP mathematics classrooms.

Teachers often use code switching for different purposes. Some of these purposes include:

- Code switching for pedagogical and curriculum access reasons;
- Code switching for communicative purposes;
- Code switching for social reasons;
- Code switching for classroom management purposes; and
- Code switching for identity purposes.

Adapted from Chikiwa, (2016)

The linguistic relevance of these teacher code-switching purposes is clarified further by Gumperz (1982), who describes them as metaphorical functions; thus, further clarifying the purposes of code switching when used in a conversation. The six metaphorical functions of code switching suggested by Gumperz (1982) are quotation, addressee specification, interjections, reiteration, message qualification, personification versus objectivisation, and situational code switching. These functions are briefly described in Table 3.5.

Table 3 .5: Functions of code switching

Function	Description
Quotation	- A form of code switching used when quoting or reporting someone else's discourse.
Addressee Specification	- A code-switched message that aims at a particular / different addressee. - Code switching that occurs when a teacher is directing a message to one of the learners or a specific group of learners.
Interjections	- Code switching that is used to express an emotion or sentiment.
Reiteration	- Teacher code switching that is used to emphasize, clarify or amplify the intended message. - A code-switched message repeated from one code to another, either literally or in a modified way.
Message qualification	- Code switching used by a teacher to add more information in order to qualify the main message. - A code-switched message that elaborates what has been said.
Personalisation vs. Objectivisation	- Code switching that relates to the distinction between talk about action and talk as action; the degree of speaker involvement in a message reflects personal opinion or knowledge, whether it relates to specific instances or has the authority of generally known facts.
Situational code switching	- Code switching that results from a change in social setting: topic or participants.

Adapted from Gumperz, (1982: 75 – 84)

Though the list is not exhaustive, the functions of code switching stated above capture the dynamic nature of teacher code-switching practices in an attempt to convey meaning in multilingual mathematics classrooms (Gumperz, 1982; Mahootian, 2006).

Since teaching and learning is a two way process that involves both the teacher and the learner, teacher code switching is directly related to learners code switching. Research has shown that learners' language practices in the classroom reflect those practices their teachers expose them to (Rollnick, 2000; Barton & Neville-Barton, 2003). Learners have the teacher as their 'more knowledgeable other' (Vygotsky, 1981) and model in the classroom. Thus the teachers' use of code switching in turn influences the learners who may, as in many cases in South African classrooms, already be using it (Chikiwa, 2016).

3.4.1.2 Code switching as a resource in mathematics instruction

Research on multilingualism in mathematics classrooms and other learning areas has indicated that code switching does not necessarily imply a breakdown in communication, but can actually serve as a resource or a competence available for use by multilingual learners and teachers

(Adler, 2001; Chikiwa, 2016; Bullock & Toribo, 2009; Howie, 2003; Moschkovich, 1999, 2002; Setati, 2005). Therefore, teachers need to take advantage of the presence of multilingualism in their classrooms and use it to achieve meaningful learning and teaching. The perception that code switching is a teaching and learning resource has attracted much attention in a range of mathematics education studies in and outside of South Africa (Adler, 1998; Chikiwa, 2016; Chitera, 2009; Halai & Karuku, 2013; Jegede, 2012; Khisty, 1995; Moschkovich, 1999; Setati, 1998, 2005, 2008; Vorster, 2008).

This study highlights the need for mathematics teachers to be enlightened on different methods of code switching and their applications to promote an effective use of the teaching strategy in IP mathematics classrooms. Once teachers are confident in the practice of code switching, they will be able to easily and purposefully switch from one language to the other, compared to embarking on the practice without planning. Planned code switching would also enable teachers to provide coherent explanations in both the mother tongue and the prescribed LoLT, and not only provide a watered-down version of mathematical concepts. IP mathematics teachers' mastery of code switching will ensure that teachers leave the learners with the correct explanations of the mathematical concepts in the language of assessment. Thus teachers will be able to explain concepts in their mother tongue and still manage to take the learners back to the English version of the concepts which learners are most likely to encounter during assessment.

The notion of bilingualism (a factor which usually gives rise to code switching) and how it is often viewed when determining the language of instruction is dealt with in detail in Chapter 4 of this study. The section below briefly describes how cultural and socio-political issues interfere with the use of language as resource in mathematics instruction.

3.4.2 Culture and socio-political issues

English is the dominant language of instruction and is perceived as the language of power in Africa, even though relatively few people have it as a first language. Setati and Adler (2000) undertook an extensive review of research that had taken place in South Africa. Their focus was on mathematics learning and bilingual education. They found a significant relationship between language proficiency and mathematical achievement. In particular, they noted that oral proficiency in English in the absence of mother-tongue instruction was negatively related to achievement in mathematics. However, an important aspect highlighted by the research is that the findings cannot only be attributed to the learner's language ability alone. Factors including social, cultural and political issues also need to be considered, as they have a significant impact on the teaching and learning process and schooling in general.

3.5 Conclusion

This chapter sought to explain how language can be used as a resource in mathematics instruction. Bohlmann (2001) highlights the importance of language for mathematical learning, given that "It is the medium by which teachers introduce and convey concepts and procedures, through which texts are read and problems are solved. For second-language speakers of English, the challenge they face is twofold in that they have to acquire the new language of learning, as well as learning mathematics through the medium of a new language" (Bohlmann, 2001). Being proficient in conversational English does not guarantee successful learning in mathematics. As Barton and Neville-Barton (2003) emphasise, proficiency in 'mathematical English' is an important factor in learning mathematics. Studies such as those by Dowker (2005) and Neville-Barton and Barton (2005) demonstrate that the mathematics register in English plays a significant role in the transition from the mother tongue to English-medium mathematics instruction. This chapter has reviewed particular aspects of the English mathematics register that may be sources of difficulty for IP mathematics learners and teachers in the transition to English-medium mathematics education in the South African education system.

One cannot overlook the importance of culture and its association with mathematical teaching, learning and understanding. This factor is heightened for this study in the sense that it is concerned with mathematics teachers dealing with learners moving between cultural environments, from a culture of mother-tongue mathematics instruction to a culture of English-medium instruction. The literature reveals that learners' language competency is related to mathematics achievement. This study concurs with research that deems language should be used as a resource in teaching IP mathematics.

In communities using a medium of instruction which is a second language to both the learners and the teachers, it is important to equip teachers with the necessary linguistic skills to facilitate mathematics instruction (specifically skills for using language as a resource in mathematics instruction), without assuming that pre-service teacher training alone adequately equips teachers to facilitate a smooth transition from mother-tongue to English-medium mathematics instruction without the support of in-service professional development courses in language competency. The literature reviewed in this chapter concurs with other educationists (Adler, 1998, 2001; Barwell, 2009; Chikiwa, 2016; Jegede, 2012; Mafela, 2009; Manu 2005; Setati, 2008), who declare that **teaching mathematics in a second language requires more teacher effort as it calls for the teaching of content, language of mathematics and English language**.

CHAPTER 4

PERSPECTIVES ON LANGUAGE COMPETENCY AND LANGUAGE OF LEARNING AND TEACHING MATHEMATICS

4.1 Introduction

This study seeks to understand the linguistic preparedness of Intermediate Phase (IP) teachers to teach mathematics in a second language (specifically English), and this in turn necessitates an understanding of second-language acquisition. This chapter locates the study within the theory and practice of language competency in relation to the language of learning and teaching. It explores diverse issues related to second-language acquisition and learning from multiple perspectives to position the current study as well as to expose the complexity of second-language learning. Since the current study is concerned about the critical and often mishandled teacher language competency to sustain effective mathematics instruction in English (a second language for both the teachers and the learners) as a LoLT at IP level, it is imperative to locate the study within the context of second-language literacy acquisition and learning. This chapter is divided into five main sections, which look at language development and acquisition, second-language acquisition, bilingualism, an overview into some theoretical and empirical studies on the role of language in learning and teaching, and mathematics teacher education in South Africa in relation to teacher language competency.

The following section outlines various language theories in order to explore the needs of IP mathematics teachers in terms of language development, acquisition and usage, and attempts to determine the effect of these theories on the quality of their instruction.

4.2 Language Development and Acquisition

One of the main focuses of this study is to interrogate the role played by teachers' language competency in mathematics instruction. It is therefore of paramount importance to highlight the theories of language development and acquisition that are associated with language competency.

4.2.1 Multiple Intelligences of Language Development

Gardner's theory of multiple Intelligences provides a clear picture of the development and acquisition of language among individuals in various specialities. In Table 4.1 Armstrong (2009) outlines the categories of Gardner's Multiple Intelligences as the basis of successful language development.

Table 4.1: Categories of Multiple Intelligences in Language Development

Type of intelligence	Description
Verbal – linguistic	- well-developed verbal skills and sensitivity to the sounds, meanings and rhythms of words
Logical – mathematical	- ability to think conceptually and abstractly, and capacity to discern logical and numerical patterns
Visual – spatial	- capacity to think in images, pictures colours and shapes, to visualize accurately and abstractly
Musical – rhythmic	- ability to produce and appreciate rhythm, pitch and timber
Interpersonal	- capacity to detect and respond appropriately to moods, motivations and desires of others
Intrapersonal	- capacity to be self-reflective and in tune with inner feelings, values, beliefs and thinking processes
Existential	- sensitivity and capacity to tackle deep questions about human existence
Naturalistic	- ability to recognize and categorize plants, animals and other objects in nature
Bodily – kinaesthetic	- ability to control one's body movements and to handle objects skilfully

Armstrong, (2009)

Gardener emphasises that people possess intelligence in different degrees, which makes them unique in various contexts. It does not matter in which language the intelligences are expressed, they contribute strongly to one's language acquisition. Thus, it is important to establish what proficiencies are appropriate for each category. The Total Physical Response (TPR) tool, which draws on physical movement, provides an additional means of successful and positive language development. The tool considers gestures, movements and physical expressions as essential in learning vocabulary, expressions and simple commands which all contribute to the ability to use language effectively. Hence, for the development of a language, grammar rules, verbs and conjunctions (for example) are memorised for effective interpretation of written texts or passages that are related to certain physical movements (Richards & Rodgers, 2001).

Language acquisition occurs in first- and second-language settings: the former generally involves learner language development, and the latter generally involves adult language development Armstrong (2009). Thus first language acquisition usually occurs when an individual is young, while second language acquisition usually occurs as the individual grows older. However, the language acquisition settings are not mutually exclusive. For the purposes of this study, adult language development would refer to IP mathematics teachers' language development for the purposes of effective content delivery in the prescribed LoLT.

In first-language learning, language is intertwined with the development of cognition, while analysis of errors made during second-language learning reveals the development of an inter-language. The correction of the errors made in second-language learning concretises the grammar of the new language and ultimately helps to improve the language-acquisition process (Hayes, 1970; Caroll & Freedle, 1972; Brown, 1973).

Language acquisition is related to the learning process, with an emphasis on understanding and communication. In this regard, language acquisition involves the interrelationships among the processes of listening, speaking, reading and writing, which are integral to communication (Clark & Clark, 1977; Krashen, 1981; Cohn, 1990; Olivier & Olivier, 2013). In language acquisition, competency can be improved by implementing certain teaching strategies, and the outcomes depend upon the nature of the tasks and the ability of the learners. Performing a collection of activities with specified outcomes enables the learners of a language to master an identified part of the curriculum (Wended & Rubin, 1987; Chamot & O'Malley, 1994; Brown, 2007).

4.2.2 Cognitive Academic Language Approach

The Cognitive Academic Language Learning Approach (CALLA) promotes language development and acquisition by intensifying the practical implementation of English language learning (Chamot & O'Malley, 1994). CALLA emphasizes the inclusion of listening, speaking, reading and writing activities in content subjects on a daily basis as the most vital mechanism for the development and acquisition of language. An increased frequency of the use of such activities would thus benefit individuals whose medium of instruction is a second language, and who usually show slow progress.

The three major theoretical foundations of CALLA are language development, content area instruction and explicit instruction in learning strategy (Chamot, 1994). These theoretical foundations develop cognitive abilities, linguistic abilities as well as metacognitive abilities. The fact that learners are viewed as mentally active participants in the teaching and learning process gives these theoretical foundations their dynamism. Other mental activities that are propounded by these theories for reinforcement at various levels include the application of prior knowledge to new problems, searching for meaning in new information, higher-level thinking and developing the ability to regulate one's own learning.

4.2.3 Communicative Language Theory

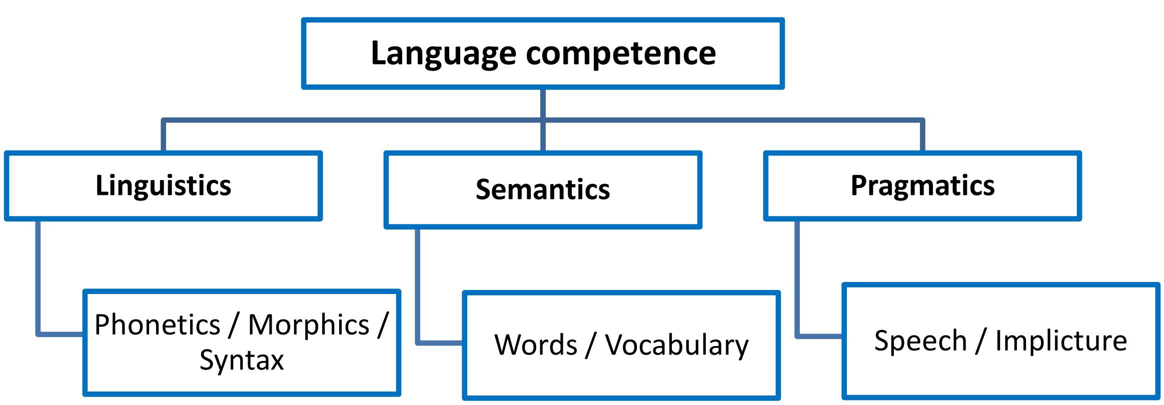
Griffiths (2003) describes the communicative approach to language learning as the techniques or devices which an individual may use to acquire knowledge. Griffiths identifies direct and indirect language-learning strategies that contribute positively to effective language learning. Direct and indirect learning strategies are characterised as follows:

- Direct language learning strategies involve clarification, verification, monitoring, memorisation, guessing (inductive inferencing) and deductive reasoning;
- Indirect language learning strategies involve creating opportunities for practising the language.

Communicative language theory describes the goal of language teaching as the act of developing communicative competences; a learner who acquires communicative competence acquires both knowledge and ability of language use. The communicative theory also incorporates the pragmatic competence and linguistic competence in which an individual learning a language communicates by addressing formal gatherings, handling examinations, dialogue, speech, report writing and academic arguments. General language features are taken into account in the process of language acquisition and learning. Thus, a learner learning a language consistently uses the language in various formats and therefore gains confidence (Hymes, 1972; Richards & Rodgers, 2001).

General language features serve an essential role in allowing learners to participate actively in learning the language successfully and therefore becoming competent. Each general language feature consists of phonemics, morphics, syntax, vocabulary and speech. The three general features of language – namely linguistics, semantics and pragmatics – that focus largely on meaning derived from language expressions are outlined in Figure 4.1.

Figure 4.1: Communicative Competence Features



Adapted from Krashen and Brown, (2007)

The communicative principles of language learning also include the abovementioned activities that promote language learning. The activities are used to carry out meaningful tasks that promote learning and also create the language that is meaningful to the learner. The activities are selected according to how well they engage the learner in meaningful and authentic language use, as well as promote second-language learning (Krashen & Brown, 2007)

Richards and Rodgers (2001) encourage language practice as a way of developing communicative skills in various communicative contexts. They suggest that the objective of the communicative approach is to provide the language speaker with opportunities to apply the language. The following pointers demonstrate that learners have acquired the required and appropriate communicative skills to use the language successfully:

- Integrative and content levels that utilise language as a means of expression;
- Linguistic and instrumental levels that utilise language as a semiotic system and an object of learning;
- An affective level of interpersonal relationship that utilises language as a means of expressing values and judgements about oneself and others;
- A level of individual learning that utilises language as a remedial process based on error analysis of language; and
- An extra-linguistic ability that prioritises language competency as the core of mastering subject specific content.

Various linguistic researchers describe different conceptual perspectives that address conversational and academic language for communicative competence, as listed in Table 4.2.

Table 4.2: Theorists and concepts addressing conversational and academic language for communicative competence

Linguistic theorist	Language concept
Vygotsky 1962	Understanding scientific concepts
Bruner 1975	Demonstrating communicative and analytical competence
Donaldson 1978	Acquiring embedded and disembedded thought and language
Canale 1983	Developing communicative and autonomous proficiency
Mohan 1986	Application of practical and theoretical discourse
Snow 1991	Ability to contextualise and decontextualise
Cummins 2000	Developing the BICS and CALPS
Baker 2001	Appropriate cognitive process, conversational proficiency and language proficiency

These conceptual perspectives need to be acknowledged in the process of teaching and learning language for communicative purposes. The perspectives enable distinctions to be make between communicative characteristics. Richards and Rodgers (2001) describe complementary communicative competence features of language knowledge, such as knowing how to:

- use language for a range of different purposes and functions;
- vary the use of language according to the setting and participants;
- produce and understand different types of texts such as narratives, reports, interviews and conversations; and
- maintain communication despite having limitations in one's language knowledge.

It is therefore evident from the background provided on the poor literacy skills among teachers in South Africa that these aspects of language should form part of the curriculum as a means of raising the standards of language competency for the purposes of improving numeracy skills.

The characteristics of the communicative view of language are closely linked with acquiring the linguistic means to perform different kinds of communication as outlined below:

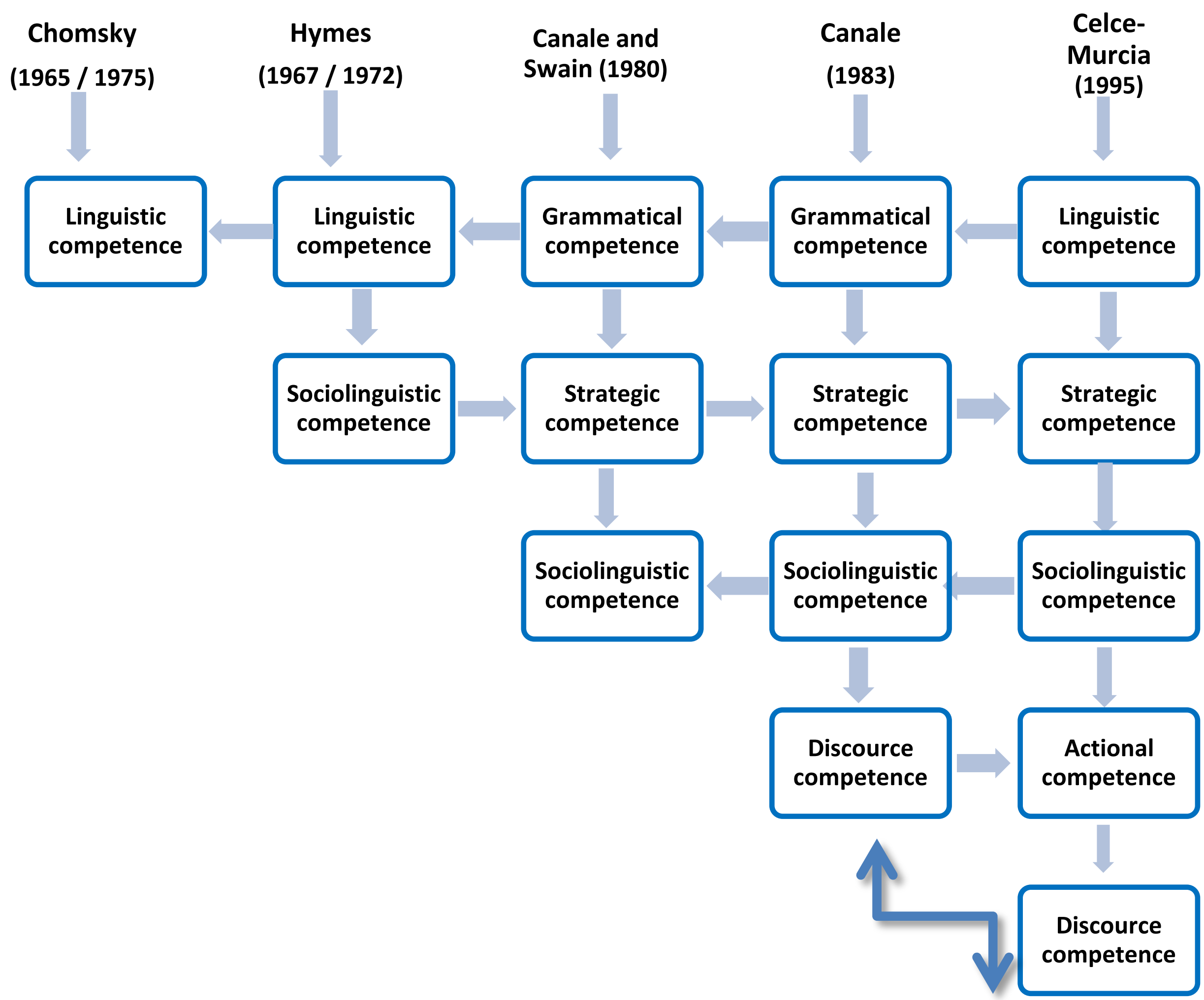
- language is a system of expressing meaning;
- language is used for interaction and communication;
- the structure of language reflects its functional and communicative uses; and
- the primary units of language are its grammatical and structural features.

As investigating IP mathematics teachers' language competency is one of the main objectives of this study, the characteristics mentioned above contribute towards successful communicative competence. The development of these communicative skills serves as an influential function that directs teaching and learning. The movement from one level to the other demonstrates the transition that occurs in terms of language acquisition and development within various contexts.

4.2.3.1 Evolution of the communicative language approach

The evolution of communicative competence implies that various linguistic experts present significant explanations of the movement from one concept to the other to explain the necessity for these conceptual changes. Figure 4.2 broadly illustrates the evolution of communicative language competence.

Figure 4.2: The evolution of communicative language competence



Adapted from Richards and Rodgers (2001)

The interconnectedness between the various language competences marks the successful progression and dynamic change which contributes to the theories and understanding of language development. It is therefore important to consider that, from the perspective of either the learner's or the teacher's language competency, all these competencies need to be demonstrated in various teaching and learning contexts.

4.2.3.2 Advantages of the communicative competence

The communicative language method allows the proficient teacher to provide a context that allows class interactions that are realistic and meaningful, but with the support needed to generate the target language. This occurs because language is a skill which needs to be practised in improvised settings. During the practise phase, there is a lot of preparation required to equip an individual learning a language with the necessary vocabulary, structures, functions and strategies to enable them to interact successfully (Ellis, 1997).

The communicative method focuses on language as a medium of communication and therefore recognises that all communication has a social purpose, as the individual learning a language has something to say or find out. In the same way, most of the communication activities that take place in the classroom maximise opportunities for learners to use their target language in a communicative way to promote meaningful activities. The communicative method is more learner-centred and is also directed by the needs and interests of learners. Learners are not limited to practising oral skills but are exposed to reading and writing skills which are developed to promote their confidence in using and learning the language.

Communicative learners become independent, highly adaptable, flexible and responsive to facts, prefer social learning and a communicative approach, and enjoy taking decisions (Ellis, 1997). These learners like to learn by watching, listening to native speakers, talking to friends in English, watching television in English and learning new words by hearing them or learning though conversation.

4.2.3.3 Language approaches associated with language competency

The intervention approach, translanguaging and code switching are the three main language approaches associated with language competency in this context. The translanguaging and code switching approaches were covered in detail in Chapters 2 and 3 respectively, including how the two approaches can be used as resources in mathematics teaching and learning. The section below describes the intervention approach.

4.2.3.3.1 The intervention approach

Clay (2001) and Nathanson (2009) describe the intervention approach and emphasise the intervention process of cognitive processing to reading and writing ability as essential elements of language competency. These cognitive processes allow learners to abstract meaning from print by crosschecking and integrating multiple sources of information, such as syntactic, semantic, visual and phonological information.

According to Cazden and Clay (1992) and Nathanson, (2009), learners should develop a rich cognitive network that allows them to read independently. By teaching reading and writing concurrently, the individual is enabled to make links between speaking, reading and writing. This also provides the teacher with valuable practical information to improve instruction. The literacy intervention approach matches the instruction to an individual’s zone of proximal development, whereby the individual’s level of potential development is determined through problem solving under the guidance of another capable individual or a mentor (Vygotsky, 1978; Ballantyre, 2008; Nathanson, 2008). Learning is therefore directed at the individual’s zone of potential development.

This study is driven by research findings which confirm that South African schools are experiencing alarmingly low literacy and numeracy levels; as such, teachers should be equipped with necessary linguistic skills to reinforce successful mathematics teaching and learning as a way of promoting academic success. The literacy learning process depends on the types of opportunities that teachers provide for further development of cognitive networks in learners (Lyons, 1981; Nathanson, 2008). These early reading and writing experiences of an individual create a network of competencies which enable independent literacy learning. Similarly, if teachers are tasked with promoting literacy levels in schools, by extrapolation teacher educators should promote literacy levels among trainee teachers and teachers already in service.

Success in learning to read and write depends on different cognitive systems (Rumelhart & McClelland, 1986; Clay 2001; Nathanson, 2008). This suggests the need for constructive approaches to literacy learning by developing interacting competencies in reading and writing. The literature correlates with the study's objective of seeking to determine the relationship between language competency and effective instruction, specifically IP mathematics instruction.

4.2.3.4 Descriptive and prescriptive approaches to communicative language

Horne and Heinemann (2003: 37 – 40) classify communicative language in terms of descriptive and prescriptive approaches as illustrated in Table 4.3.

Table 4.3: Descriptive and prescriptive language approaches

Descriptive Language Approach	Prescriptive Language Approach
- Emphasises the description of actual language usage without making judgements about the right and wrong usage of the language	- Emphasizes the rules that govern language usage which are imposed on language users
- Describes and records language diversity as critical	- Prioritises standards of language usage as essential
- Positions the use of language as the first point of reference	- Positions rules of grammar for various texts as the point of reference
- Accepts non-standard varieties of language	- Does not accept or tolerate non-standard varieties of language and they are regarded as bad language

Adapted from Horne and Heinemann (2003: 37 – 40)

The two approaches clearly depict the opposing views on the acceptable ways of using language. The facts that the views are opposing each other may create confusion for learners of a language and, most important, impact negatively on the ability and rate of achieving competence in language learning. However, Trask (1995) is of the opinion that effective communication should be guided by principles which allow educational institutions to teach a uniform standard of a language that promotes understanding. Thus educational institutions should recognise the existence and value of other varieties of language.

4.2.3.5 Implications of language theories in developing language competency

Failure to continue first-language development inhibits levels of language proficiency and cognitive academic growth. Thus, home-language proficiency is a strong indicator of second-language proficiency (Saville-Troike, 1988; Hakuta, 1990). Therefore it will not be assumed that non-native speakers of English who have attained a high degree of fluency and accuracy in everyday spoken English have a corresponding academic language proficiency. Some non-native speakers exhibit disparities in language usage and these disparities interfere with their ability to learn. For the purposes of this study, such disparities are deemed to be associated with mathematics teachers' ability to teach using English as LoLT.

In separate studies conducted by Maxwell (1998), Starkey (1998), Stephen, Welman and Jordan (2004) the results revealed that more than 90% of black students in tertiary institutions lacked the comprehension skills required for successful completion of their studies. By extrapolation, pre-service mathematics teachers are a subset of this group. Poor comprehension skills among tertiary-level students result in high dropout rates, poor attendance of lectures and low examination pass rates.

Duffy (1993) and Stephen, Welman and Jordan (2004) state that teachers are faced with the challenge of helping learners to acquire the vocabulary and linguistic structures needed for successful academic performance. If the teachers are not competent in the language, they only expose learners to limited language functions deemed important to access academic content.

Chamot (1997) and Brown (2007) are of the opinion that academic success depends on an individual's ability to understand the language of the textbooks and school discourse. Academic language is therefore inextricably tied to academic language functions and to higher-order thinking skills. These higher-order thinking skills need to be developed during the teaching and learning process.

Language competency assists an individual to construct and integrate acquired information into their own understanding and linguistic incompetence therefore results from the lack of linguistic knowledge to fulfil various communicative needs that aid better performance. It is highly likely that challenges in understanding the LoLT spill over and affect other aspect of the academic environment ranging from the basic ones such as following directions to understanding instructions, reading, comprehension as well as the more complex ones such as interpretation of questions and discussions. Such challenges may result in an individual experiencing difficulty in expressing thoughts on paper as result of language limitations.

Gabela (2005) and Uys, van der Walt, van den Berg, and Botha (2007) consider the use of English as a LoLT as a disadvantage for learners, considering that some teachers have a low proficiency in English as an additional language. This situation is compounded by the background of learners who need additional academic support in the area of language development. Dalvit, Murray, Mini, Terzoli and Zhao (2005) state that teachers' use of English is limited to the school environment; the concepts of a given subject and the knowledge taught. This predicament seems to intensify when the teachers have to improvise and use alternative strategies such as code switching to interact with the learners.

A diagnostic report compiled by chief examiners and markers of matric examination papers (DBE, 2013) identifies the following factors as responsible for low scores across the curriculum:

- lack of subject terminology;
- poor language usage;
- lack of vocabulary;
- misunderstanding of questions and instructions;
- difficulty in expressing oneself;
- misspelling of words; and
- poor reading and comprehension skills.

All the factors listed above are essential to language literacy and they associated with performance as well as the ability to communicate in various school contexts. Although these literacy-related factors are diagnosed at matric level, they are usually carried over from lower grades and learners carry them right across the curriculum if they do not receive adequate corrective measures from their teachers.

Teachers who neglect early writing skills severely limit learners' opportunities to learn and thereby contribute to slower progress; furthermore, when most teachers respond to learners' inability to understand English, they resort to code switching to compensate for their own incompetence in oral language as well as low confidence levels in using English as a LoLT (Clay, 2001; Nathanson, 2008). This study contends that if teachers often resort to code switching in order to assist learners, the should be well versed with the practice and functions of code switching for meaningful learning to take place.

There is no consensus on what constitutes a sound second-language learning strategy or how this differs from other types of learner activities and their relationships (Rubin, 1980; O'Malley, Chamot, Stewner-Manzanares, Küpper & Russo 1985; Ellis, 1986; Griffiths, 2003). Communication strategies and language-learning strategies are therefore seen as two separate manifestations of language-learning behaviour. Thus, language-learning strategies compensate for inadequate resources.

Tarone (1981) and Griffiths (2003) believe that communication strategies expand language learning when individuals are assisted to express themselves. The communication may not be grammatically or lexically correct, but it exposes the individual to language input which may result in learning. Tarone and Griffiths reiterate that differentiating between communication strategies and language learning strategies on the grounds of motivation may create confusion where the learner has a dual motivation for both learning and communication. Learners may learn even though the basic motivation was to communicate; thus, it is difficult to establish a clear relationship between communication strategies and learning strategies.

There is widespread concern over South African learners' extremely low literacy levels and how this affects their ability to read (Townsend & Turner, 2000; Bloch, 2009; Ramphele, 2008; Spaull, 2016). These South African educationists also argue that poor reading skills impact on learners' academic performance and their overall development. A portion of these learners who end up choosing careers in teaching transmit their own inadequacies to their learners, sparking a chain reaction of mediocrity in the mastery of the LoLT and hence compromising the overall quality of learning and teaching in the country.

Rothwell (2010) proposes various constructionist models which describe the process of communication in various contexts as illustrated in Table 4.4.

Table 4.4: Constructionists models of communication

Model	Descriptions
Linear	One-way model to communicate with others while assuming there is a clear beginning and end to communication: a message sent through an email, letter or a lecture presentation.
Interactive	Two-way communication which has added feedback such as the sender sending the message to the receiver, which in turn is channelled by the receiver back to the original sender.
Transactional	A model which assumes that people are connected through transactional communication and affects all parties involved such as talking or listening to a friend and providing feedback through facial expressions.

Rothwell (2010)

The social constructionist considers communication to be the product of sharing and creating meaning among speakers. The truth and ideas are constructed or invented through the social process of communication. This study intends to identify the most appropriate communicative model that can be adapted and used to improve IP mathematics teachers' quality of instruction using English as LoLT.

Cuvelier, Du Plessis and Teck (2003) highlight that parents usually dissociate themselves from deciding the LoLT used in schools, partly as a result of fear of disrupting the status quo in schools. According to the Language in Education Policy (LiEP) (DAC, 2003), the SBG is mandated with this task, and most often English is chosen as the LoLT. This makes the LoLT a critical aspect of the teaching and learning process. The South African government is well aware that the acquisition of initial literacy *and numeracy* in the home language for at least the first four years of schooling leads to improved literacy levels; however, the choice of the LoLT lies with the parents. Most parents choose to have their children taught in English, because the language is perceived to be linked to better opportunities, which reflects the language of social and economic mobility, whether or not there is the appropriate supportive environment for teaching and learning in English. Oxford University Press, for example, published all core Grade 1-3 textbooks and workbooks in all 11 languages; but there was so little demand for African language editions after Grade 3 that virtually no publishers produced them, except for textbooks for learning African languages (McCallum, 2004: 180).

Studies conducted by the Organisation for Economic Co-operation and Development (OECD) showed that learners, and teachers themselves prefer to use English as LoLT; however, prevailing practice in teacher education does not equip teachers to confidently use English as LoLT. The issues of LoLT and 'time on task' (TOT) are also relevant to learner achievement; the available data show that, where learners are taught in their home language by teachers whose first language is also the language in which they teach, learning outcomes are higher than for learners whose LoLT is not their (*or their teachers'*) first language (OECD, 2008: 188).

Without promoting the hegemony or dominance of the English language, immediate measures need to be put in place to capacitate teachers to be confident and proficient in the use of English as LoLT, especially at IP level, where the transition from mother-tongue to second-language instruction occurs. Failure to prioritise this will continue to see South Africa occupying the lowest position in its mathematics and science education compared to other sub-Saharan countries. Without drastic changes under-resourced schools, staffed by under-qualified teachers, will continue producing half-baked school leavers who cannot cope with the demands of tertiary education.

4.2.3.6 Related approaches and theories to language competency

English second -language speakers' academic success is dependent on their proficiency and competence in academic language (Brown, 2007). Therefore teachers of ELLs should move beyond the functional syllabi stipulations and provide a content-rich and high-standard curriculum that prepares the second-language speakers to become academically successful in content learning. Against the backdrop of the South African education system, providing essential communicative skills that will ensure language competency among primary school teachers would be positive way of modelling good practice for emulation by the teachers in their own classroom settings, where the majority of the learners are second-language speakers of the English language.

Low levels of academic performance and unsatisfactory overall rates in some South African schools and higher institutions of learning suggest that responses to the teaching and learning needs of the underprepared learners are not sufficient (SAUVCA, 2003; Paredes, 2010; Eid, 2012). Furthermore, teacher professional development initiatives like the ones proposed by this study, aimed at strengthening primary school teachers' language competency in the prescribed LoLT, need to be prioritised.

4.2.3.7 Implications of low language competence for teaching

Since South Africa's democratisation English has become the lingua franca in public life and the language is prevailing as the LoLT at primary and secondary school levels as well as in higher education (Cuvelier, Du Plessis and Teck, 2003). Since many educational institutions are in a state of change (Cuvier et al., 2003) further content that School Governing Bodies (SGBs) are mandated with the power to decide on the LoLT for their schools. A common practice that has been adopted by most SGB is additive bilingualism, where FP is taught in the mother tongue, while English is taught as a first additional language in preparation for a transition that takes place in the IP, when English becomes the LoLT. While this is a plausible attempt at balancing the attention given to marginalised languages, SBGs that have adopted this policy need to further support it by making sure the transition is smooth enough and does not compromise the quality of learning and teaching at IP level.

Language learning and teaching thus becomes the imperative for communicative competence (Bryant, Roberts, Bryant & DiAndreth-Elkins, 2011; Kock & Woods, 2004). Thus, the main objective of language teaching involves stimulation of an individual's oral communication to enable the individual to produce and receive communication in that language. For this reason it becomes imperative to improve usage of language in various learning contexts, including the mathematics learning context.

4.3 Second-Language Acquisition

There is a vast amount of literature dealing with second-language acquisition, which is a sub-discipline of applied linguistics. Being fluent in a second language is essential for gaining meaningful access to education, the labour market and broader social functioning. In sub-Saharan Africa the question of how best to develop second-language fluency amongst large parts of the citizenry remains a critical component of education planning. South Africa is one such country facing the challenge of how to most effectively equip the majority of its population with a second language, in this case English.

It is easier to acquire and learn the other basic interpersonal communication skills, particularly by individuals who spend huge amounts of time interacting with native speakers (Cummins, 2000: 2). Second language speakers who have attained a high degree of fluency and accuracy in everyday spoken English have the corresponding academic language proficiency, which dispels the myth that speakers who exhibit language disparity have special educational needs, when they actually need more time to learn the new language. Cummins further notes that the common underlying proficiency in language learning provides the basis for the development of both the first language and the second or additional languages.

4.3.1 The nexus between First Additional Language and Second Language

The Curriculum Assessment and Policy Statements (CAPS) document describes a first additional language as a language which is not a mother tongue, but which is used for certain communicative functions in society. It is also called a second language and assumes that learners do not necessarily have any knowledge of the language when they begin schooling (DBE, 2011a: 12). In South Africa there is a distinction between home language, referred to as a first language, and the first additional language i.e. the second language.

This second language is learnt is taught in addition to one's home language and it may be taught formally in kindergarten, reception year 'Grade R', and at school. The second language may be introduced earlier by parents at home, and/or as learners interact with others in their immediate environment (Mohlabi-Hlaka, 2016: 11; Manyike, 2007: 14; National Council for Curriculum and Assessment, 2006: 04).

A clarification of the use of the term 'additional language' within the South African context is that the term 'additional language' is preferred to 'second language', because the language will exist alongside the first language and be of equal but not necessarily of greater importance to the learner. This clarification is important for its relevance to South African constitutional stipulations and the (LiEP) (DAC, 2003: 8).

For the purposes of this study it is of paramount importance that the teachers who are entrusted to manage the transition period from learning to read at Foundation Phase to reading to learn at Intermediate and higher phases are adequately trained and master the first additional language beyond mediocre levels in order to facilitate a smooth transition later. Therefore, this study is particularly interested in the second-language acquisition models as reviewed in the following section, because the LoLT at IP level is a second language to 90% of the learners and teachers.

4.3.2 Models of Second Language Acquisition

This section gives an overview of the models of second-language acquisition which attempt to explain how a second language is acquired. The seven models are input hypothesis, output hypothesis, interaction hypothesis, acculturation model, automaticity model, conditions outcomes model and the associative model (Sibanda, 2014). Each of these models highlights different but crucial features of the language acquisition process.

4.3.2.1 Input Hypothesis

The input hypothesis model contends that the second language is acquired in the same way the first language: through comprehensible input. Krashen (1985) considers input as all that is necessary for the acquisition of a second language provided it is comprehensible to the language learner and that the learner has a low affective filter (attitudinal and mental dispositions which would not interfere with the acquisition of the input). Hart and Risley (1995) identified characteristics of parent language input in terms of linguistic diversity and feedback as predictive of vocabulary scores at ages 9 – 10. From their study, the lower the input learners received, the lower their language knowledge and skills were. Gersten, Baker, Haager and Graves (2005) state that English-language learners who reach near-native-like proficiency in English are those in classrooms where language input is of high quality. According to van Patten (2003), all the second-language acquisition models have an element of input. The input hypothesis highlights the role of input in second-language acquisition above all the others, because it is necessary and sufficient for learners to acquire a second language, provided the conditions are suitable. It is the sufficiency of input that Swain (2005) challenges in her output hypothesis.

4.3.2.2 Output Hypothesis

The output hypothesis acknowledges the role of input in second-language learning; however, it deems input as inadequate to account for second-language acquisition. Despite the vast input to which second language learners are exposed to, and which positively impacts on their oral proficiency, their productive language skills of speaking and writing are limited compared to those of native speakers (Swain, 2005). Swain (2005) identifies three functions of output, namely noticing/triggering, hypothesis testing, and metalinguistic / reflective functions. By trying to produce language either through speaking or writing, learners would become aware of gaps and problems in their current second-language system (noticing), which motivates or 'triggers' them to pay greater attention to that which can make up for the lack. Output also compels the learner to hypothesize what the message encoded should look like (for writing) or sound like (for speaking). Learners go further to test the hypothesis through the actual production of the utterance, which will attract feedback from the more knowledgeable others.

It provides them with opportunities to experiment with new structures and forms (testing hypothesis) On the basis of this feedback they can then modify their utterance or make further hypotheses.

The metalinguistic function of output is what leads the learner to use language to reflect on their or others' language with a view to modifying it. Second-language production (i.e. output), demands that learners engage in complete grammatical processing and promote the development of second-language syntax and morphology. Closely linked to the role of output is the concept of access, which involves "searching the vocabulary store, or lexicon, in the brain to find appropriate words and forms of words necessary to express a particular meaning" (Antony, 2008: 473). Both the input and output hypotheses present distinct explanations for second-language acquisition; however, the interaction hypothesis provides a connection between the input and the output.

4.3.2.3 Interaction Hypothesis

Within the interaction process, interlocutors negotiate meaning and facilitate comprehension, which leads to language learning. The input is not just consumed; it is queried, recycled and paraphrased, which increases its comprehensibility (Mayo & Soler, 2002). Within the interaction pattern, there is modified input and modified interaction. Within the negotiation process, the output is also modified as is the attendant feedback. Modification of the interactional structure of discourse through negotiated interaction between interlocutors is one way in which input is rendered comprehensible (Sibanda, 2014). In relation to the social constructivist model, classrooms therefore need to be optimal learning environments, where contexts for interaction are carefully designed to enable learners to create their own language knowledge within a socially constructed process of discovery.

From the three major hypotheses, it is apparent that second-language learning proceeds on the basis of an interplay between input and output within a context of interaction (Sibanda, 2014). The acculturation model, automaticity model, conditions outcomes model, and the associative model (Bialystok, 2009, 1982; van Lier, 1996) have also been used to explain second-language acquisition but their application in classroom teaching is limited.

4.3.2.4 Acculturation Model

The acculturation model posits that the extent of second-language learning is influenced by the social and psychological distance between the first and second language (Barjesteh & Vaseghi, 2012). The culture of the second language system and how the learners view and are viewed by the new target language group impacts on their acquisition of the language. The model accounts for natural rather than taught second-language acquisition, but its usefulness to the current study is to reveal the importance of second-language acquisition occurring incidentally through exposure to much input. Proximity of a second-language acquirer to the native speakers exposes the acquirer to a great deal of input, which ultimately leads to acquisition. The model is more useful in teacher preparation as a model that examines the impact of external factors on second-language learning. Equally limited in application is the automaticity model (Sibanda, 2014).

4.3.2.5 Automaticity Model

The model distinguishes between explicit and implicit language knowledge and the degree to which the individual analyses, monitors and uses two languages with ease, using language with automaticity or control (Bialystok, 2009, 1982). The model has limited application to second-language instruction, but provides a framework for cognitive learning in the second language.

4.3.2.6 Conditions Outcomes Model

The conditions outcomes model merges both input and output factors in second-language acquisition (van Lier, 1990). It identifies the critical conditions required for language acquisition such as learner receptivity, attention and practised intake. These are accessed in authentic forms rather than formal artificial forms. A creative way to use them is devised. In this way, the learner's second-language proficiency is developed. The model places emphasis on optimal learner output or production within authentic and meaningful interaction. Awareness, autonomy and authenticity are key principles in second-language acquisition.

4.3.2.7 Associative Cognitive Model

Ellis (2006: 100) posits that "Second language learning is governed by the same principles of associative and cognitive learning that underpin the rest of human knowledge." This perspective is based on the fact that high-frequency constructions are more readily processed than low-frequency ones. Such associative learning of a language from frequency of usage applies to words, letters, morphemes, syntactic patterns and so forth. Frequency of both the use of and exposure to language aspects leads to their acquisition. Again here the elements of input, interaction and output are implied, with the frequency of use being the general ingredient leading to associations and ultimately cognitive learning. The most significant contribution of the model to the current study is the key role it assigns to *frequency*, *recency* and *context* of constructions in second-language learning, concepts which are also key in this study. Acquisition is perceived as progressing through repeated exposure to input.

A broader picture of second-language learning emerges from viewing all the models outlined above as interconnected perspectives that enrich the understanding of second-language acquisition, rather than viewing them as independent and mutually exclusive. Although there is diversity in the second-language acquisition models, there is consensus on the stages learners pass through in their acquisition of a second language (Sibanda, 2014). Different stages of second language acquisition are outlined in the following section of the study.

4.3.3 Stages in Second-Language Acquisition

One similarity between first-language acquisition and second-language acquisition is that both proceed by stages and are characterized by developmental orders. Language is acquired through predictable and sequential stages of language development (Orosco & Hoover, 2009; Baca & Cervantes, 2004; Cummins, 2000; Grossman, 1995; Ovando, Collier & Combs, 2003). Thus, second language learners go through the same stages; however, these stages are sometimes named differently.

In the early stages of learning a second language, learners pass though developmental stages similar to those of learning a first language. Initially, learners may err in their use of the grammar and vocabulary, just as first language learners do. Although the process of second-language acquisition varies with each learner, depending on various factors, all second-language learners pass through the general developmental stages. With increased exposure to the English language, second-language learners progress from acquiring social language to the more complex academic language. Social language is considered conversational, contextualised language and can be developed within two to three years. Academic language is defined as utilising the combination of cognitive skills and content knowledge necessary for successful academic performance at secondary and university level. Achievement of academic proficiency can take between 7 to 10 years, if all of the schooling takes place in the second language (Krashen & Terrell, 1983; Collier, 1995; Thomas & Collier, 2002).

There are five main stages of second-language acquisition. Table 4.5 summarises general behaviours of second language learners at each stage of second-language acquisition.

Table 4.5: Behaviour of second-language learners at each stage of language acquisition

Stage of Second-Language Acquisition	General Behaviour of Second-Language Learners
Silent / Receptive Stage • 10 hours to 6 months • 500 receptive words	• Point to objects, act, nod or use gestures • Respond using Yes / No • Speak hesitantly
Early Production Stage • 6 months to 1 year • 1000 receptive / active words	• Produce one or two word phrases • Use short repetitive language • Focus on key words and context clues
Speech Emergence Stage • 1 to 2 years • 3000 active words	• Engage in basic dialogue • Respond using simple sentences
Intermediate Fluency Stage	• Use complex sentence • State opinions and original thoughts

• 2 to 3 years • 6000 active words	• Ask questions
Advanced Fluency Stage • 7 – 10 years • Content area vocabulary	• Converse fluently • Understand grade-level classroom activities • Argue and defend academic points • Read grade-level text books • Write organised and fluent essays

Krashen, (1982); Collier, (1995)

Stage 1: Silent / Receptive Stage

The initial stage a second-language acquirer passes through is the silent stage. The stage, which is also called the pre-production stage, takes up to 6 months. This initial active listening stage is characterized by very little use of the second language. Second language use may be in the form of 'Yes / No' type responses with no elaboration. Non-verbal responses are also characteristic of this stage. These should demonstrate comprehension. The focus at this stage is on internalizing the new language's vocabulary, structure and grammar. There is no compulsion for language production at this stage, even oral language. At this stage shy and withdrawn behaviour and even some inattention may result from lack of facility with the productive aspects of the language. The learners develop a repertoire of about 500 receptive words.

Stage 2: Early Production Stage

Language production becomes more manifest in the early production stage. During this stage the learners encode communication on a more regular basis rather than just decoding it. The learners develop a repertoire of about 1,000 receptive and/or active words which they draw from to communicate. In the early stage learners can give one-word responses to questions, employ repetitive language patterns, and begin to verbalise.

Stage 3: Speech Emergence Stage

As learners progress to the speech emergence phase, vocabulary develops to about 3,000 active words which the learners draw on to communicate in short phrases and full simple sentences. Learners at the stage are prone to errors and the frustration the errors bring. With an increase in vocabulary repertoire, learners develop some measure of second-language fluency in the intermediate fluency stage.

Stage 4: Intermediate Fluency Stage

The intermediate fluency stage again takes about an additional one year from the previous stage. Here a learner understands and uses about 6,000 active words. They can now generate complex sentences, seek clarification, speak for extended periods and give opinions. Their facility in written language has significantly improved, although they still make errors.

Stage 5: Advanced Fluency / Continued Language Development Stage

At this stage the learners develop and refine their language skills and fluency. Their comprehension and expressive ability have advanced and this is manifest in their making few errors. The learners have also developed content area vocabulary. This stage requires 5 to 10 years to develop fluency in the second language. In Cummins's (2000) second-language proficiency model this stage represents a learner operating at CALP. There is use of academic language. The progression of learners from one stage to the next is itself dependent on the factors that act upon second-language learning and these also merit consideration.

The five stages of language acquisition described above provide a general framework for understanding how second-language learners progress; however, learning is an on-going, dynamic and fluid process that varies from one learner to another. Learners may move back and forth between stages, depending on the academic demands of a lesson and the amount of participation required (Krashen, 1982).

4.3.4 Key elements of an effective language-learning environment

For language acquisition to occur, learners must:

- receive understandable and meaningful messages and
- learn in an environment where there is minimal anxiety.

Collier, (1995); Krashen, (1982); Vygotsky, (1978)

An awareness of these two principles can assist teachers to create a natural language-learning environment in their classrooms. Table 4.6 outlines five key elements of an effective language-learning environment.

Table 4.6: Elements of an effective language-learning environment

Element	Description
Comprehensible input	Teachers can make their language more comprehensible by modifying their speech, avoiding colloquialisms, speaking clearly, adjusting teaching material, adding redundancy and context, and scaffolding information within lessons.
Reduced anxiety level	A learner's emotions play a pivotal role in assisting second-language learning. Teachers can assist learners by creating a comfortable environment that

	encourages participation without fear of feeling embarrassed.
Contextual clues	Visual support such as tangible objects, facial expressions or models of abstract concepts makes language more comprehensible.
Verbal interaction	Learners need opportunities to work together to solve problems and use English for meaningful purposes. They need to give and receive information and complete authentic tasks.
Active participation	Lessons that encourage active involvement motivate second-language learners, engage them in the learning process and help them to remember content more easily.

Collier (1995); Krashen (1982); Vygotsky (1978)

Use of these strategies can assist learners to better access the content material, in particular mathematical content, which has its own specific register. Thus, for the purposes of this study, the IP mathematics teachers should draw on these strategies when assisting learners.

4.3.5 Factors influencing Second-Language Learning

There is extensive literature on the factors influencing success in second-language learning. The pace at which second-language learners progress through the five stages of language acquisition and develop conversational and academic fluency depends on a number of influencing factors. These factors can be broadly categorized as learner variables and environmental factors. The learner variables are the internal factors, while the environmental factors are the external factors (Sibanda, 2014). Learner variables include age, aptitude, motivation and attitude, personality, cognitive style, hemisphere specialization and learning strategies. Environmental factors influencing instructed second-language acquisition include the type and quality of instruction and input, the environment, the material of instruction (graded, sequencing, ungraded, skill-oriented materials), among others. The section below elaborates on some of these factors which have a bearing on the current study, namely age, aptitude, personality, motivation and attitude as well as the role of the first language.

Age of the learner

Age affects second-language learning in a number of ways: older learners acquire the second language the fastest, followed by adults and then by young learners – a finding which favours acquisition of a second language during adolescence. The exception is in pronunciation where younger learners fare better and can eventually acquire native accents and pronunciation more easily than older learners.

Older learners are often more inhibited about speaking in front of peers, because they are usually self-conscious and feel vulnerable about taking risks and making mistakes. Class discussions and textbook-reading levels are more academically demanding for older second-language learners than for younger learners; therefore, it may take longer for older learners to achieve grade-level performance in content classes (such as mathematics classes).

Older learners and adults are advantaged by their prior literacy experience, as they already know how to read and write in their first language; and this literacy experience allows them to compare and contrast their first- and second-language linguistic patterns and forms, and analyse the language abstractly (van Patten & Williams, 2007). Older learners usually possess prior knowledge and skills in a first language which they can rely and tap into during the process of second-language learning. For instance, older learners begin the process of second-language learning when they already possess skills such as the scientific method, skimming or scanning for information and taking notes – skills that they would already have mastered in their first language. However, older learners need to learn the English vocabulary needed to discuss and study the concepts they are learning in the second language (Cummins, 2000). On the other hand, for younger learners who do not have as much prior knowledge and skills, it may take them longer to learn new academic content, since the learners will be dealing with the simultaneous task of learning a new concept as well as English vocabulary.

All learners of second languages subconsciously transfer grammatical properties of their first language to the second language. They have also developed sociolinguistic competence in language use.

> Over the long run, those who start second languages as learners will usually reach higher levels of competence than those who start as adults. Over the short run, however, adults are faster in attaining second-language proficiency than younger learners.
>
> Krashen and Terrell, (1983: 45)

The critical period for language acquisition has been set at different times. Penfield and Roberts (1959), who first introduced the concept of a critical period for language learning, posit that the human brain gets progressively more stiff and rigid after the age of 9 years. Kumaravadivelu (2006) sets the age limit at puberty. He further notes about the debate around the critical period hypothesis that, for some, it only applies to foreign language accents, while for others it applies to both accents and grammar, and for yet still others, this critical period does not exist at all. Marinova-Todd (2003) asserts that availability, access and quality of second-language input and instruction influences second-language learning more than the age factor does.

The diverse findings on how the age of the learner influences second-language learning acknowledge both the opportunities and limitations of acquiring and using a second language at various ages.

Aptitude

Aptitude relates to innate attributes learners are individually endowed with which facilitate or constrain their acquisition of a second language. Carroll (1991) identifies four sub-components of aptitude, namely phonetic coding ability (capacity for sound discrimination), associative memory (capacity to connect native and second-language equivalents), grammatical sensitivity (appreciating the function of words in sentences), and inductive language analysis (ability to identify patterns, especially in verbal material, which may involve implicit or explicit rule representation). Skehan's (1989) sub-components of aptitude are auditory (ability to convert acoustic input into processable input), linguistic (capacity for language rule inferences, linguistic generalizations or extrapolations) and memory abilities (acquisition, storage and retrieval of new information like formulaic expressions). Aptitude differs from intelligence in that aptitude relates more closely to language-learning success, expressed as a talent for languages. Aptitude on its own is not adequate if it is coupled with motivation and a positive attitude.

Learner motivation and positive attitude

Learner motivation may be integrative, instrumental or resultative. In second-language acquisition, parental and peer attitudes may also shape learner attitudes. Learner attitude towards the learning context and the language impacts on their language learning. Their attitude towards the native culture and people will affect the motivation to acquire the language.

Personality factors

Self-esteem correlates with second-language learning. Introverts usually perform better on reading and grammar, while extroverts usually persevere with their study, which ultimately promotes second-language acquisition. Anxiety can facilitate or constrain, and therefore can be associated with language acquisition positively or negatively depending on the circumstances. Willingness to take risks and use the language facilitates language acquisition whereas being sensitive to rejection constrains language acquisition.

Literacy in a first language

According to the separationist model, there is compartmentalisation of the languages within the language user, where one language has nothing to do with the other. Such a mono-linguistic view contends that second-language learning proceeds autonomously from first-language influence (Riches & Genesee, 2006). This is because the second-language learners cannot make the connection between the two languages in their mind. The integration model, however, sees the two language systems as integrally linked to the extent that one impacts on the other and the two share a single system (Cook, 2003). While maintaining that the two language systems are separate, the partial integration model acknowledges the overlap of the language systems within the language user (Cook, 2003).

The fact that there is interplay between the first language and the second language in the learning of the latter is widely acknowledged. Two hypotheses explain this notion, namely: the **Linguistic Interdependence Hypothesis** (LIH) and the **Linguistic Threshold Hypothesis** (LTH) (Cummins, 1979). The LIH argues that first-language reading ability transfers to second-language reading as learners make a cross-linguistic transfer of their abilities from the first language to the second language. The LTH posits that such ability transfers are only possible among learners who have attained a certain level of second-language proficiency. The LIH would predict that proficient first-language readers would be equally proficient second-language readers, whereas the LTH would predict the extent of learners' proficiency in second-language reading from how much of the second language the learners know. According to the LIH, the degree of congruence between the first language and the second language eases or complicates the acquisition of the second language; thus, close languages would have many cognates which expedite the lexical development of learners (Koda, 2007).

The learner's proficiency in the first language will influence their acquisition of the second language as they can transfer some skills to second-language acquisition. The complementary nature of the first language to the second language is expressed in the observation that "the mother tongue is the launch pad for the second language" (Morgan & Rinvolucri, 2004: 8), and that the most effective way to begin to learn the meaning of a word is by translation into the first language (Nation, 2003). The degree to which the first language would positively impact on second-language learning is dependent on the level of learner proficiency in the first language. The higher the proficiency, the more the first language eases the acquisition of the second-language forms.

The factors influencing second-language learning are presented from a learner's perspective. For the purposes of the current study, these factors are deemed necessary for equipping teachers of ELLs on the linguistic characteristics that impact on their use of the second language as a medium of instruction. However, there is a gap in the literature on factors influencing teachers' second-language learning for the purposes of using the language to deliver subject knowledge. The section below explores the implications of second-language acquisition on the teaching and learning process using a second language.

4.3.6 Implications of Second-Language Acquisition for Teaching

Hulstijn (1997) explains the major limitation in the field of research on second -language acquisition as being the vast number of variables regarding the comparability of groups who underwent different second-language learning experiences. Hulstijn states that “One of the most difficult methodological challenges is to keep all such variables constant. This is almost impossible in normal classrooms with real second-language learners. It comes as no surprise, therefore, that the outcomes of studies conducted in natural learning environments, including classrooms, often form the object of considerable disagreement." In South Africa, for example, it is invalid to simply compare schools that adopt a straight-for- English approach with schools that transition from first language to English in Grade 4, because these two kinds of schools possess different characteristics, operate under different contexts and are usually located in different environments (Sibanda, 2014).

A further challenge that must be overcome in order to produce meaningful evidence on the relative effectiveness of alternative language-of-instruction regimes is that studies must be conducted over a period of several years. Thus, the control group, which is either receiving mother-tongue instruction or using English as a LoLT must be observed over several years. Furthermore, the desired outcome should not be English proficiency at the end of the treatment period or the duration of a particular study, but at a later stage once those in a bilingual programme have transitioned to English as language of instruction. The outcome of interest is really educational outcomes, in particular long-term second-language acquisition. The majority of studies have not used data with a long enough time span to address this fundamental research question.

Although literacy in a first language is generally perceived to influence the process of learning a second language, for the purposes of the South African context it is worth highlighting that some immigrant learners may enter the country with limited or interrupted schooling. In some cases learners may originate from rural communities where literacy and schooling were not emphasised, while others may originate from countries where political turmoil prevented them from attending school regularly. Such learners face the additional challenge of learning appropriate school behaviour and expectations at the same time as they are learning content and concepts, and the second language used as the language of learning and teaching. Learners with such backgrounds and with limited or no first-language support may spend 7 to 10 years striving to achieve academic parity with their peers (Thomas & Collier, 2002). Teachers can assist these learners by explicitly modelling appropriate school behaviour. It is also essential for the teacher to assess such learners’ backgrounds knowledge before introducing a new topic in order to identify gaps and create opportunities to build and strengthen the missing background knowledge. Assessing circumstances around second-language learners’ decisions to move or relocate implies that the teacher will be better able to understand the learners' emotional and psychological wellbeing, as well as factors affecting the learners' motivation and academic achievement.

Understanding second-language acquisition as a process highlights the complexity of bilingualism, yet it is necessary in order to determine how learners become bilingual. The central issue is "*Who learns how much of what language under what conditions*?" (Spolsky, 1989: 3). The "who learns" is concerned with individual differences and is constantly changing. The 'how much of what language' part is concerned with the specific language skills that are being developed, the measures used to assess this skill development, as well as cultural influences. The element "*under what conditions*" focuses on situation and context, thus the learning environment and the strategies influencing language learning. Given the huge diversity between learners and in the approaches to learning a language, the following frameworks and theories have been proposed by researchers in the field as guidelines for those working with learners learning through the medium of a second language, and to draw attention to prevalent issues influencing their learning.

The section below presents a review of bilingualism and its application in contexts where a second language is used as a medium of instruction. The theories on bilingualism referred to in the section below are largely adapted from Sibanda (2014).

4.4 Bilingualism

Bilingualism is a characteristic that describes a person who is proficient in two languages (Adler, 2001; Essien, 2013), though literature reveals numerous definitions used to describe this characteristic.

The majority of definitions of bilingualism include reference to an ability or proficiency to speak two languages, but there is actually a spectrum of definitions (Baker & Prys Jones, 1998; Sibanda, 2014). At one end of the spectrum is a minimal ability in one or more of the language skills (reading, writing, speaking and listening) in the person's second language. At the other end of the spectrum is native-like control of the two languages. Grosjean and Moser-Mercer (1997: 165) developed the notion of a "complementarity principle" in which they emphasise that bilinguals use their languages for different purposes and in different domains of life. Dominance in one language over the other is common among bilinguals depending on the use and function of each language, but little progress has been made in measuring the exact degrees of bilingualism evident.

Similarly, studies involving bilinguals tend to focus on only one language, but due to the complex nature of the issue of bilingualism, aspects of both languages need to be taken into account. Grosjean (1998) highlights the vital importance for researchers in the field to specify what knowledge bilingual subjects have of their respective languages, because contradictory findings emerge depending on the use of different interpretations of 'bilingual'. Terms such as 'balanced bilingual' and 'semi-lingual' have been coined, but these are vague and lack precision, primarily because of the difficulty and lack of valid instruments to measure bilingual proficiency. Thus there is a need to develop precise definitions and measurements of bilingual proficiency. However, bilingualism is more than just possessing an ability to use two languages. Bilingualism is a consequence of educational, social, economic, cultural and political struggles (Baker, 2000). For example, a government plays a major role in deciding on the official language(s) of a country and what language(s) is to be used as a medium of instruction in the education system. Similarly, the economic and cultural status of a language will determine its perceived value in an education system.

4.4.1 Types of Bilingual Education

The term bilingual education may be superficially interpreted as teaching and learning through the medium of two languages. However, Baker and Prys Jones (1998) reiterate how complex the expression and phenomenon actually are and that a set of questions needs to be addressed in order to assess the learning context. These questions include:

- Are both languages used in the classroom?
- For how long are the languages being used in school?
- Are two languages used by all or some learners?
- Are two languages used by the teachers or just by the learners?
- Is the aim to teach a second language or to teach through a second language?
- Is the aim to support the home language or to move to an alternative majority language?

Adapted from Baker and Prys Jones (1998: 464)

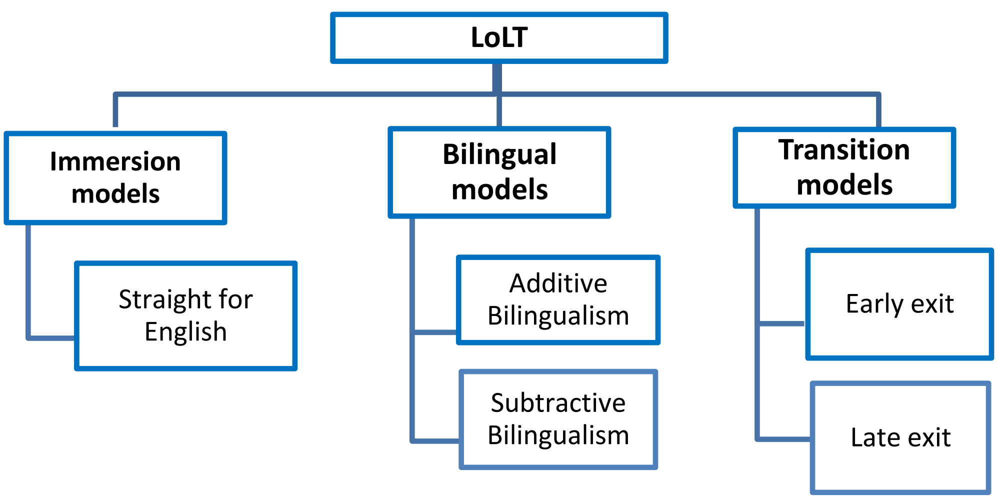
There are several different types of bilingual education programmes and within these types there are further subdivisions. These programmes have developed over the past four decades, mainly in the United States of America, where there are a variety of second-language contexts. These programmes can be classified under the broad terms of weak or strong bilingual education (Baker, 2000). Weak forms include schools and learning institutions that contain bilingual individuals as opposed to encouraging bilingualism. These schools and learning institutions usually enrol language minority learners with the aim of developing learning through the majority language (Baker & Prys Jones, 1998). Development of the home culture and language are not fostered. On the other hand, strong forms of bilingual education are developed when the primary aim is to develop complete bilingualism in both languages and both cultures are supported (Baker & Prys Jones, 1998). Naturally, the type of bilingual programme implemented is reflective of cultural beliefs in that society and will impact on the learning outcomes of the learners. A classification system for bilingual education programmes has been developed by Baker and Prys Jones (1998) and is summarised in Figure 4.3.

4.4.1.1 Immersion versus bilingual transitional models

English language proficiency impacts on academic opportunities through its influence on educational success. However, Casale and Posel, (2011) demonstrate that English proficiency also improves labour market returns directly.

As such, South African curriculum developers are challenged by the question of when and how the teaching of English should be introduced in schools, and when and how a transition to English as the Language of Learning and Teaching (LoLT) across the curriculum should take place. Research reveals several theoretical models, each with numerous variations that have been tried in different parts of the world.

Figure 4.3: Immersion versus bilingual transitional models



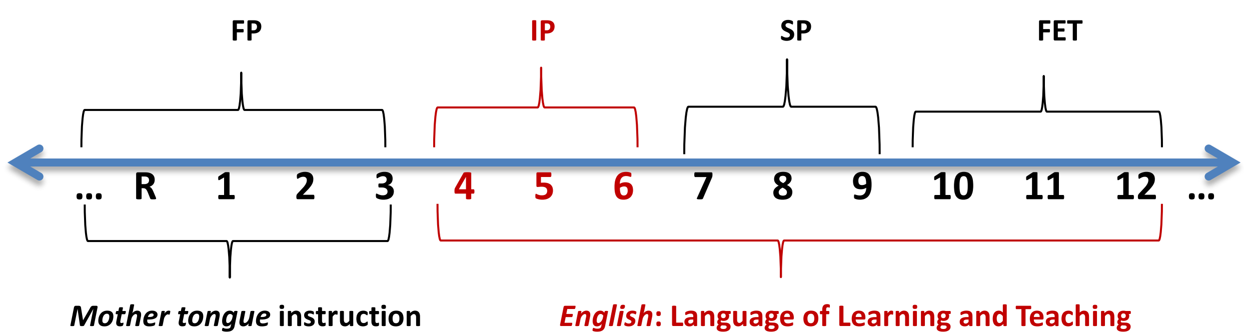
Adapted from Taylor and Coetzee (2013)

In Figure 4.3 Taylor and Coetzee describe one end of the spectrum as the immersion model with variations occurring in between, and the other end of the spectrum as the transition model.

In the immersion model learners are taught in the second language right from the beginning of their school life. The straight-for-English approach is a type of the immersion model. In contrast, there are various types of bilingual models. Transitional models prescribe that a learner's first language be used in the first years of schooling followed by a transition to the second language as the LoLT. In early-exit transition models the transition to second-language instruction occurs after at least three years of schooling. In late-exit transition models the transition occurs after about six or eight years of schooling. There are also various models of additive or subtractive bilingualism in which the first and the second language are used alongside each other, with the balance of use changing through the school years.

It is important to note that these are general classifications and it is not assumed that all bilingual education contexts can be classified under one of the above. For the purposes of this study, the primary concern lies with the **early-exit context** – learners transitioning from learning mathematics through mother tongue instruction to learning mathematics through the medium of English as shown in Figure 4.4.

Figure 4.4: Language of instruction in the South African ordinary school education system



4.4.2 Cognitive Theories of Bilingualism

> "Some people would argue further that language is somehow related to thinking, learning and cognitive development."
>
> Stubbs, (1980)

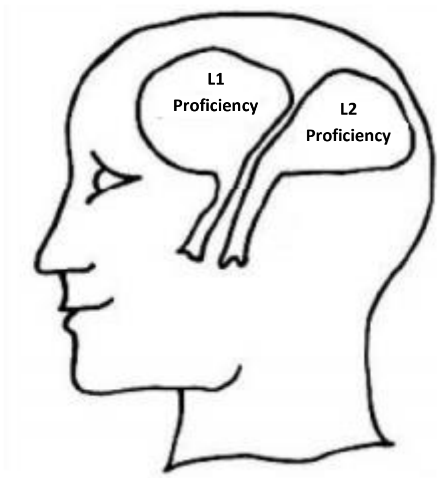
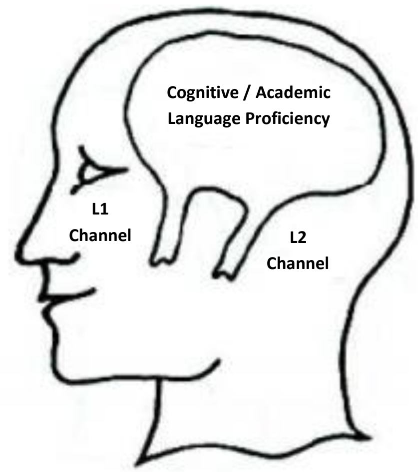
Cognitive theories emerged at the beginning of the twentieth century and have developed into practically applicable approaches (Sibanda, 2014). Applications of these theories relate to language acquisition and learning. Misconceptions about how the brain stores language have led to negative perceptions of bilingualism; the most prominent is that bilingualism may result in cognitive overload and thus disadvantage the learner (May, Hill & Tiakiwai, 2004). The following sections will discuss a number of theories and theorists who have had a considerable impact on the areas of learning and language.

4.4.2.1 Separate and Common Underlying Proficiency (SUP/CUP)

The misconception about bilingualism alluded to above is associated with the perception of the mind and its storage of language(s) and is described as the Separate Underlying Proficiency (SUP) model. This misconception views the two languages as being stored separately and independent of one another (Baker, 2000; Baker & Prys Jones, 1998). Analogies include that of the brain having two separate balloons with a restricted amount of space for the balloons (each language) to expand. Or as a set of scales – an increase in the weight of one of the languages will result in an imbalance and loss of a portion of the other language (Baker & Hornberger, 2001).

This model is not an accurate reflection of the working of the mind. A large body of research demonstrates that when abilities in both languages are continued and developed throughout schooling, learners develop a deeper understanding of language and its functions (Cummins, 2002). It is inaccurate to assume that languages are separated in the mind as illustrated in Figure 4.5a (Baker & Hornberger, 2001). Learners who learn mathematical operations (addition, subtraction, multiplication, division) in isiXhosa will also be able to perform the same operations in English as illustrated in Figure 4.5b. Therefore there is interplay between the two languages.

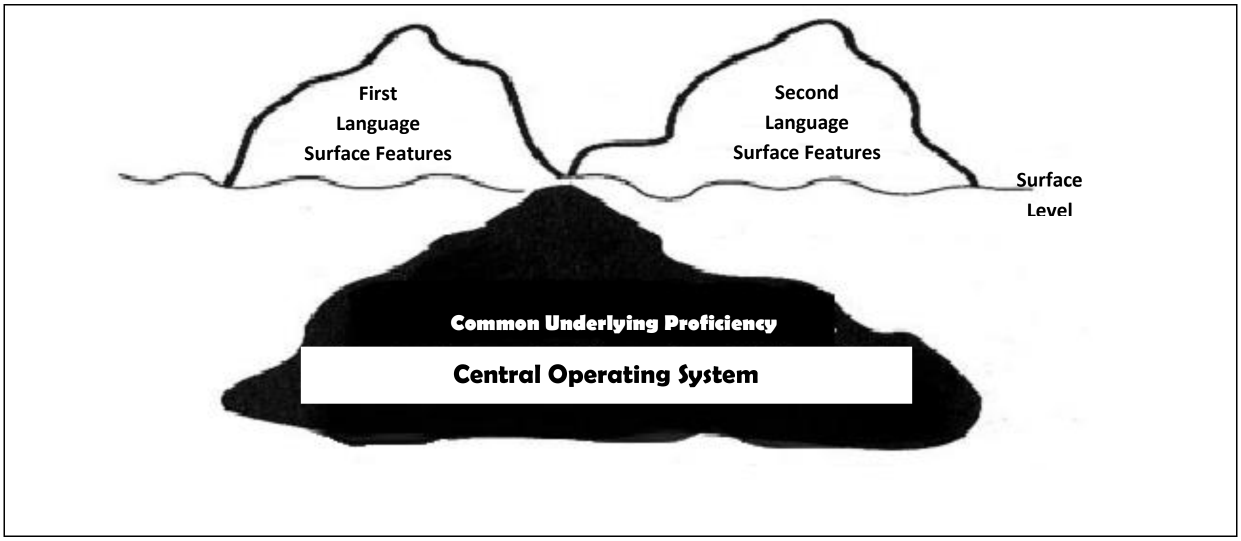
Figure 4.5: Separate and Common Underlying Proficiencies

a) Separate Underlying Proficiency (SUP)	b) Common Underlying Proficiency (CUP)
	

Adapted from Baker and Hornberger (2001: 131 – 132)

The Common Underlying Proficiency (CUP) is a more plausible description of language construction within the mind (Cummins, 1981). The CUP model is depicted in the form of two iceberg peaks, which are separate above the surface. This represents the fact that outwardly both languages are different regarding the way they are used in conversation. However, underneath the surface both languages are merged in a way that demonstrates they do not function independently of one another (Baker, 2001; May, Hill & Tiakiwai, 2004) as illustrated in Figure 4.6. The storage of both languages occurs below the surface and it acts as a central processing unit that both languages contribute to, access and use, (Baker, 2001; Baker & Prys Jones, 1998).

Figure 4.6: Model of Common Underlying Proficiency



Baker, (2001: 165)

According to Baker (2001: 165 – 166), the CUP model of bilingualism may be summarized in six points.

1. Irrespective of the language in which a person is operating, there is one integrated source of thought.
2. Bilingualism and multilingualism are possible because people have the capacity to store easily two or more languages. People can also function in two or more languages with relative ease.
3. Information-processing skills and educational attainment may be developed through two languages as well as through one language. Both channels feed the same central processor.
4. The language the learner is using in the classroom needs to be sufficiently well developed to be able to process the cognitive challenges of the classroom.
5. Speaking, listening, reading or writing in the first or the second language helps the whole cognitive system to develop. However, if learners are made to operate in an insufficiently developed second language in a subtractive bilingual environment (as occurs for many bilingual learners in English-language-only classes), the system will not function at its best. If learners are made to operate in these classroom contexts, the quality and quantity of what they learn from complex curriculum materials, and produce in oral and written form, may be relatively weak and impoverished.
6. When one or both languages are not functioning fully (e.g. because of an unfavourable attitude to learning through the second language, or pressure to replace the home language with the majority language), cognitive functioning and academic performance may be negatively affected.

Therefore, given that both languages are dependent on one another, this need to be taken into account when investigating bilinguals and their learning of and understanding of mathematics. One cannot investigate one language without examining the other language also and it is necessary to utilize a framework for investigation that reflects this view best.

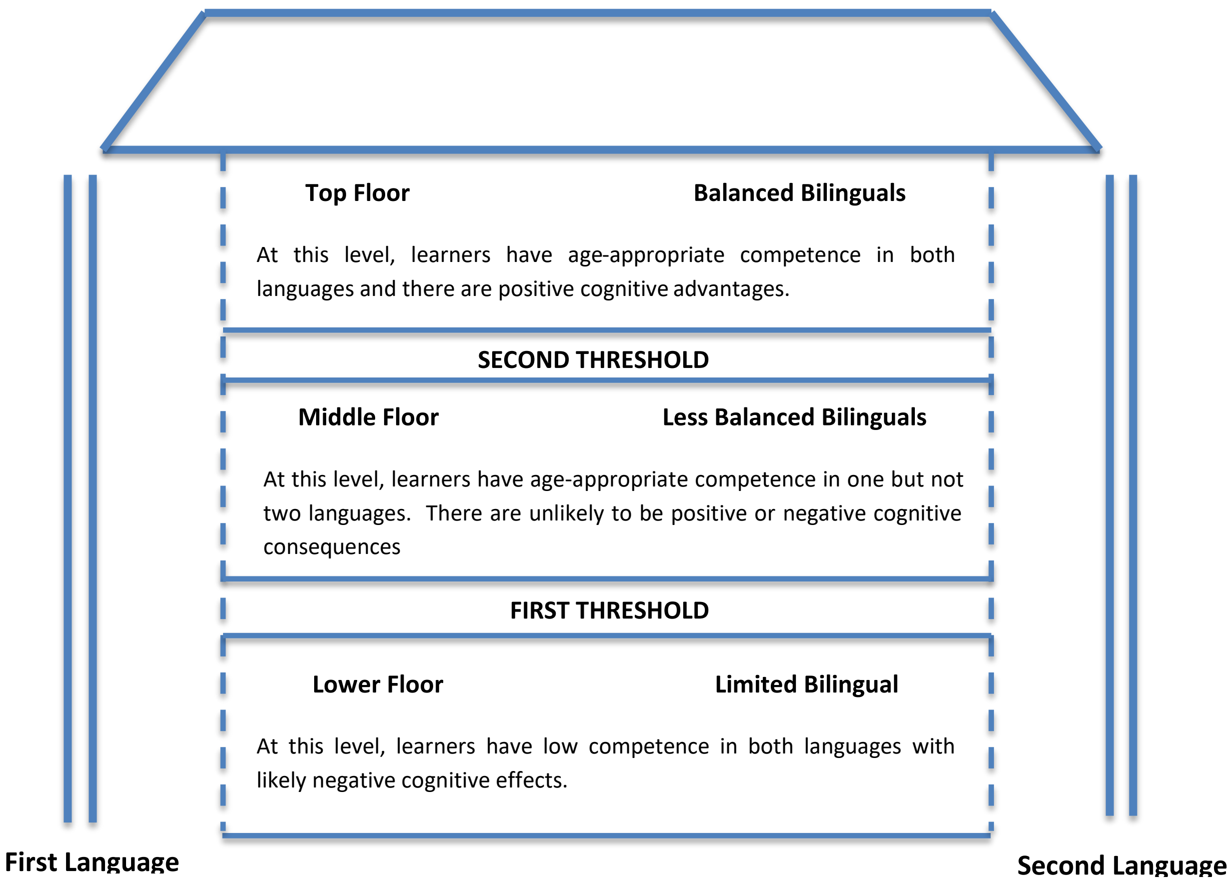
4.4.2.2 Cummins (1976) – Threshold Hypothesis

This hypothesis states that the level of mother-tongue proficiency already reached by a learner determines if they will experience cognitive deficits or benefits from learning in a second language (Cummins, 1976). This implies that there is a certain 'threshold' that one must reach in their first language before the benefits of studying in a second language can develop. For those who begin studying in a second language before achieving this level, there will be serious learning difficulties and repercussions (Cummins, 1976). Cummins further developed his theory and claimed that there is a threshold for the second language also, which must be achieved so as to allow the potentially beneficial aspects of second-language learning to influence a learner's cognitive and academic functioning (Cummins, 1976: 222).

In order to avoid the negative consequences of bilingualism it is necessary to reach the first threshold. By reaching the second threshold, a bilingual learner should experience positive benefits from learning in a second language (Baker, 1996). An important inference of Cummins's Threshold Hypothesis is that learners who are not sufficiently fluent in either of the two languages that they use tend to experience difficulty in mathematics (Minami & Ovando, 2001). At the first level of this hypothesis the bilingual learner has a low level of proficiency in both of the languages and there will be negative cognitive affects for the learner's learning (Baker, 2001). At the middle level the bilingual learner will have age-appropriate proficiency in one of their languages (comparable to a monolingual learner) but not in both. This dominance in one of the languages is unlikely to influence cognition in any significant positive or negative way (Baker, 2001). The third or top level of this hypothesis encompasses well-developed bilingual learners who have age-appropriate proficiency in both languages and are likely to demonstrate cognitive advantages over monolingual or weaker bilingual learners (Baker, 2001). Therefore, this implies that learners who have learnt through the medium of isiXhosa but have not developed their language to a sufficient level will experience difficulties when transferring to learning through the medium of English.

Learners who have an appropriate level of proficiency in mother tongue but not in English may not experience any cognitive advantages when learning mathematics through the medium of English. A more positive aspect is that those who have reached the 'threshold' in both mother tongue and English should experience positive cognitive benefits in their learning. Given that both languages are interdependent and proficiency in both is important for cognitive performance, the languages cannot be looked at in isolation as suggested by the SUP model. Thus, the CUP model is consonant with Cummins's Threshold Hypothesis (1976), which reflects the realities of bilingual contexts and is supported by research (Dawe, 1983; Clarkson, 1992). The significance of this theory is twofold (May, Hill & Tiakiwai, 2004). Primarily it seeks to establish why minority learners under-perform academically when submerged in a school environment where they are learning through the medium of a second language, their weaker language. Secondly, it demonstrates how learning through the medium of a minority first language does not appear to hinder the development of the majority language, and it may actually have positive cognitive benefits (Cummins, 2000). Baker (1996) has developed a triple-storey house analogy in order to demonstrate the bilingual linguistic requirement at each level as illustrated in Figure 4.7. Ideally a bilingual learner needs to progress beyond the second level in order to attain cognitive benefits from learning in a second language.

Figure 4.7: Bilingual linguistic requirements



Baker, (1996: 149)

Although the Threshold Hypothesis clarifies the dissimilar findings in bilingual education, there are a number of weaknesses that need to be addressed. There have been criticisms of Cummins's theory because it cannot be supported experimentally, since there is no definition of the "threshold level necessary" (Ahmed, Marriot & Pollitt, 2000: 21). A prominent criticism relates to the terms used to describe the various bilingual proficiency levels within the theory, which include 'semilingualism', 'dominant' and 'balanced' bilingualism. In particular the term 'semilingualism' has been criticised because it implies a deficit (MacSwan, 2000) and consequently the term has been disregarded by Cummins (2000). It has also been argued that the use of these terms reflects a narrow view of language competence (Romaine, 1995) and thus a perception of language as stagnant, and also of the variation of language use.

However, Cummins, (2000) has defended these terms as reflective of educational contexts such as in schools that use two languages of instruction, noting that these contexts influence the development of bilingualism. For example, one language may be used more than the other, thus resulting in 'dominant' bilingualism in one of the languages. Geva and Ryan (1993) argue that individual differences in intelligence and memory span may also be involved in the transfer of cognitive abilities from one language to the other. Similarly, Hoffman (1991) interrogates the measurement and definition of educational success and states that reliance on traditionally measured school tests does not take into account factors such as motivation, attitudes, social issues, schooling or parental support, which are important when determining educational success. Setati, (2002) argues that academic achievement is influenced by a number of inter-related factors and that performance cannot be attributed to the degree of language proficiency alone. Consideration needs to be given to wider social, cultural and political factors that pervade schooling (Setati, 2002: 7). Studies in support of the Threshold Hypothesis provide an explanation of the variation amongst bilingual learners and have influenced educational policies in the USA and in the United Kingdom (Bialystok, 2009; Clarkson, 1992; Dawe, 1983; Lasagabaster, 1998; Mohanty, 1994; Yushau & Bokhari, 2005).

4.4.2.3 The Developmental Interdependence Hypothesis (1979)

In 1979 Cummins refined his Threshold Hypothesis and this led to the development of his Developmental Interdependence Hypothesis, which had a more in-depth focus on the relationship between a learner's two languages. The Interdependence Hypothesis proposed that the level of proficiency already achieved by a learner in their first language would have an influence on the development of the learner's proficiency in their second language (Baker, 2001).

> … the level of second language competence which a bilingual learner attains is partially a function of the type of competence the learner has developed in first language at the time when intensive exposure to second language begins: …an initially high level of first language development makes possible the development of similar levels of competence in second language. However, for learners whose first language skills are less well developed in certain respects, intensive exposure to second language in the initial grades is likely to impede the continued development of first language.

Cummins (1979: 233)

Therefore, the greater level of proficiency achieved in the first language will allow for a better transfer of skills to the second language. This hypothesis stemmed from a proposal by Oller (1979) that proficiency in all language skills (listening, speaking, reading and writing) was derived from a single dimension of language proficiency. This was not in line with Cummins's philosophy, which proposed that language proficiency was multidimensional.

4.4.2.4 Basic Interpersonal Communicative Skills versus Cognitive Academic Language Proficiency

Another theory about language acquisition that can help teachers understand and better manage the challenges faced by second-language learners is the distinction between social and academic language proficiency. Cummins, (1981) suggests that there are two types of language proficiency, which can be classified as individual registers which bilingual learners have to develop and accomplish in their first and second languages:

- Basic interpersonal communication skills (BICS);
- Cognitive academic language proficiency (CALPS).

BICS relates to communication skills and conversational competence. It relies on the phonological, syntactic and lexical skills required to function in everyday contexts – most of the time these contexts are cognitively undemanding and contextually supported (May, Hill & Tiakiwai, 2004). Second-language learners generally develop conversational fluency (BICS) within two years of studying a second language (Cummins, 2000).

CALP relates to the fluency in the more technical, grade-appropriate academic language. Second-language learners develop academic language fluency CALP within five to seven years, depending on the learner's age and level of home-language literacy. Cummins's theory of second-language acquisition makes a distinction between two types of language proficiencies, namely BICS and CALP. The difference between two types of language proficiencies as the basis of language learning and development is illustrated in Table 4.7.

Table 4.7: Language proficiencies for second-language acquisition

Language proficiency	Function
Basic Interpersonal Communication Skills (**BICS)**	- The surface skills of listening and speaking acquired quickly by language-learning individuals during the language-learning process.
Cognitive Academic Language Proficiency **(CALP)**	- The language learner's ability to cope with the academic demands placed upon their various subjects during the language-learning process.

Cummins (2000)

Failure to understand the distinction between these two types of language proficiency may lead to inappropriate assumptions about a learner's language ability; for instance, second-language learners may be exited from direct English instructional programmes because they appear to be fluent in conversational English; however, they may lack the necessary academic language, reading and writing skills essential for success in the content area (Cummins, 2000).

In his early works Cummins (1981) states that multiple language proficiencies are required to meet various needs in various communicative contexts. In his later works Cummins (2004) buttresses the notion by stating that multiple language proficiencies in the educational systems are related to literacy forms of language and differ from those used in everyday conversations, which may be problematic for language users.

Baker (2001) supports Cummins's descriptions of BICS and CALP by noting that BICS occurs where there is contextual support of language delivery. Contextual support occurs in the form of face-to-face situations which provide non-verbal support to secure understanding. In addition, actions like eye contact, hand gestures, instant feedback, cues and clues support verbal communication. On the other hand, CALP supports academically-oriented contexts. This involves higher-order thinking skills that are required by the curriculum.

On the other hand, CALP is required for context-reduced academic situations. CALP demands manipulation of the surface features of a language in impersonal contexts (May, Hill & Tiakiwai, 2004). The skills required are higher order in nature such as analysis, synthesis and evaluation. Cummins (2000) argues that these skills are a prerequisite for CALP as they provide learners with the facility to use language as an instrument of thought in problem solving and this justifies the assertion that it takes five to seven years for learners to acquire academic-language proficiency in a second language. This is further complicated by the fact that learners not only have to develop proficiency in the academic register in English, but also learn new mathematical content in that language.

An appropriate mathematical example demonstrating the difference between BICS and CALP:

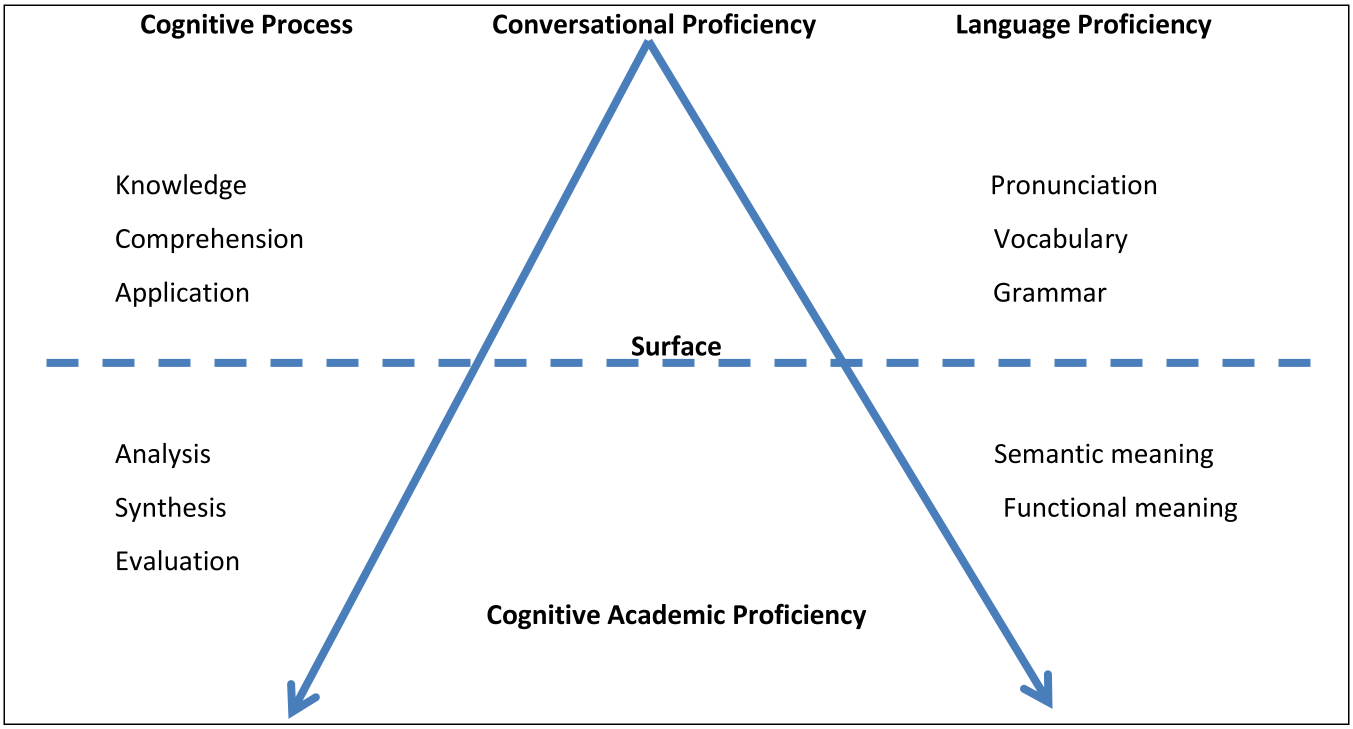
> A learner is given a mathematical question such as: 'You have 20 rands. You have 6 rands more than me. How many rands do I have?' At the higher CALP level the learner will conceptualize the problem correctly as 20 minus 6 equals 14. At the BICS level the word 'more' may be taken to mean 'add-up' with the learner getting the wrong answer of 26. The BICS learner may think of 'more' as used in basic conversation. However, in the mathematics classroom this illustration requires that 'more' be understood by the mathematical phrasing of the question.

Baker (1996)

4.4.2.4.1 The relationship between BICS and CALP

The iceberg analogy can be used to demonstrate the underlying concepts of BICS and CALP. Language skills such as comprehension, speaking, pronunciation, vocabulary and grammar lie above the surface and are used in conversation (BICS). Below the surface lie the academic language skills such as analysis, synthesis and semantic meaning as illustrated in Figure 4.8.

Figure 4.8: The relationship between BICS and CALP



Baker, (2001: 170)

According to Cummins (1979), in order for bilingual learners to master academic-language proficiency in their second language, their Common Underlying Proficiency must be well developed. What is important to note here is that, while second-language learners may pick up oral proficiency (BICS) in their new language of learning in as little as two years, it may take up to seven years to acquire the decontextualised language skills (CALP) necessary to function successfully in a second-language classroom. Mathematics is located within this CALP and in order for learners to attain mathematical academic-language proficiency, their CUP must be well developed (Cummins, 1979). This underlying ability in turn can be advanced through application of the Developmental Interdependence Hypothesis and, depending on the type of schooling, either through a learner’s first or second language. Once again there are a number of criticisms of the distinction between language registers, in particular that the differentiation underestimates the demands of conversational proficiency, while overemphasizing the demands of academic proficiency. Also, a potential deficit may be associated with learners who do not acquire academic proficiency (Fredrickson & Cline, 1996). However, the study reiterates that the distinction between language registers facilitates an explanation of bilingual learners' relative success or failure when they encounter a new language of instruction in educational contexts.

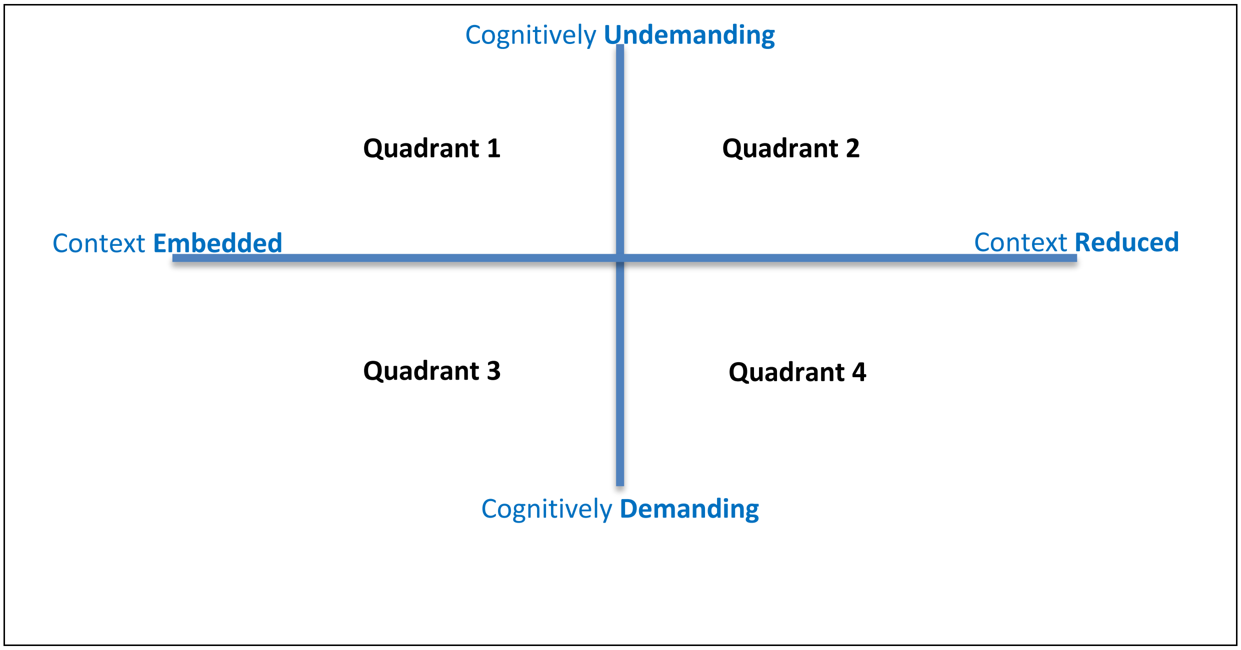
Cummins (2000) denotes that BICS and CALP are language registers that encompass both oral and written modes of communication during an individual's language development and learning process. Westby (1994) concurs that an individual learns to talk in their early school life and later talks in order to learn academic language. Cummins 2000 reiterates this notion by stating that language for academic purposes requires understanding and the use of classroom discourse, which includes the teacher's verbal instructions and lessons. Communication therefore develops as a result of exposure to this form of education.

Chomsky (1975) contends that human language cannot be scrutinised simply in terms of observable stimuli and responses, but that language acquisition is a gradual and creative built up of knowledge systems resulting in improved general competence and not just performance of habits in isolated instances. Chomsky uses rational logic, reason, extrapolation and inference to explain language acquisition. For example, Chomsky explains that even if two learners from different families receive different input, both learners will have developed a sound grasp of English grammar by the time they turn 5 or 6 years of age. Although Chomsky concentrates on first-language acquisition, his theory is also relevant to second-language acquisition. The gist of his theory is that there is innate creativity in language learning which is based on cognitive processes.

4.4.3 Implications of bilingualism, BICS and CALP for Teaching

Distinguishing between BICS and CALP has implications for teachers of second-language learners. As a consequence, Cummins extended his model so as to assist teachers in designing and implementation of their programmes to cater for these learners. The model is two-dimensional in relation to cognitive demand and contextual embeddedness as illustrated in Figure 4.9.

Figure 4.9: Implications of BICS and CALP for teaching



Cummins, (1981); Baker, (1996: 153)

The first continuum (horizontal) is the level of contextual support available to the learner. At one extreme is the context-embedded, informal, face-to-face communication and learners can actively negotiate meaning, and the language is supported by paralinguistic and situational clues (May, Hill & Tiakiwai, 2004). In the context-reduced extreme, learners have to rely mainly on linguistic cues. The latter reflects classroom situations (Cummins, 2000). The second continuum (vertical) reflects the amount of cognitive involvement necessary for particular situations or activities. Communicative tasks in the upper section of the continuum require minimal cognitive involvement as the linguistic tools required have already been developed and thus can be applied automatically. Tasks in the lower end of the continuum require language skills that have to be developed and therefore are more cognitively demanding. Often, in a learning environment learners are required to organize their language production consciously, while dealing with new and perhaps difficult concepts (May, Hill & Tiakiwai, 2004). Many classroom activities are located in the fourth quadrant and such activities are demanding, in particular for learners learning through the medium of a second language.

Therefore, Cummins's theory is suggesting that bilingual learners will achieve success only when they have developed an appropriate level of language proficiency in the language of instruction so that they can cope with the context-reduced, cognitively demanding situations that arise in learning environments as illustrated in the fourth quadrant on Figure 4.9. On the other hand, learners working at a context-embedded level may be hindered in developing their understanding of the content of the lesson, while also failing to develop higher-order cognitive processes (May, Hill & Tiakiwai, 2004). Teachers of bilingual learners must avoid making the assumption that their learners are proficient in the language of instruction if the learners demonstrate conversational competence. Teachers must acknowledge that bilingual learners experience greater difficulties in acquiring the academic-language proficiency in the language of instruction and also that appropriate teaching strategies and interventions need to be implemented in order to facilitate bilingual learners' understanding of mathematics. Figure 4.10 illustrates the cognitive demands of language in mathematics learning and teaching.

Figure 4.10: The cognitive demands of language in mathematics learning and teaching

Cognitively **Undemanding**

Outdoor mathematics skills

- Compare lengths
- Find total by counting
- Tell time of day by name, event,
- Identify shape, colour of concrete objects
- Count concrete objects, people, cows,
- Sort, classify, match concrete objects

Classroom mathematics skills

- Relate ‘add’ to ‘putting together’
- Listening to and retell a story problem, comprehend and place value
- Learn to use symbols to make / complete the week, month, season
- Compute money
- Count forwards/ backwards in 2s, 5s, 10s
- Match group identify concrete objects by size or colour
- Recite, read, write number rhymes 1 - 20

Context **Embedded**

Context **Reduced**

- Explain, justify, compare components
- Solve simple puzzles
- Play counting games
- Use simple measuring instruments
- Give instructions about a computation task
- Comprehend lateness / punctuality
- Add subtract using money

- Reflect on complexity of a computation
- Use an ever increasing array of symbols
- Comprehend, convert, read units of measure
- Solve real life problems involving money
- Estimate
- Round off to a whole number
- Use and interpret time tables
- Perform mental computations
- Distinguish fractions and whole numbers
- Relate ‘multiply’ to ‘divide’
- Relate ‘add’ to ‘ subtract’
- Relate ‘divide’ to ‘repeated subtraction/grouping/equal sharing’
- Relate ‘multiply’ to ‘repeated addition’
- Relate ‘subtract’ to ‘taking away’

Cognitively **Demanding**

Kasule and Mapolelo (2005)

As illustrated in Figure 4.10, it is apparent that even when the context-embedded setting is maintained, the linguistic demands on the learner become increasingly complex. The range of outdoor mathematical skills relies on games learners play using their first language in very familiar and less rigid settings. Therefore these skills are not challenging to learn (Kasule & Mapolelo, 2005). However, the classroom mathematical skills appearing on the right side of the quadrant demand greater linguistic proficiency, because they are learnt in a rigid classroom setting through a second language. Unfortunately, mathematics classroom learning becomes increasingly context-reduced, consequently becoming more cognitively demanding from one grade to the next.

Language competence is a complex skill that needs to be developed continuously and consciously among practising teachers. It can best be developed through practice when an individual reflects on how they acquire language and express themselves through communicative activities. It is therefore imperative to use the correct strategies that promote the use of language to yield positive results.

This section has located the current study by positioning it within the broad debates on the nature of second-language learning and acquisition among biliterates. The section has also located the study within related studies conducted in contexts similar to the current study's context in South Africa. The current study also acknowledges that the majority of the South African population is described as multilingual (competent in more than two languages)[5] rather than bilingual. The reviewed literature sheds more light to the current study by revealing the nature of the classroom dynamics impacting on the acquisition of a second language by learners. The current study investigates the presence and nature of these and more factors as well as seeking to determine the learners' knowledge of critical vocabulary as influenced by the teacher's competence in the language of instruction.

The section below reviews literature on different educational practices regarding the language of learning and teaching, which is pivotal in understanding the current study.

4.5 Language of Learning and Teaching

The language of learning and teaching (LoLT) refers to the language or languages used for both learning and teaching across the curriculum and gives equal importance to both learning and teaching. It is also the language or languages used in textbooks, classroom materials and for examination purposes across the curriculum. LoLT also refers to the language adopted by a particular school for pedagogic purposes (Adler, 2001; Essien, 2013).

For many learners worldwide access to higher education and lucrative labour markets depends on becoming fluent in a second language. This presents a challenge to Language in Education Policies (LiEP) regarding when and how in the school programme the transition to the second language should occur. While there is extensive theoretical literature on this topic, evidence is limited by the difficulties inherent in measuring the causal effect of language of instruction, which for the purposes of this study is referred to as the language of learning and teaching.

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[5] Many South Africans, whose main language is not English or Afrikaans, speak three or more languages (Adler, 2001; Essien, 2003).

To ensure that learners acquire strong foundation skills in literacy and numeracy, schools need to teach the curriculum in a language that learners understand. Mother-tongue based bilingual (or multilingual) education approaches, in which a learner's mother tongue is taught alongside the introduction of a second language, can improve performance in the second language as well as in other subjects (UNESCO, 2016). The pedagogical theory promotes the use of mother tongue as the LoLT until a level of academic proficiency has been attained in that language (which may take three to six years) rather than using a second language from the start of school (Hakuta, Butler & Witt, 2000).

Educationists who promote the immersion approach argue that first-language instruction will delay the acquisition of English (Taylor & Coetzee, 2013). The approach dictates that learners start learning English as early and as comprehensibly as possible. The theoretical foundations of this argument are that language acquisition, including that of a second language, comes more naturally to young learners than older learners. Imhoff (1990) argues that bilingual education denies the reality that practice makes perfect.

In contrast, educationists who promote bilingual transitional models maintain that a learner must first develop cognitively to a sufficient level in the medium of their home language in order to gain the skills necessary for second-language acquisition (World Bank, 2005; UNESCO, 2016). Cummins (1992) argues that there is a great interdependence between literacy skills across languages, specifically referring to the languages that learners learn. He also points out that academic proficiency in a language takes considerable time to master – at least five years; therefore, once academic mastery in the home language has been attained, a learner will possess the necessary literacy skills to acquire a second language with ease.

The notion of a zone of proximal development developed by Vygotsky (1962) is also relevant to second-language acquisition. This notion suggests that all learning builds on existing skills and knowledge, and that consequently there is a zone between what is known and unknown in which new knowledge and skills can be developed using existing foundations. However, substantially more advanced skills or very different learning areas will be unattainable because the links to existing skills have not been established. Consequently, if a certain level of language proficiency and understanding of the principles of literacy such as decoding a text have not been reached in the first language (in which a learner already possesses a substantial written and oral vocabulary), then academic mastery of a second language will be beyond the zone of proximal development. For these reasons, proponents of bilingual transitional models predict that not only will a later transition to English benefit a learner's first language proficiency, but it will also lead to greater proficiency in English in the long run (Taylor & Coetzee, 2013).

While the pedagogical theory supports late-exit transitional models, there are often practical realities which may influence the relative effectiveness of alternative models (Taylor & Coetzee, 2013). In multilingual countries such as South Africa, with numerous home languages, the late-exit transitional models are deemed impractical because:

- it may be difficult to provide quality instruction using the various home languages as LoLTs;
- sufficient high-quality teaching materials may not be available in all the home languages;
- in schools where multiple home languages are used within the same classroom, it may be preferable to teach using English as the LoLT rather than any particular home language; and
- there may be a shortage of teachers who are proficient in the various home languages.

On the other hand, the success of an English immersion model may be impeded by teachers who are not fluent in English, thus compromising the delivery of an English immersion programme. Generally, the teachers' capability and motivation may also be a critical mediating factor.

The proponents of structured immersion programmes generally recommend sophisticated instructional methods which may, even if pedagogically sound, be flawed at the level of implementation in certain contexts (Rossell & Baker, 1996). Similarly, the transition to English that must occur in bilingual models may be extremely disruptive and educationally damaging if there is not a high quality of support materials nor teacher expertise to manage this phase effectively, a concern that is often expressed in South Africa (van der Berg, Burger, Burger, Vos, Randt, Gustafsson, Shepherd, Spaull, Taylor, Van Broekhuizen & Von Fintel, 2011; Taylor & Coetzee, 2013).

In as much as late transition seems to be beneficial, the gist of this study is that at one point or the other a transition will take place. Whether the transition to the use of English as LoLT is made early or late, the teacher must be sufficiently equipped to manage this transition. Therefore, for the teacher to function as a competent classroom practitioner, the teacher's competency in using English as the LoLT must be investigated. IP teachers who usually manage the transition from mother-tongue to English-medium education must be well prepared to manage the transition at whatever stage of the education system the transition occurs.

There may be numerous other political or ideological motivations behind the adoption of a particular language in education policy, such as using a single language to promote national unity or developing a diverse cultural heritage (World Bank, 2005). However, the question of which approach is most suitable in a particular context is ultimately an empirical one. As the next section will show, there is a dearth of empirical work using credible methods to identify the causal impact of alternative language-of-instruction models on second-language acquisition or on other educational outcomes. There is an even more acute shortage of such research conducted in developing countries, especially those in Africa. Consequently, ideology often trumps evidence in language policy debates (Slavin, Madden, Calderon, Chamberlain & Hennessy, 2011; Taylor & Coetzee, 2013).

The next sections review studies conducted globally, in sub-Saharan Africa, in South Africa and in the Eastern Cape Province of South Africa. Each section commences by reviewing studies that investigated the language of teaching and learning across the curriculum, before focusing on studies that review the language of teaching and learning in relation to mathematics education.

4.5.1 Language of Learning and Teaching: The Global Landscape

Global language dynamics are such that 40% of the global population does not have access to an education in a language they speak or understand as their home language (Walter & Benson, 2012; UNESCO, 2016) and this limits the learners' ability to develop foundations for learning. About 221 million learners are estimated to speak a different language at home from the language of learning and teaching in school (Dutcher, 2004). This section provides an overview of international studies that address the language of instruction in the following countries: United States of America, New Zealand, England, Spain, Saudi Arabia and Papua New Guinea.

Chan (1982) compared the differences in discourse patterns between bilingual and monolingual Mexican-American tutors when tutoring mathematics to bilingual Mexican-American learners based in the United States of America. The study revealed that the bilingual tutors used more general explanations illustrated by examples and counter-examples than monolingual tutors. The bilingual tutors also used and received more accepting and acknowledging responses from learners, while monolingual tutors used and received more negating responses with questions. The study concluded that differences in discourse patterns confirm that more communication occurs when a bilingual person is taught by another bilingual person rather than a monolingual person (UNESCO, 2016).

Several studies reviewing the literature on alternative language-of-instruction regimes have been conducted, mainly pertaining to the question of language policy for Spanish-speaking learners in the United States of America. Rossell and Baker (1996) argued that the evidence from studies of sufficient methodological quality suggested no significant difference between bilingual education approaches and English immersion approaches. However, subsequent re-analysis of the same studies (Greene, 1997; Cheung & Slavin, 2005, 2012) demonstrated that many of these studies had serious methodological flaws and that the most credible studies in fact favoured bilingual approaches.

Cheung and Slavin (2012) found 13 studies that met their methodological criteria for inclusion; however, the 13 studies do not all provide strong grounds for causal inferences and the studies reviewed contain samples that are really too small for precise measurement. For example, the study conducted by Slavin et al. (2011) in six schools was described as the only multiyear randomized evaluation of transitional bilingual education. The small sample of participants was considered as a weakness.

Ramìrez, Pasta, Yuen, Ramey and Billings (1991) followed three types of schools in several districts in the United States of America (immersion schools, early exit to English schools and late exit to English schools) for four years. The study revealed two weaknesses: a lack of comparability of teacher and school characteristics across school types; and the English proficiency of those in the late-exit programme was not observed in years subsequent to the varying treatment. Furthermore, as Cheung and Slavin (2005) denote, the study did not adequately control for pre-test scores. Nevertheless, the study found no significant differences across the three groups of schools at the end of the treatment period. Cummins (1992) argues that this finding supports bilingual approaches, since it demonstrates that they can lead to equal levels of English proficiency despite less time being spent on English instruction.

Thomas and Collier (2002) conducted an influential study in the United States of America investigating the language of teaching and learning. The study concluded that learners who had undergone dual language instruction performed better at the end of high school than learners who had only experienced immersion in English.

4.5.1.1 Language of Learning and Teaching Mathematics: The Global Landscape

Many indigenous communities in high-income countries are marginalised – the marginalisation has been identified through learner assessments – but this has received minimal attention in international education debates. According to an analysis of TIMSS data, in Australia, approximately two thirds of indigenous learners achieved the minimum benchmark in mathematics in Grade 8 between 1994/1995 and 2011, as compared with almost 90% of their non-indigenous peers (Thomson et al., 2012; UNESCO, 2016).

Dawe (1983) investigated the teaching of mathematics using English as the LoLT to bilingual Punjabi, Mirpuri, Italian and Jamaican primary school learners living in England and for whom English is a second language. The study concluded that first-language competence was an important factor in the learners' ability to perform mathematical reasoning in English as a second language.

Aidoghan (1985) investigated the predictive validity of selection measures and related variables used on 1,261 Saudi Arabian university students. The study concluded that skill in English is a good predictor of success only up to a certain level, above which differences in English proficiency had no major influence on success.

Mestre (1986) compared groups of bilingual Hispanic learners and monolingual learners, all undertaking a degree in engineering at university in the United States of America. All learners completed a reading test in English, an algebra test and a mathematics word problem test. On the word problem test the bilingual learners were slower and less accurate than the monolingual learners. The study concluded that the reading and interpretative demands of the mathematics word problem test was a source of difficulty; knowing the vocabulary in a word problem is no guarantee that the mathematical relationship will be appropriately interpreted by non-native speakers. This evokes the need to investigate further elements such the syntax and semantics of written mathematical text that may pose problems for second language speakers of a language.

Cuervo, (1991) investigated the effects of mathematics instruction in two languages, English and Spanish, on the performance of bilingual Hispanic college students in the United States of America. The study concluded that the bilingual students who received mathematics instruction in English and Spanish obtained higher academic achievement. Thus the study revealed that bilingual instruction was more effective than traditional instruction provided in English only.

Clarkson (1992) conducted similar studies in Papua New Guinea. The first study confirmed that comprehension errors constitute a large number of the errors made by Grade 6 learners when solving mathematical word problems and concluded that the influence of English, the LoLT, as well as the influence of the learners' home language Pidgin, had a significant impact on their mathematical performance. The second study concluded that bilingual learners competent in both the languages performed significantly higher in mathematics than both the low-competence bilingual and monolingual learners. The studies argued that competence in the mother tongue as well as in English plays an important role in the comprehension of mathematical texts.

Bearde (1993) investigated the correlation of oral language proficiency and mathematics achievement 1,498 primary school learners for the Woodcock-Johnson Psycho-Educational Battery Revised Test. Results of the test revealed oral language proficiency as a strong predictor of both mathematical reasoning and basic skills. The study thus suggested that a surface level understanding of language is insufficient for mathematics achievement; a deeper level of language, involving an understanding of relationships, is needed.

Han (1998) investigated the relationship between the clarity of specific mathematical terms and learners' mathematics achievement among Chinese learners living in the United States of

America. The sample for the study was comprised of newly immigrated, monolingual Chinese-speaking learners, American-born, monolingual English-speaking Chinese learners and bilingual Chinese/English-speaking learners. The study revealed that Chinese language ability was a strong predictor in mathematics achievement and the relative clarity of mathematical terms in Chinese contributed to the better performance among the Chinese-speaking learners.

Lim (1998) investigated the relationship between language and mathematics among Korean learners living in America. The study investigated the associations between various background factors such as reading skills, English proficiency, parent's educational background, Korean-language school attendance and length of residence in the United States. The study concluded that language is associated with mathematics achievements, especially in tasks that require substantial amounts of language processing such as problem solving; background factors that are directly or indirectly related to language proficiency are also associated with mathematics problem solving. These findings suggest that bilingual learners' success in problem solving is interwoven with their level of proficiency in English and factors that relate to English proficiency. The study recommended greater exposure to the LoLT and the language of mathematics for learners whose proficiency in English is limited.

Gorgorió and Planas, (2001) investigated mathematics teaching and learning in schools with large numbers of immigrant learners in Spain. The study found that the language practices that learners bring to school inevitably affect how and what they learn. The study also concluded that in mathematics lessons, the learners had difficulties with understanding everyday words within a mathematical context, as well as a false sense of understanding and communication, or lack thereof, with the teacher. From a teaching perspective the study concluded that the linguistic barrier is extended beyond everyday communication and teachers feel that the absence of a common language amongst learners is a barrier to their mathematical learning. The study recommended that more research is necessary with a focus on how mathematical language can be taught and on the relationship between the language of the mathematics class, mathematical language and the process of constructing mathematical knowledge.

Dakroub (2002) investigated the role of Arabic literacy in the academic achievement of middle school learners in English in Michigan, United States of America. Learners were tested to determine their level of literacy in Arabic in relation to academic achievement in English reading, language and mathematics. The study confirmed a significant positive relationship between the learners' literacy in the Arabic language and achievement in English reading, language and mathematics. Learners with high levels of English literacy performed better than the learners with high levels of Arabic literacy.

Barton and Neville-Barton (2003) investigated the dynamics of learning mathematics using English as the LoLT for 80 university students whose mother tongue is not English in New Zealand. The study concluded that in comparison to students who are native speakers of English, students who are not first language speakers of English experience between 10 and 15% disadvantage in overall performance through a lack of understanding mathematical texts. The study provided an insight into how language affects mathematical understanding. The study reiterated that mathematics is not a language-free phenomenon (Reborn, 1995) and the particular vocabulary, syntax and discourse of mathematics challenges learners when English is used as the LoLT.Yushau and Bokhari (2005) investigated Saudi Arabian preparatory-year mathematics students for whom English was a new language of instruction. Prior to entry into university, the students would have learnt entirely through the medium of Arabic – their first language. The general consensus at the university is that these students perform below expectation, contrary to the level of mathematics ability on selection for entry into the university, and this low performance is attributed to lack of English proficiency. The researchers implemented a mediated teaching approach with the primary focus on providing language support in order to improve the students' understanding in mathematics by providing handouts with translations of the important terminology. The findings of the experiment showed that the use of translation encouraged students to connect previous learning with new learning, and that there was increased participation in class and improved performance in examinations. The researchers found that this approach minimised the language barrier evident in the classroom and, because of the improved performance in examinations, it demonstrated the existence of a positive connection between language proficiency and mathematics learning.

Latu (2005) conducted a study in New Zealand and found that Pasifika learners' learning of mathematics through the medium of English was hindered by an under-developed mathematical discourse in both Tongan and Samoan languages and accordingly their ability to deal with complex mathematical sentences, phrases and mathematical terms. This demonstrates the importance of a speaker's first language of learning for the transition to English-medium mathematics education.

Clarkson (2007) investigated high ability Australian-Vietnamese bilinguals and their use of language(s) when engaged in mathematical problem solving. He found that the learners rely on language switching and thus their competencies in both languages is of importance to how they perform on mathematics problems. When language switching (English to Vietnamese) did occur, it was mainly translating entire problems (as opposed to individual words). This may be a result of all learners having a well-developed mathematical register in Vietnamese, suggesting that it is more than just vocabulary that plays a significant role in the transition to learning mathematics through the medium of English.

According to UNESCO (2016), when language, ethnicity and poverty interact, they can produce an extremely high risk of exclusion and being left behind. Learners from poor households who speak a minority language at home are among the lowest performers. In 2012 poor 15-year-olds in Turkey speaking a non-Turkish language, predominantly Kurdish, were among the lowest performers. Around 50% of poor non-Turkish speakers achieved minimum learning benchmarks in reading, against the national average of 80%. In 2006, of the poor learners in Guatemala speaking an indigenous minority language, only 38% learned the basics in mathematics, while 77% of rich learners who speak Spanish reached that level. In Guatemala learners in bilingual schools have higher attendance and promotion rates, and lower repetition and dropout rates. Moreover, they have higher scores on all subjects, including mastery of Spanish. A shift to bilingual education would reduce repetition and result in a significantly more cost-effective education system (Patrinos & Velez, 1996; UNESCO, 2016).

The literature reveals that the challenges regarding language in education are most prevalent in regions where linguistic diversity is greatest, as in Asia, the Pacific and sub-Saharan Africa (UNDP, 2004).

4.5.2 Language of Learning and Teaching: The sub-Saharan Landscape

There is a lot of work that needs to be done to increase studies on language in education in developing countries; especially countries in Africa require attention. More studies focusing on the African continent still need to be conducted in order to increase the number of studies that have a large enough sample for precise estimations, and a multi-year duration so as to shed light on ultimate educational outcomes. The majority of studies on language of learning and teaching in African countries are written by linguists in favour of mother-tongue instruction. This section provides an overview of studies conducted in the sub-Saharan region that address the language of instruction in the following countries: Mali, Uganda, Kenya, Burkina Faso, Nigeria, Ethiopia, Tanzania, Cape Verde, Cameroon, Mozambique, Botswana, Zimbabwe and Lesotho.

According to Bühmann and Trudell (2008), in Mali's Pédagogie Convergente programme learners commencing school with mother-tongue instruction ended up with better mastery of the official language, French. Between 1994 and 2000 learners who began their schooling in their mother tongue scored 32% higher on French proficiency tests at the end of primary school than those in French-only programmes.

Piper and Miksic (2011) investigated the relationship between language of instruction and reading acquisition in Uganda and Kenya using observational data and regressing reading scores on a set of observed characteristics, including language of instruction, which varies across schools. Piper and Miksic (2011), however, concede that the cross-sectional nature of their data precludes causal inferences.

Nikiema (2011) recorded the results of tests in French carried out with learners from bilingual schools in Burkina Faso and found them to be comparable to or higher than those of learners in traditional French-instruction schools. The benefits of bilingual/multilingual programmes extend beyond cognitive skills to enhanced self-confidence and self-esteem. In Burkina Faso mother-tongue instruction facilitated the use of effective teaching practices in the classroom and encouraged learners to be active and become involved with the subject matter.

Earlier research and common practice in the past have supported earlier transitions from home language to official language. However, recent evidence now claims that at least six years of mother-tongue instruction – increasing to eight years in less well-resourced conditions – is needed to sustain improved learning in later grades for minority language speakers and reduce learning gaps (Heugh, Benson, Bogale & Gebre Yohannes, 2007; UNESCO, 2016). However, many countries in sub-Saharan Africa that support bilingual education continue to favour early transition to the official language, usually by Grade 4 (Alidou et al., 2006).

Fafunwa (1989) documented the Six Year Primary Project (SYPP) also called Ife project conducted in Nigeria is regarded as the most authoritative case study on the use of the mother tongue in formal education (Bamgbose, 2000, 2004; Ali-dou, Boly, Brock-Utne, Diallo, Heugh & Wolff, 2006). The project began in 1970 with two experimental schools using Yoruba as the medium of instruction for the six years of primary education, while one control school used only three years of mother-tongue instruction and then switched to English as LoLT. Evaluations of the project found that learners who switched to English after six years of mother-tongue instruction performed better in English and in other subjects compared with those who did so after only three years. The project claimed to clearly demonstrate the positive effects of late-exit transitional models relative to early exit from the mother tongue. Although, several additional schools were added to the project in subsequent years, the small sample size remains a weakness in comparison with recent standards in randomised control trials. Secondly, apart from receiving more years of mother-tongue instruction, experimental schools received other instructional materials as well as a specialist English teacher. Therefore as Akinnaso, (1993) contends, it was not possible to separate the effects of language of instruction from other aspects of instructional quality.

Adetula (1990) investigated the extent to which the language of instruction contributes to performance in mathematics in Nigeria. The findings revealed that learners performed better when the mathematical problems were presented in their home language than when presented in English. The study concluded that the teaching and learning process is compromised when learners are forced to learn mathematics in a foreign language. This is because they have to learn new vocabulary as well as being able to express themselves mathematically in the new language.

Ethiopia has gone further than many countries in seeking to combine mother-tongue instruction with Amharic and English in Grades 1 to 8. Learners' participation in bilingual programmes for eight years improved their learning in subjects across the curriculum and not just in the language of instruction. Primary school learners learning in their mother tongue performed better in Grade 8 in mathematics, biology, chemistry and physics than learners with English-only schooling (Heugh et al., 2007; UNESCO, 2016).

Walter and Chuo (2012) conducted an experiment in Cameroon in which 12 schools received instruction in the mother tongue (Kom) for Grades 1 to 3 switching to English instruction in Grade 4. Twelve matched schools received the traditional instruction in English. After five years of schooling (i.e. two years after the switch to English for experimental schools) those in experimental schools were performing better in English reading than those in control schools. Learners taught in Kom showed a marked advantage in achievement in reading and comprehension compared with learners taught only in English. Learners taught using Kom as the LoLT also scored twice as high on mathematics tests at the end of Grade 3. However, the learning gains were not sustained when the learners switched to English only instruction in Grade 4. There was no significant difference in mathematics skills between experimental and control schools at the end of the experiment. Thus, the early exit from a mother-tongue environment prevented them from sustaining this performance across the curriculum (Walter & Chuo, 2012). The major advantage of this study is its 5-year duration (2007 – 2012). However, a major weakness is that the experimental schools were recommended by local education officials. Therefore, despite the matching process, these schools may differ in certain unobserved ways from the control schools.

Benson (2000) reports on an experiment in Mozambique comparing a bilingual programme to the traditional Portuguese-only programme. Although sample size was again small (four treatment and four control schools) and there were admittedly several design problems, Benson maintains that the project pointed to increased classroom participation, self-confidence and language proficiency amongst learners in the experimental schools.

Teachers in Botswana view code switching negatively and refer to it as a compensatory strategy. Unlike Lesotho learners, Botswana learners have not been reported to switch codes. In Grade 1 and Grade 2, there is an effort on the part of some Lesotho teachers to make learners listen to English, while others do not do this. The former group speaks English and switches to Sesotho for clarity. The latter group speaks Sesotho and switches to English only to introduce a few new English words. Drills are a common feature in most lessons. The switching of codes in this manner has been observed in Lesotho schools and is thought to facilitate understanding of new and difficult concepts (Akindele & Letsoela, 2001; Arthur, 2001).

Teachers' and learners' communicative competence and experience warrant attention. Most teachers are competent in English for the classes they teach; there are, however, some instances of broken grammar or use of wrong expressions that could lead learners to giving incorrect answers. One teacher, for example, asked the class the question: '*How much do you pay apple?*' Most learners lack communicative competence in English, except in the English-medium schools, where English is the medium of instruction from the first grade upwards. Most of these English-medium schools depend on fees as well as public funds. So the greater linguistic competence of learners may be partly attributed to social selection. Nevertheless, the contrast is informative. Learners in the English-medium schools do use English for communicative purposes. They do not merely mimic what teachers say, but use English to analyse the content of the lesson. They make rich individual comments, based on grounded analyses, and use creative language. To some extent, this indicates what could be achieved in other schools where Sesotho is in practice the main medium of communication among teachers and learners, even in the higher grades and learners hardly ever speak English. This environment is shaped by teachers' attitudes and mechanical approach to their work which effectively denies the learners the chance to improve their communication skills in English and appreciate its structure. The task of raising learners' competence in English, both spoken and written, requires a communicative approach to both the teaching of the subject and the use of the language across the curriculum.

Mufanechiya (2011) conducted a study to assess the language of instruction in Zimbabwean primary schools. The study was aimed at assessing the challenges faced by both teachers and learners when using English as the LoLT in Masvingo province. The study concluded that English is perceived to be the economic gatekeeper by both learners and teachers. Although the Language in Education Policy of 1987, which stipulated English as the LoLT in schools in Zimbabwe was revised in 2006 to include other dominant languages in the country, teachers still preferred to use English in their classroom. Learners also strove to use English at all times and do not shy away from using 'broken English' as long as their efforts increase their mastery of the language. In that study a lot of code switching was used by the teachers to help learners access the content taught. Learners also conducted their group discussions in English, but made an effort to report back to the class in English. For a country that has suffered huge amounts of economic turmoil, teachers and learners viewed English as a means to getting a job, a chance to get educated, the ability to participate more fully in the life of their own country, or have the opportunity immigrate to another country. Fluency in English also translates into an expansion of one's literary and cultural horizons, the expression of one's political opinions or religious beliefs. The study noted, however, that changes in the country's language in education policy were not accompanied by sufficient teacher preparation, and as a result teachers used methods that worked best for them in the classroom.

Moloi, Morobe and Urwick (2008) noted in a study conducted in Lesotho that the LoLT in the first three grades is Sesotho, the mother tongue of most learners; from Grade 4 onwards the prescribed LoLT becomes English. However, they noted that the actual situation in most schools is one of either using Sesotho predominantly or of switching between Sesotho and English.

4.5.2.1 Language of Learning and Teaching Mathematics: The sub-Saharan Landscape

Taole (1981) investigated the effect of studying a selected mathematics topic among 444 Lesotho learners and ten teachers from six secondary schools in Lesotho. In each school the learners were divided into three groups: the first group was taught in English, the second group was taught in Sesotho using translated resources, while the third group has access to both the English and Sesotho materials. The results showed that the learners taught in Sesotho performed slightly better than those taught in English, while learners taught bilingually performed slightly better than those taught in Sesotho. The study also revealed that among the learners taught in English, those who performed better had a higher level of English proficiency than those who failed.

Ferro (1983) investigated the influence of language on the mathematical achievement of 89 tertiary level bilingual students enrolled for a two-year basic mathematics course in Cape Verde, South East of Senegal. The students were divided into three groups, the first group was taught entirely in English, the second group was taught in a mixture of Cape Verdean and English, while the third group was taught in a mixture of Portuguese and English. The study concluded that students whose mother tongue is Cape Verde, and were taught mathematics using a mixture of Cape Verde and English, performed better than those taught entirely in English and those taught in a mixture of Portuguese and English.

Maro (1994) investigated the ability of Tanzanian secondary school learners to reason using English, their second language. English and Kiswahili versions of a mathematics reasoning test were used to test the learners' reasoning ability in the two languages. The study concluded that the performance of the learners on the mathematical reasoning tests varies depending on the language of the test. Better performance was recorded on the Kiswahili tests.

According to Arthur (2001: 354), the practice of using mother-tongue instruction in the first three grades of school and then switching to using English as the LoLT from Grade 4 onwards is prevalent in many sub-Saharan countries including Botswana, Tanzania and South Africa.

4.5.3 Language of Learning and Teaching: The South African Landscape

This section provides an overview of studies within the South African context that address the language of instruction. The studies have literacy transition and literacy-related foci.

In South Africa prior to the Nationalist Party rule in 1948, there was a relatively loose policy of mother-tongue instruction which varied from province to province (Hartshorne, 1992; Sepeng, 2015). When the Nationalist government came into power in 1948, Afrikaans was established alongside English as a fully-fledged official LoLT (Adler, 2001) for all learners in minority white, coloured and Indian schools. The Bantu Education Act of 1953 changed the language policy and extended the use of mother tongue and Afrikaans as LoLT and by 1959 all eight years of primary education for black learners was done in the mother tongue and secondary education used English and Afrikaans as LoLT in a ratio of 50:50. To implement the new policy, all teachers in black schools had five years to become competent in Afrikaans through the intensive in-service Afrikaans language courses that were offered by the government (Hartshorne, 1992). This LiEP was specifically and explicitly designed to serve the apartheid regime, and it was vehemently resisted, leading to the 1976 Soweto uprisings.

Mbude-Shale (2013) describes the Bantu Education System (1953 – 1976), which offered African learners mother-tongue instruction for eight years, as an impoverished curriculum whose basis was to educationally disable black learners. The current study contends that some products of the Bantu Education System who ended up as teachers, specifically primary school teachers in public schools, could have transferred their impoverished curriculum knowledge to their learners.

Nel and Swanepoel (2010) investigated the language errors of English second-language teachers and how these affect their learners at the University of South Africa (UNISA), a large, open distance-education university in South Africa, and found that the majority of the practising teachers who enrolled as students for the practical component of the Advanced Certificate in Education (ACE): Inclusive Education (Learning Difficulties) for the year 2008 lacked English proficiency. Because the student teachers' home language is not English, they found it difficult to master the course, as reflected by the low throughput rate of 44 per cent in 2008. The main question of the study was: *Does poor proficiency in English of English second language (ESL) student teachers influence English second language learners' progress during learner support lessons taught by student teachers as part of their teaching practice for the ACE: Inclusive Education (Learning Difficulties)?* In an attempt to answer the question, they reported on typical errors made by the learners and the student teachers, and on the similarities between teacher errors and learner errors, against the background of a literature overview which included the relationship between input and output and prominent theories of second-language acquisition. A qualitative analysis of the student teachers' portfolios was undertaken.

Documentary analysis was conducted by means of error analysis of the student teachers' portfolios, which included ELL support lessons and ELL evidence submitted by the student teachers.

The fact that language errors occurred in the portfolios of qualified practising English second-language teachers teaching ELLs was disconcerting. Research findings revealed that practising teachers who were enrolled for the ACE were themselves in need of corrective measures and interventions that would enable them to acquire English proficiency before they could be expected to help their ELLs. The findings concurred with Cloud (2005) who notes that:

> The practical knowledge base of teachers should be grounded in theory and principles and should be informed by effective language and content teaching that is appropriate for the different stages of a programme and teachers' development.

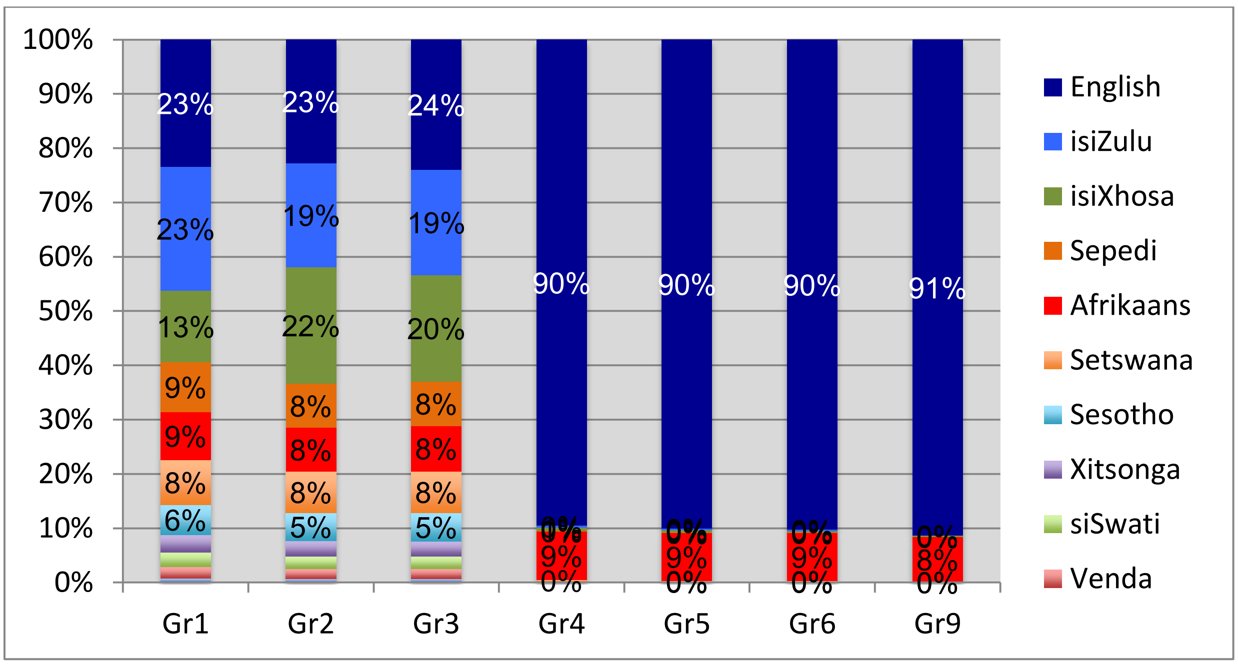
Cloud, (2005: 279 – 280)

Thus, various concepts and descriptive accounts should be considered to enable teachers to understand their classroom experiences and offer pedagogic choices to their learners. (Mitchell & Myles, 2004: 261). In addition, teachers should be trained to teach through the medium of English as they have been seen to lack the knowledge and skills to teach the four language skills and ignore the importance of methodological skills (Uys et al., 2007: 77). The reading ability of students at tertiary-level institutions should be tested and their reading skills developed (Pretorius, 2002: 101). Given the fact that vast amounts of research focuses on primary school learners, the study highlighted the fact that more research into the language proficiency of practising English second-language teachers is needed, including those who use English as LoLT, as well as a more comprehensive study into the effect that a low level of language proficiency of English second-language teachers has on ELLs.

The results of Nel and Swanepoel's investigation are relevant, timely, significant and in line with the current study, because they alert academia to the extent and impact of the qualified practising English second-language teachers' low level of English proficiency and its possible effect on the ELLs' ability to develop English proficiency. Nel and Swanepoel further recommended that research is necessary in order to identify the critical contributing factors and to develop a multifaceted solution to the problem, including a re-evaluation of teaching methodologies. A two-tiered approach is needed: firstly, the student teachers' level of English proficiency should be raised; and secondly, guidelines should be developed to improve learner support lessons presented in student teachers' practical teaching portfolios to ensure that ELLs are taught effectively (Nel & Swanepol, 2010). In as much as many higher academic institutions support first-year English second language students by assisting them in upgrading their cognitive academic language skills, the study indicated that even students with three-year qualifications may require assistance in upgrading their CALP (Nel & Swanepoel, 2010). Thus, Nel and Swanepoel's study serves as a springboard for the current study to explore the language proficiency of IP mathematics teachers.

South African language dynamics are such that 90% of learners of South African learners are not native English speakers (Spaull, 2016); therefore English becomes their first additional language in school. The teaching of English is key to the overall success of learners as their ability to speak English inevitably impacts on all areas of their learning; not only listening, speaking, reading and writing, but also in mathematics (as emphasized by the current study), sciences and all other content areas where an understanding of concepts and effective communication skills are required. Figure 4.11 shows the frequency of the use of the 11 official languages in South Africa as languages of learning and teaching as well as assessment at primary school level. Different home languages are used in the first three grades while from Grade 4 onwards, English dominates as a language of learning and teaching.

Figure 4.11: Language of Learning and Teaching in South African primary schools



Spaull, (2016)

Reports have shown that learners' language competency across all phases is disturbingly lower than the expected standards and consequently learners progress to higher grades and phases without the prerequisite knowledge and language skills (Mohlabi-Tlaka, 2016: 7; Krugel & Fourie, 2014: 220; van Dyk, 2005: 38). The reality in many public schools is that learners transit from the Foundation to the Intermediate phase while still battling to read, let alone write in the first additional language. Learners' poor and inadequate language skills create a perpetual and recurring problematic situation which contributes to the lack of intellectual growth necessary for national socio – economic development.

MacDonald, (1990) and Hoadley, (2010) describe a study conducted in pre-independent South Africa's Bophuthatswana homeland which examined learner challenges in coping with 'crossing the threshold' to learning all subject areas using English as a LoLT. The study indicated that the learners had a vocabulary repertoire of 700 words when the curriculum demands could only be met with a minimum of 7,000 words. The most proficient among the learners had only about 10% of the requisite vocabulary and this compromised learners' reading with comprehension and effective learning in general. According to Hoadley (2010: 8), "the sudden transition resulted in most learners resorting to rote learning content which they did not understand". There was significant loss of meaning on the part of the learners. Learners' pedagogical experiences were connected to the high dropout rate at Grade 4 at the time.

> Chorusing and rhythmic chanting in classroom and absence of individual, evaluated performances was a strategy to mask both teacher's and learners' poor command of English and their lack of understanding of academic content. In a sense it represented a form of learning that enabled them to hide the absence of substance.
>
> Hoadley (2010: 8 – 9)

The quality of teacher language use and classroom dynamics is an important feature of the current study. Teacher talk, may determine the quality of instruction, particularly in an IP mathematics classroom. The next study by Taylor and Moyane interrogated classroom dynamics regarding language competency.

Taylor and Moyane's (2004) Khanyisa Education Support programme baseline study of 24 randomly selected primary schools in two rural Limpopo province districts confirmed chorusing, low cognitive demand, weak assessment, slow pacing, poor quality and quantity of reading and writing as characteristic at the Grade 3 level. Individual learner interaction with books constituted a mere 3% of time in the literacy classrooms. The most manifest form of learner reading was the reading of three or four sentences on the board chorally after the teacher. The scant writing that was evident was that of decontextualized words and not sentences. The existent classroom practices were exposed as very limiting in terms of developing learners' proficiency in the target language. Taylor and Moyane's study is instructive because it indicates the extent to which attempts were made to enhance Grade 3 isiXhosa-speaking learners' proficiency in the English language as the key to establishing the extent to which they were prepared for the challenges of reading in Grade 4.

Since the transitional challenges informing the current study are related to reading, a review of research in reading was necessary. Hoadley (2010) reports on a study on the teaching of reading conducted by the Human Sciences Research Council (HSRC) in twenty schools in Limpopo Province in Grades 1 to 4 classes. The large-scale study involved 2-hour observations in 77 classes. Results indicated very little evidence of reading: in 12% of the classrooms virtually no reading was evident. In the few instances where it was evident, teacher modelling was absent and the reading was confined to words in isolation and not extended texts. Only picture discussions were evident. In 69% of the time learner responses were not elaborated on. The study concluded that "the scale of exposure to vocabulary and text falls way below what should be expected at each grade level observed" (Hoadley, 2010: 18).

Taylor and Coetzee (2013) interrogated language of instruction practices in South African primary schools. The study suggested a positive correlation between English instruction in the first three grades and subsequent performance in Grades 4, 5 and 6. The study also found that mother-tongue instruction in the early grades significantly improves English acquisition, as measured in Grades 4, 5 and 6.

Vorster, Mayet and Taylor, (2013) conducted a national study[6] to estimate the disadvantage of writing a test in English compared to writing in mother tongue. The study was composed of two sets of test scores for the same learners in the same year on the same test administered in English on one occasion and in the mother tongue on another occasion. However, the study does not provide specific recommendations on when the language of learning and teaching should switch from mother tongue to English.

Taylor and Coetzee (2013) used longitudinal administrative data from the Annual National Survey of schools as well as test scores in English and maths from standardised tests written as part as the Annual National Assessments (ANA). The baseline estimates indicated that instruction in English is beneficial both for the performance in the English and the mathematics tests. However, after controlling for school fixed effects; they also found that there was a significant disadvantage to receiving instruction in English rather than the learner's home language. They also interrogated the robustness of the results against a list of factors in order to make sure that the results were not driven by changes in school quality correlated with the change in language of instruction over this period. Their findings were in line with the pedagogical theory which promotes the acquisition of a first language before moving on to a second language. The importance of their study is in being the first robust study which attempted to disentangle the impact of language on the performance of learners in South Africa.

[6] The study by Vorster, Mayet and Taylor (2013) excluded one of the nine provinces.

The results of the study by Taylor and Coetzee (2013) indicate the advantage of additional years of home-language education to learners in the under-resourced schools in South Africa. However, although the results are robust, they are also very heterogeneous and do not hold for all schools in South Africa. They therefore concluded that the results could be used as suggestive evidence that the current language in education policy, where schools have the autonomy to make their own decisions regarding the language of instruction adopted (DoE, 1997), may be the most appropriate. However, as long as this is the case, there is little incentive to switch to an African language as the LoLT in schools (Taylor & Coetzee, 2013). With a view to promoting multilingualism in the post-apartheid period, parents have been given the right to choose the language of instruction at their children's schools. In practice though, the majority have chosen English as the language of teaching and learning, because they consider it to be the language that will afford their children the greatest success and status.

> '...in selecting a strategy to have their children learn English, they demonstrably take the worst route, namely to choose English as the language of instruction from as early a grade as possible.'
>
> Weideman and van Rensburg (2000: 157)

There is substantial evidence in the language and education literature to suggest that learners need to have reached an adequate competency in reading and writing in their mother tongue first before they are able to acquire competency in a second language. In support of this view, it emerged from Taylor and Coetzee's study that adults in their sample who were proficient in their home language were also significantly more likely to be proficient in English. The analysis revealed that home-language proficiency is one of the most important determinants of English-language proficiency among Africans. The study recommended that it would be difficult to implement mother-tongue instruction in a country where African languages have low economic value and status and are rarely used in public life. The study further noted that the consequences of not tackling the mismatch between parents' perceived intentions and language outcomes in the South African LiEP are apparent in the alarmingly low throughput rates of learners within the ordinary school system as well as the poor language skills among those who have just completed school. Thus, parents and teachers need to be made aware of the benefits of mother-tongue instruction so that they can make informed decisions regarding the best way for learners to achieve both English-language proficiency and a suitable level of cognitive development (Taylor & Coetzee, 2013).

4.5.3.1 Language of Learning and Teaching Mathematics: The South African Landscape

Rakgokong (1994) argued that using English only as the LoLT in multilingual primary mathematics classrooms in South Africa has a negative effect on the learners' meaning-making and problem-solving ability. The study highlighted that in classrooms where English was the only language used for teaching and learning, learners were unable to conceptualise the relevant discourses. The study concluded that when English was the sole language used in the learning environment, learners were constrained in engaging in the discourse of the classroom, thus affecting the development of their mathematical knowledge and understanding.

Varughese and Gencross (1996) found that South African first-year mathematics students using English as LoLT had difficulty in understanding terms such as *integer*, *perimeter* and *multiple*. The study supported the contention that language influences mathematics learning and understanding. The current study contends that these students' transition from mother-tongue instruction at primary level might have been mishandled; consequently misconceptions of these terms which are introduced at primary level are carried forward into higher levels of education.

Naudé (2004) conducted a comparative study between Afrikaans learners who attended English lectures and Afrikaans learners who attended Afrikaans lectures, and found that there was no significant difference in performance between the two groups, even though the Afrikaans learners attending the English lectures were academically stronger. This finding supports the view that the students were disadvantaged as they were not proficient in mathematical English. Similarly, when examining the influence of language on the mathematical performance of learner; Dawe and Mulligan (1997) concluded that teachers need to encourage learners to recognise and distinguish between 'mathematical' English and 'natural' English as these are sources of confusion and lead to errors in performance.

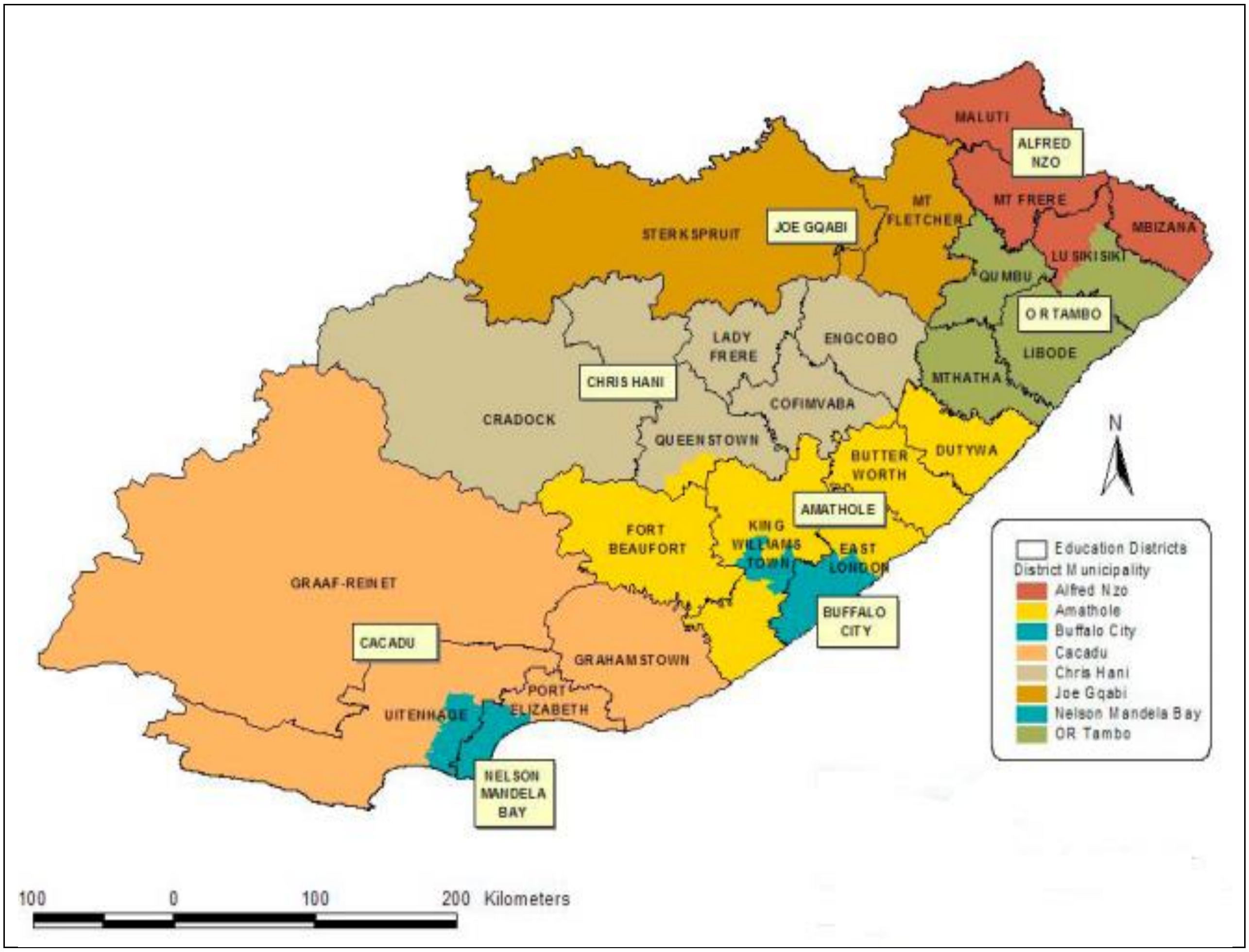
4.5.4 Language of Learning and Teaching: The Eastern Cape Province

> The Eastern Cape was the hub of education for black people for a long time, a province with a wonderful history of production of educated heroes and heroines of struggle; individual teachers, learners, parents and all community based organisations should play a leading and pivotal role in rebuilding the Eastern Cape Education; no individual or an organisation should be allowed to act in a manner that is against the spirit of rebuilding the Eastern Cape Education Department.

Ms Makgate in Ncanywa, (2014)

The Eastern Cape Department of Education (ECDoE) is divided into 24 districts namely, **Bisho**, **Butterworth, Cofimvaba, Cradock, Dutywa, East London, Fort Beaufort, Graaff-Reinet, Grahamstown, King William's Town, Lady Frere, Libode, Lusikisiki, Maluti, Mbizana, Mt Fletcher, Mt Frere, Mthatha, Ngcobo, Port Elizabeth, Queenstown, Qumbu, Sterkspruit** and **Uitenhage.** The education districts overlay with district municipalities and metropoles as shown in Figure 4.12**.**

Figure 4.12: ECDoE District Boundaries



ECDoE (2014)

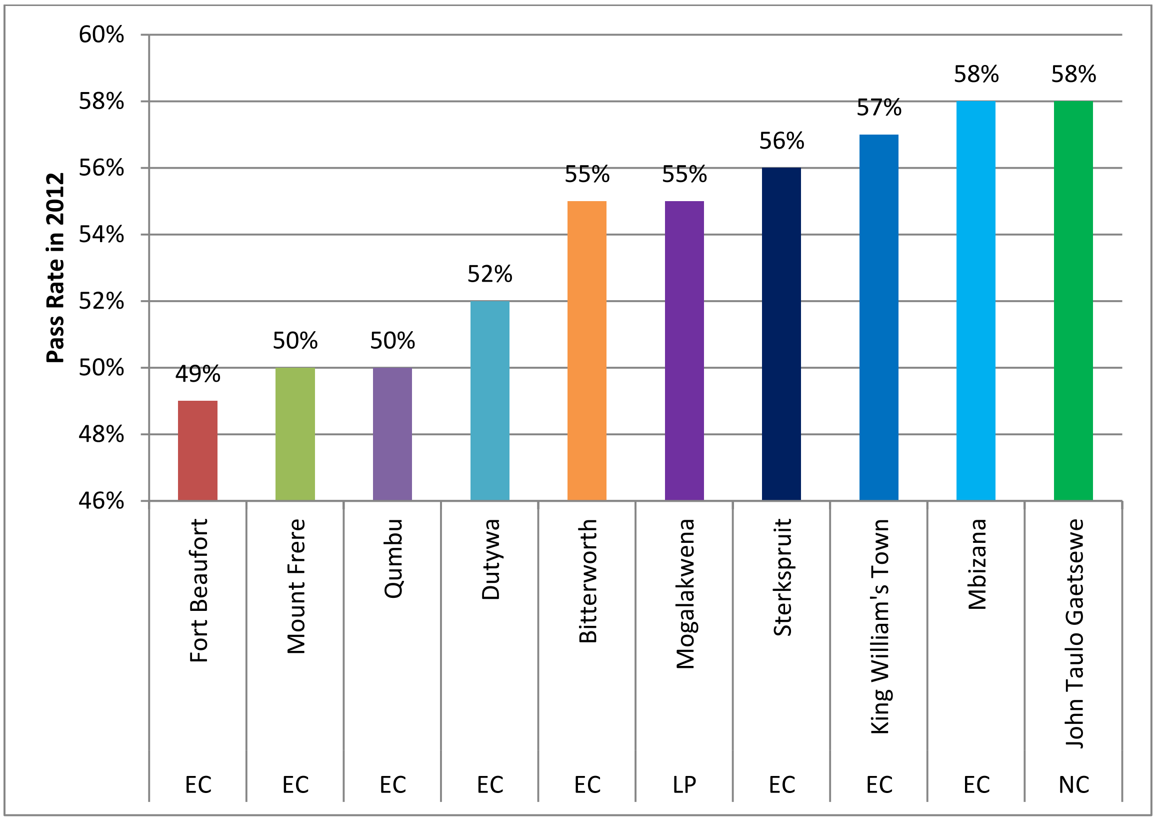
With regards to the LoLT, which is usually the mother tongue at the FP level and English and/or Afrikaans in the former *Model C schools*,[7] Afrikaans learners who are taught and examined in their mother tongue perform better than other learners who have no choice in being instructed in English (ECDoE, 2010). Even former Model C schools are populated by non-Whites as a large population of black middle-class households enrol their children in these schools. The province has about 5% of teachers in REQV 15 and 16; and a high percentage (52%) of under-qualified teachers in REQV 10, 11 and 12 (ECDoE, 2010).

Ncanywa (2014) analysed the state of the ECDoE schools during the second decade of democracy, and revealed among other factors that, as an important human resource, teachers need to be: properly trained and well paid; and attracted to and retained within the teaching

[7] Model C schools are well resourced, exclusive schools which were formerly reserved for White learners under the apartheid government.

profession. In addition, the study revealed that the curriculum should address the language used for instruction as well as cater for all types of learners, so that there are no learners left behind; and that learner performance is largely influenced by teacher quality, school and community characteristics (Ncanywa, 2014). Figure 4.13 shows matriculation pass rates for the 10 worst districts in in the country in 2012. Eight of these districts are found in the ECDoE.

Figure 4.13: Matriculation pass rates for the 10 lowest districts in 2012



DBE: Atlas of Education Districts in South Africa (2013)

For the purposes of this study, it is worth noting that the significantly low learner performance that surfaces at matriculation level could be emanating from the lower levels of the ordinary school education system, such as the IP level as stated in Chapter One; hence improving IP mathematics teachers' qualifications through upskilling their competency in the language of instruction could contribute to positive matriculation results in the ECDoE and contribute to rebuilding the province into the hub of education it once was.

Studies on the impact of language of instruction in the ECDoE are even scarcer. Most existing studies are small-scale qualitative studies. Brock-Utne (2007) used observations from two classes to illustrate that IsiXhosa-speaking learners learn better when instructed in their home language. The few existing English second-language studies conducted amongst isiXhosa speakers in the ECDoE (Mayaba, 2009; Webb & Webb, 2008; Webb, 2010; Sepeng, 2014a, 2014b) reveal that learners are not interested in learning to read or write in their home language. These educationists attributed this notion to the fact that isiXhosa has long been marginalised and devalued. Hence the current evidence on the impact of language of instruction on learning outcomes is insufficient.

4.5.4.1 Language of Learning and Teaching Mathematics: The Eastern Cape Province

According to Govender[8] (2015), a unique project involving learners in 81 schools in rural Cofimvaba District in the ECDoE is paying huge dividends. Learners from Grades 4 to 7 in these schools are studying mathematics, natural sciences and technology in isiXhosa, their mother tongue. The practice of teaching learners in their mother tongue is largely confined to learners who are in Grades 1 to 3 (DoE, 1997). But the ECDoE supports the initiative, which is known as mother-tongue-based bilingual education. In 2014 Grade 6 learners at Luzuko Junior Secondary School scored 100% in mathematics in the Annual National Assessment (ANA), compared to a dismal 40% obtained in 2012. The school does not have a library or science laboratory and learners still use pit latrines. The school principal, Nkosinathi Mvumbi, said learners' results had improved dramatically in the two subjects since being taught in their mother tongue.

> Previously, their results were really poor in those subjects because they were taught in English. Now we are getting marvellous results.
>
> Mvumbi (2015)[9]

Learners are still being taught their other subjects using English as the LoLT.

> English is not their mother tongue and that is why they do so badly. They understand mathematical concepts better when they are taught in Xhosa.
>
> Mvumbi (2015)

Mvumbi was hoping that learners could be taught all their subjects in their mother tongue. Mayizole Skama, Comfimvaba District Director, expressed the view that mother-tongue instruction was having a positive impact on learners' academic performance in the district.

There is no doubt that it has helped improve our Annual National Assessment results.

Skama (2015)[10]

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[8] Govender, P. in Sunday Times, 2015 – 05 – 17.

[9] Mvumbi, N. in Sunday Times, 2015 – 05 – 17.

[10] Skama, M. in Sunday Times, 2015 – 05 – 17.

Contrary to these assertions, Sepeng (2015) suggests that isiXhosa does have a place alongside English, playing a dual role of language of teaching and learning mathematics in multilingual classrooms (Sepeng, 2013, 2014a). While investigating the impact of isiXhosa as LoLT in multilingual mathematics classrooms in four Port Elizabeth Township schools in the ECDoE, Sepeng (2015) made two key findings: firstly: both English and isiXhosa are used together; and secondly both learners and teachers lacked competence in their home language. As such, although the teachers acknowledged the dilemma of using English as LoLT, because of the difficulties encountered when persuading learners to speak English during a mathematics lessons, the teachers preferred and continued to use English as the language of instruction (Barkhuizen, 2002; Brock-Utne, 2002).

These key findings shed significant light on the questions posed by the current study: if both learners and teachers lack competence in their home language, it may be inferred that their competency in the LoLT, which is a second language to them, is even direr. In addition, if the teachers prefer and continue to use English as LoLT, they should be supported to improve their own English-language competency and upskilled in effectively using different languages as resources in mathematics classrooms for their own as well as the learners' benefit.

4.5.5 Language of Learning and Teaching Mathematics: Implications for Teaching

Because of the difficulties experienced by teachers and learners when a language that is not their home language is used as LoLT, and after considering the benefits of learning in one's home language, organisations such as the United Nations Educational, Scientific and Cultural Organisation (UNESCO) and German Agency for Technical Cooperation (GTZ) have been at the forefront of promoting the use of home languages in African classrooms (GTZ, 2005; Chitera, 2016).

The current study acknowledges the research and other attempts that have been made in the ECDoE to promote mother-tongue instruction beyond the stipulated FP level. Earlier sections of this chapter noted that fluency in the mother tongue is essential for better acquisition of additional languages. Case studies discussed in earlier sections of the chapter also highlighted that teachers who over-rely on mother-tongue instruction usually do so as a substitute for incompetence in the prescribed LoLT. To combat such incompetent teacher practices, teacher education programmes should include language competency modules so that teachers can effectively use code switching and translanguaging to make informed decisions regarding the use of learner multilingualism as a resource in their mathematics classrooms. Otherwise an unnecessarily prolonged use of mother-tongue instruction may seem a disservice to the learners who will at one point or the other have to change into using English as LoLT.

Continuing mother-tongue instruction unnecessarily is only delaying a transition which is inevitable and therefore the current study emphasizes that the teachers should be competent in using English as LoLT, so that whenever the transition eventually occurs, the teachers will be better able to manage it. In a nutshell, teachers and the entire ordinary school system need to confront the challenges posed by using English as LoLT instead of evading them and producing learners who would find it difficult to cope with science, technology, engineering and mathematics (STEM) careers at university level. Such unintended eventualities of seemingly good practices in education are bound to keep the Eastern Cape as the least satisfactorily performing province in education, warranting government administration more often than other provinces in the country. With the world becoming a global village, it is necessary to afford all learners with equal opportunities that can make them compete fairly beyond the borders of where their home languages are spoken.

As illustrated through the above-mentioned studies conducted globally, in the sub-Saharan countries, in South Africa and in the ECDoE, the factors that affect achievement are multidimensional (Setati, 2003). As a result, it is a complex task to determine the most appropriate LoLT for use in classrooms. However, complex as the task may be, teacher competency in the prescribed language of instruction is a crucial component which deserves more attention that it is currently being awarded. In addition, poor performance of multilingual learners cannot be solely attributed to the learners' language competency (which is affected by the teacher's language competency in the prescribed LoLT) in isolation from the wider spectrum of social, cultural and political factors that pervade the teaching and learning spectrum (Setati, 2003). The studies reviewed in this section of the chapter emphasise that language is one of the many factors that are related to learner performance; and for the purposes of this study, teacher language competency in the prescribed LoLT needs to be prioritised in order to positively influence achievement across the curriculum, including achievement in mathematics.

There are many debates among researchers on the appropriate language to be used as LoLT, whether to use the languages with European roots or the Indigenous African Language (IAL)(s) of the learners. There are some who are in favour of the languages with European roots or second languages, while others favour IAL. For those in favour of the former, the argument is that the use of languages with European roots, such as English, Portuguese and French, as LoLT has more benefits for the learners, because these languages are often spoken widely elsewhere in the world. In addition, these languages are seen as a symbol of power, status and prestige (Baldauf & Kaplan, 2005; Gutierrez, 2002; Hameso, 1997; Pennycook, 1998; Setati, 2005; Tollefson, 1991; Trewby & Fitchat, 2001). They are mostly used to gain access to social status, tertiary education and business opportunities.

Chitera (2016) reveals that teaching and learning of mathematics in home languages is as complex as teaching and learning in foreign languages. It is a well-known fact that mathematical language is not well developed in most African languages and Chitera argues that mathematics teaching using a language that is not well developed undermines the confidence of teachers. As a result, teacher-centred approaches, chorus answers and use of one word answers still dominate the mathematics classrooms even though both teachers and students can communicate freely.

Studies have also shown that there are tensions between formal and informal mathematical language in a classroom where LoLT is the home language. It emerges that textbooks used words which they referred to as 'formal mathematical language', yet the words are uncommon to both teachers and students. As a result teachers are faced with a dilemma of choosing what words to use between the common ones referred to as informal versus the formal ones. It was seen that teachers preferred the informal terms rather than the formal ones, since learners were unfamiliar with them. However, even though they preferred the informal terms, they were not sure which ones to use as they still switched between the two terms being used (Chitera, 2016).

Thus, even though the LoLT is the home language, teachers tend to dominate classroom discussions. One of the reasons for introducing the local languages was that teachers were using teacher-centred approaches because the LoLT was English; however, even in the classrooms where the LoLT is a local language, this approach still dominates. The implication here is that introducing the home languages as LoLT when the mathematical language is not developed does not make the teaching and learning of mathematics easier. There is more than just the LoLT. Furthermore, because of a lack of technical terms and proper mathematical discourse in the local languages, both teachers and books tend to use a lot of ambiguous words in the lessons. The context does not enrich the development of the teachers' nor the learners' mathematical discourse. In this way, learners' attention risks being drawn away from the concept by the context. In as much as the literature notes that the use of a second language as LoLT limits learners' participation, lack of explanations of mathematical concepts in home languages also limits both the teachers' and learners' interaction (Chitera, 2016).

Chitera (2016) also argues that mathematical concepts and discourses produced when teaching and learning in home languages are distorted when the concepts and discourses are not well developed in the home languages. Being fluent in the LoLT does not mean that one will be able to explain the concepts without distorting them. Chitera noted that textbooks and policy makers assume that when one is fluent in the home language, then the teaching of mathematics would be straightforward. However, the literature has shown that this is not the case. This indicates that being fluent in the LoLT and being able to teaching mathematics correctly are different things that need to be intertwined skilfully in order not to distort the mathematics. Chitera (2016) thus argues that teaching mathematics in home languages is not as easy as it is assumed, more especially if the mathematical discourse is not well developed. However, being fluent in the LoLT, the same language that is used in textbooks to explain mathematical concepts helps the teacher to better understand the concepts and to explain these concepts to the learners, a view endorsed by the current study.

4.6 Multilingual Teacher Education: The African Landscape

As alluded to in earlier sections of this chapter, an education system is only as good as its teachers. This section reviews different studies with a focus on multilingual teacher education, since multilingualism is a reality in many classrooms. There is a vast array of research on multilingual teacher education; however, not much of it focuses on mathematics teacher education. This section provides an overview of practices in teacher education institutions in some African countries that have policies targeting teachers who are intended to teach in multilingual classrooms. The section also reviews some programmes put in place by various countries in an attempt to prepare teachers for multilingual classrooms. The countries reviewed include Burkina Faso, Ethiopia, Niger, Ghana and Malawi.

In Burkina Faso teachers who receive regular pedagogical support from linguists at the the University of Ouagadougou and are familiar with the country's official languages used as LoLT in schools teach in Ecoles Bilingues (Brock-Utne & Alidou, 2005; Chitera, 2009a). Ecoles Bilingues cater for learners aged 9 years and above, who have not had a chance of enrolling in formal primary schools. The learners are more mature and usually have fully developed home-languages skills before enrolling in schools classified as Ecoles Bilingues; which provide instruction in two languages.

In Ethiopia the prescribed LoLT for primary school teachers being prepared to teach in the first four years of schooling is the same as the LoLT for the first four years of schooling in primary schools; however, this LoLT stipulation is not followed in actual practice (Mekonnen, 2005). There is a mismatch between the LoLT of primary education of the second cycle (Grades 5 – 8) and the LoLT of primary teacher education for the second cycle: the LoLT for Grades 5 – 8 is the mother tongue, but the LoLT being used in the teacher education institutions is English. Without the teacher educators implementing the policy on the ground, student teachers graduate with little or no knowledge of how to teach in their local languages. Thus, mathematics teacher educators need to upskill student teachers with methods to teach in home languages, since teaching in the learners' first language differs considerably from teaching in a second or third language.

In Niger there are significant numbers of untrained teachers and new graduates from secondary schools awaiting other employment opportunities (Traore, 2001; Benson, 2002; GTZ, 2005; Chitera, 2009a). Large numbers of practising teachers awaiting training are not found in Niger only, but also in other African countries and they usually have inadequate school-based support. Though enthusiastic, they need to be trained to teach effectively in the mother tongue and the respective official languages:

> Teacher's enthusiasm cannot substitute for qualification required for teaching in mother tongues and official languages. Many bilingual teachers face serious professional challenges. They may be able to speak the LoLT, but they have not mastered reading and writing in that language.
>
> GTZ, (2005: 120)

In Ghana Addabor (1996) found that there was no teacher education in the mother tongue or in bilingual teaching methodology. However, Alidou and Brock-Utne, (2005) reported the emergence of GTZ in the teacher education scenario working to strengthen teaching in local languages in many teacher education colleges in the country. Through the GTZ, teachers receive ongoing training for the classes they are going to teach later, and at the same time new teachers are educated in using the local languages for instruction.

In 1996 Chilora (2000) reported that the Malawi government invested significantly in teacher training programmes to assist teachers cope with the implementation of the then LoLT, Chichewa. Teachers were trained in teaching in Chichewa as the LoLT. Textbooks were also produced in Chichewa with the exception of teachers' guides produced in English to accommodate teachers not fluent in Chichewa (Chilora, 2000). Teacher training colleges did not do much to help teachers cope with the implementation; therefore, mathematics teachers struggled to cope with the demands of LoLT when teaching mathematics in bi/multilingual classrooms. Teacher education programmes do not have standardised LoLT competency programmes.

Teaching behaviour is frequently moulded by prior educational experiences. Student teachers bring into the programme their prior knowledge, beliefs and experiences, which affect their assimilation and construction of new knowledge; teacher educators are themselves products of their own prior experiences in traditional settings. Therefore, it is crucial to monitor and regulate what happens in primary teacher education institutions (Shiundu & Mohammed, 1996; Gay & Ryan, 1999).

4.7 Mathematics Teacher Education: The South African Landscape

In South Africa specifically, it is generally accepted that there is both an absolute shortage of teachers and a relative shortage of teachers qualified and competent enough to teach specific subjects or learning areas (primarily mathematics, the sciences, technology and languages, but also arts and culture, and economic and management sciences), in specific phases (especially but not only the FP), in specific languages (African languages in particular, and also sign language and Braille), in special needs schools, in early childhood development (ECD), and in rural and remote schools (DoE, 2011).

In South Africa teacher education is located in the higher education sector and there is strong emphasis on the completion of degree studies. However, while the country already possesses a similar system of institutional providers, programmes and teacher development centres at various levels, the system is not adequately coordinated or integrated, and there is a need to improve the capacity, cooperation and reach of existing institutional providers and development centres to enhance the quality and relevance of both initial and continuing, as well as formal and informal, teacher education and development programmes (Parker, 2013).

It is important to note the historical context of teacher education in South Africa as this has directly impacted on the current capacity, quality and quantity of mathematics teachers in schools today.

4.7.1 Teacher Education Colleges

In 1994 there were approximately 101 public colleges of education in South Africa, eight of which were distance-education institutions. These colleges produced teachers across all disciplines through a four-year Diploma in Teacher Education, equivalent to a bachelor's degree (Hall, 1996).

Ten years later all of these colleges had ceased to exist as independent entities. Between 1994 and 2000 many colleges of education were closed, merged or incorporated into larger entities, as part of provincial rationalisation processes aimed at overcoming the educational inequalities of apartheid and reducing an identified over-supply of primary teachers. In December 2000 25 colleges of education, including two distance-education colleges, were declared by the Minister of Education as subdivisions of various universities and technikons, with effect from 31 January 2001 (DoE 2000). These 25 colleges were intended to function under the name and auspices of the particular university or technikon to which they were transferred along with their assets, plant and property. A 2008 survey (Parker, 2013), however, found that only nine of the 25 were still listed on the books of, and being used by, a higher education institution. The remaining approximately 76 colleges were retained by the provinces, destined for the most part to continue to carry out education-related functions as campuses of FET colleges, teacher development institutes, education resource centres, schools and/or provincial education offices, with a small remainder being utilised by other government departments.

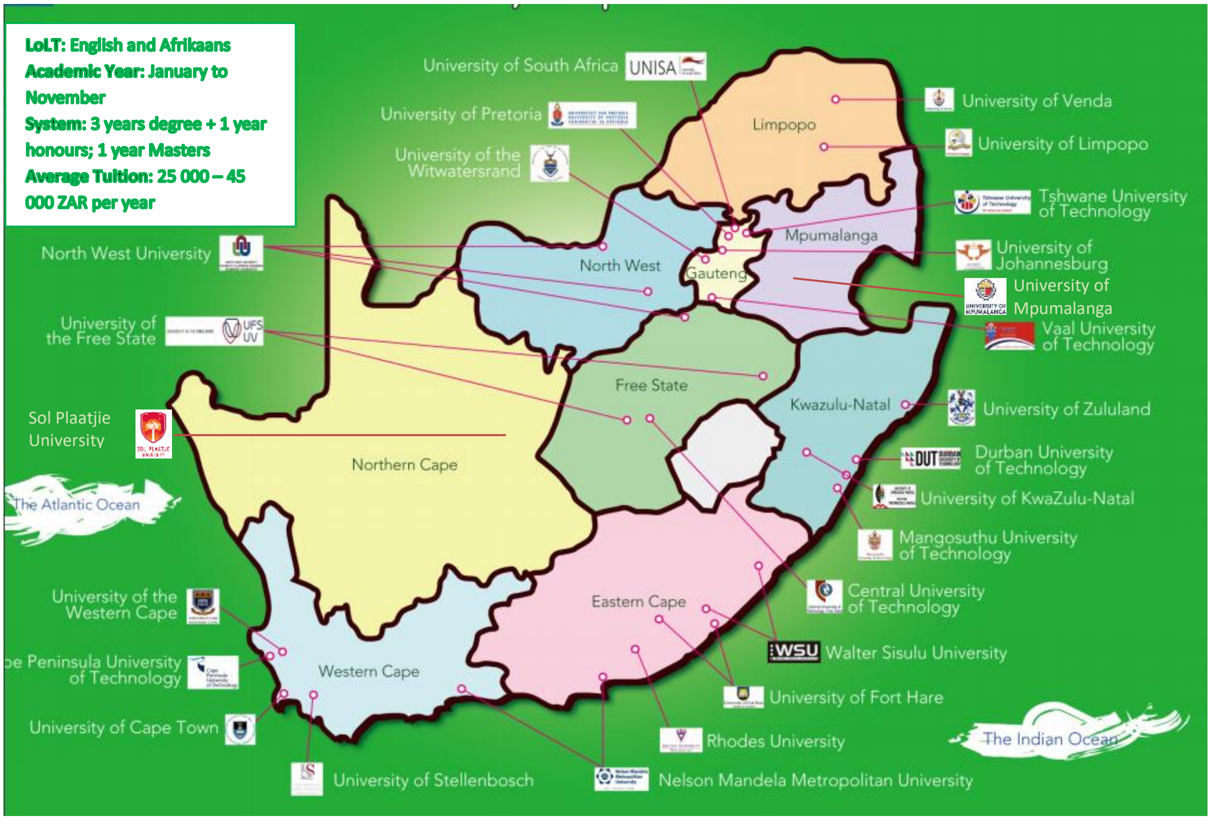
In 2013 the Department of Higher Education and Training (DHET) initiated the process of reopening[11] teacher education colleges as an attempt to work towards South Africa producing more and better qualified teachers. The first scheduled to be re-opened is the former Ndebele College Campus in Mpumalanga for Foundation Phase teacher education in 2013, and from 2014/2015 there are plans to open one former teacher education college each in KwaZulu-Natal and the Eastern Cape provinces. The process is still underway. Current updates on these colleges indicate that they are open to students for registration and courses in some of the academic modules have commenced, but no qualified teachers have yet been produced as the time period is still insufficient for that measurement. These colleges focus on pre-service teachers with none of them currently providing any professional development or resource support to in-service teachers – this is only planned for the future (after 2017).

4.7.2 Departments of Mathematics Education in South African Universities

All Universities in South Africa that have a Department of Education provide a 4-year Bachelor of Education degree which trains pre-service teachers. Figure 4.14 shows the distribution of the 25 South African universities.

[11] http://www.sanews.gov.za "SA to re-open teacher training colleges" Accessed 25 January 2016.

Figure 4.14: South African Universities offering degrees in teacher education



British Council, (2013)

The University of Mpumalanga opened in 2013 and Sol Plaatje University opened in 2014 are the latest additions to the South African universities. Some of the university departments extend their services on an ad-hoc basis to the professional development of in-service teachers; however, the interventions are not government subsidized and have to be fully paid by the participants. 40% of all South African teachers are produced by UNISA. The Department of Mathematics Education at UNISA offers courses across the undergraduate and postgraduate levels for both pre- and in-service teachers across the phases. The department also engages in community education and outreach projects: there is currently one project underway entitled "Maths Teacher Professional Development". It is a research project and does not involve any direct teacher education, but it observes the mentoring of other institutions to capture best practices. Witwatersrand University operates the Marang Centre for Mathematics and Science Education, a division of the school of education which focuses on pre-service and in-service mathematics and science teacher development. They accommodate teachers from many African countries, not just South Africa. Their programmes are all linked to degrees, both undergraduate and postgraduate (BSC, MSc and PhD in mathematics and science education). They do offer some certificate programmes, but this is not their core focus. Similarly the University of Stellenbosch operates the Institute of Mathematics and Science Teaching

(IMSTUS), while the North-West University operates the Unit for Open and Distance Learning (UODL).

4.7.3 Private Higher Education Institutions

The number of new teachers currently being produced by private higher education institutions is negligible. Fewer than 100 new teachers graduated from the three private higher education institutions offering initial teacher education qualifications. The teacher attrition rate in the country has remained stable at around 5 – 6% per annum since the late 1990s. Assuming a 5% attrition rate, and taking into account that there are currently just over 400,000 practising teachers in the schooling system as a whole, a minimum of 20,000 teachers need to be replaced every year (DBE, Annual School Survey Report, 2014).

4.7.3.1 In-service Mathematics Teacher Education Institutions

Table 4.8 documents some institutions in South Africa offering mathematics teacher education programmes to practising teachers in the form of professional development courses.

Table 4.8: In-Service Mathematics Teacher Education Institutions

Institution	Description
Sci-Bono Discovery Centre	As part of their commitment and work to improve the results of school learners in maths and science, they offer a well-structured teacher development programme. As part of this programme the teachers also have access to free online support and teaching tools. These courses, however, are not accredited or linked to any university. All their work is currently within the Gauteng Province only.
Umlambo Foundation	This foundation's goal is to achieve and sustain improvement and high-standard learner outcomes in public schools, especially in rural and underprivileged areas. Their initiatives consist of targeted interventions in disadvantaged schools with a focus on improving school leadership to drive overall school effectiveness in curriculum delivery. Their focus is on rural schools in South Africa and in developing teachers as part of their whole school approach.
Dinaledi Schools Project	In 2001 the Department of Education established the Dinaledi Schools Project to increase the number of matriculants with university-entrance mathematics and science passes. The strategy involves selecting certain secondary schools for Dinaledi status that have demonstrated a potential for increasing learner participation and performance in mathematics and science, and providing them with the resources and support to improve the teaching and learning of these subjects. Part of the support given to these schools is the professional development of their mathematics HODs and teachers, as well as equipment to use in class and access to ICT platforms for support.
LEAP Future	LEAP is a school in Cape Town that educates high school learners in mathematics,

Leaders Programme (Langa Education Assistance Programme)	science and English. LEAP runs a "Future Leaders Programme" that specifically is a teachers training programme. It focuses on disadvantaged communities where there is a significant lack of adequately trained teachers in South Africa. It mainly focuses on pre-service teachers who are further supported after the initial training programme.
African Teacher Education Network (ATEN)	This network is about encouraging understanding, use and sharing of Open Education Resources (OER) to support teacher education and development in Africa. The network is a loosely connected group of teacher educators, with participants currently from Botswana, Ghana, Kenya, Malawi, Mauritius, Mozambique, Nigeria, South Africa, Tanzania, Togo, Uganda, Zambia, UK and USA. Specific tools in this network relate to the ACE Maths programme.
TESSA	TESSA is an international research and development initiative which brings together teachers and teacher educators from across sub-Saharan Africa. It offers a range of materials (OER) in 4 languages to support school-based teacher education and training. These materials are authored primarily by academics from across Africa. TESSA is currently part of a case-study project with Fort Hare University's teacher training programme.
Embury Institute of Teacher Training in South Africa	Embury Institute of Teacher Education offers a number of short courses as part of professional development for in-service teachers. These are run on an ad-hoc basis and participants pay for each course.
SAMF – South African Mathematics Foundation	SAMF is registered as a non-profit organisation aiming to advance the mathematics development and education of South African learners and young people through improved quality teaching and learning of mathematics as well as through public awareness activities. Founded in 2004 by the Association for Mathematics Education of South Africa (AMESA) and the South African Mathematical Society (SAMS), SAMF serves as a national office for mathematics to promote the effective co-ordination, administration and advancement of mathematics in South Africa. SAMF has four main pillars: learner development, teacher development, advocacy and research.
CASME – Centre for the Advancement of Science and Mathematics Education	CASME is a non-profit education development agency that was established in 1985. The centre possesses vast experience and expertise in teacher professional development and implements a range of interventions in partnership with the Department of Education, parastatals, government agencies, Corporate Social Investment programmes, universities and national development initiatives amongst others. The Centre's focus is on the advancement of mathematics and science teachers' subject competence and teaching skills in South African schools through hosting vacation schools and resource portals.
Thandulwazi-Rokunda Teacher Development Programme	Thandulwazi is derived from the isiZulu, meaning "the love of learning". The Thandulwazi Maths and Science Academy is an education programme run by the St Stithians Foundation. It was established in 2006 out of the need for effective action in addressing the critical issues pertaining to the teaching of Maths and Science in schools

	in and around Gauteng Province. The Thandulwazi-Rokunda Teacher Development Programme focuses on up-skilling the teaching methodologies of teachers currently working in schools in previously disadvantaged areas and providing professional development for these teachers. In addition to teacher development, Thandulwazi also provides extra mathematics lessons for learners, learner sponsorship programmes as well as internship teacher training programme.

The scope of some of the institutions detailed in Table 4.8 is within the general arena of teacher development. The South African Council for Educators (SACE) is responsible for monitoring and managing the Continuing Professional Teacher Development (CPTD) System. CPTD is a system for recognizing all teacher development activities. SACE does not deliver the professional development interventions itself, but it endorses the teacher education courses offered by the various in-service teacher education institutions. The National Education Collaboration Trust (NECT) is an organisation dedicated to strengthening partnerships among business, civil society, government and labour in order to achieve the education goals of the National Development Plan. It strives both to support and influence the agenda for reform of basic education. NECT does not deliver on teacher training itself, but it is a key stakeholder in the larger network and influences policy and implementation frameworks for teacher training. Workers' Unions like SADTU have recently established teacher training programmes. The Department of Basic Education's Teacher Education and Development Units like the Cape Teaching and Learning Institute (CTLI) in Cape Town offer professional development courses for practising teachers.

4.7.3.1.1 AIMSSEC

The African Institute for Mathematical Sciences (AIMS) is a pan-African network of centres of excellence for postgraduate training, research and outreach in mathematical sciences. Its mission is to enable Africa's brightest students to flourish as independent thinkers, problem solvers and innovators capable of propelling Africa's future scientific, educational and economic self-sufficiency. The first AIMS centre was opened in Muizenberg, Cape Town, South Africa in 2003 and since 2011 AIMS has opened five additional centres in Senegal, Ghana, Cameroon, Tanzania and Rwanda. The goal of the AIMS Next Einstein Initiative (AIMS – NEI) is to establish a pan-African network of 15 centres of excellence on the African continent by 2023.

The African Institute for Mathematical Sciences Schools Enrichment Centre (AIMSSEC) is part of AIMS South Africa, a cost centre of Stellenbosch University which delivers a structured master's degree in mathematical sciences to students from all over Africa. The delivery of professional teacher development courses has been the focus of AIMSSEC since its inception in 2003. AIMSSEC achieves this goal of the professional development of maths teachers through the following courses:

- The **Mathematical Thinking course** is a 3 months blended learning program endorsed by SACE which includes 10 days of intensive contact sessions followed by submission of two assignments;
- The **Advanced Certificate in Teaching** (ACT, NQF level 6) is a two-year blended learning program with four contact sessions offered in partnership with the IMSTUS of University of Stellenbosch (2009 – 2012); with the University of Fort Hare (2010 – 2014) and with North-West University from 2016 onwards;
- An **Advanced Diploma in Education** (ADE, NQF Level 7) and a **Postgraduate Diploma in Education** (PGE, NQF Level 8) are planned as follow-on courses from the ACT, so that AIMSSEC will be offering a 6-year part-time blended learning professional development programme for mathematics teachers;
- The **Aiming Higher 'Maths with Wings'** programme is a course which trains and empowers teachers to teach up to an internationally equivalent university entrance standard to prepare students for higher education in the mathematical sciences. After completing this course, teachers are able to prepare learners to sit for the South African Independent Examination Board (IEB) and Advanced Mathematics Programme examinations;
- The Structured **Master's Degree in Mathematics Education** (underway).

The courses offered at AIMSSEC are structurally similar to those offered by other teacher education institutions, except that AIMSSEC provides bursaries for the teachers' tuition. These courses are designed for the majority of mathematics teachers who are mathematically underqualified, preparing them to be effective teachers. For the purposes of this study it is worth highlighting that none of the AIMSSEC mathematics courses includes any structured language proficiency modules for teachers; hence the existence of a gap which the current study seeks to fill.

4.7.4 Language proficiency training for in-service mathematics teachers in South Africa

In 2012 the DBE and the British Council signed a co-operation agreement which led to the training of over 300 subject specialists and advisors in the FP, IP and FET bands. These three teacher training programmes – CiPELT, CiSELT and LEAP programmes – are aimed at strengthening and supporting curriculum delivery in English First Additional Language (EFAL). These teacher education programmes have been rolled out nationally and the Eastern Cape Province is one of the targeted provinces because of its poor performance (British Council, 2013).

In 2015 the DBE identified 183 high schools that do not offer mathematics as a subject choice at Grade 10 level. This shortage of high schools offering mathematics as a subject choice compounded several problems, namely a continued shortage of skilled and qualified teachers able to teach MST and a shortage of skilled professionals in the science and mathematics-based disciplines such as medicine, engineering, and other technology-related fields. The DBE decided to reintroduce mathematics to these 183 schools and embarked on a multi-pronged strategy to enable this and to help achieve the targets set in South Africa's National Development Plan (2030), which aims to increase the number of learners eligible to study towards obtaining maths and science based degrees to 450,000 by 2030.

The DBE partnered once again with the British Council to pilot an in-service teacher training programme using a "work together and work away" model supported by classroom observation technologies and remote feedback. This model will establish a system of on-going, contextualized support for mathematics teachers at schools which are reintroducing mathematics as a subject in Grade 10. The teacher education programme will focus on "problematic areas" of the South African mathematics Grade 10 curriculum and will be aligned to the South African Curriculum and Assessment Policy Statements (CAPS) (British Council, 2013).

Pearson is a multinational company that provides textbooks as well as professional development services through its Teacher Education and Leadership Academy. One of the courses provided by Pearson's teacher education academy is Teaching Mathematics to Additional Language Learners, a six-day course intended for Intermediate Phase teachers of Mathematics. The course outcomes include provision of deeper knowledge of teaching techniques and classroom strategies; active, hands-on learning and practice; peer teaching, observation and feedback; improved content knowledge, especially in traditionally "difficult" topics as well as fun, interactive approaches with homework DVDs. By the end of the six-day course, teachers are expected to understand how to teach particular mathematical concepts to increase learner understanding and engagement; how to teach academic vocabulary that learners need to be successful; and appreciate the practical experience of teaching the concepts through demo lessons. Pearson's teachers training courses are guided by the Sheltered Instruction Observation Programme (SIOP), a method which was initiated, tested and implemented in the United Stated of America.

4.7.5 Implications of Language of Learning and Teaching Mathematics in Teacher Education Institutions

This context reveals that:

- Prior to 2000 there was a vast array of institutions producing qualified teachers in South Africa, and that since 2000 these numbers have significantly decreased;
- All teachers that qualified through teacher training colleges up to the early 2000s obtained a four-year teacher training Diploma in Education;
- Since the colleges were closed down or incorporated into the universities and technikons, the Diploma was changed to a bachelor's degree in Education;

- There is a greater need for newly qualified teachers at this point in the SA context than the professional development of existing teachers – although this does not imply that the professional development of teachers is not needed;
- Mathematics teachers are part of the critical skills set that is currently needed in the South African context; and
- Teachers in the rural and poorer schools require more support than those in urban areas.

In as much as the environmental scan of the South African teacher education landscape has established that the teaching profession is characterised by drastic shortages of qualified teachers (across all learning areas and mostly mathematics) (DBE, 2014) in public and under-resourced schools, it is worth highlighting that the available teachers need support regarding language proficiency skills. This is a significant factor regarding the purposes of the current study which seeks to alert educationists and inform curriculum design about the crucial but largely ignored fact that qualified practising mathematics teachers are not necessarily proficient in English and that this may have an effect on the quality of instruction through using English as LoLT. There may be several other contributing factors and further in-depth research is required. Nevertheless, a re-evaluation of teaching methodologies and the upgrading of both pre-service and in-service teachers' levels of language skills are suggested as a matter of urgency.

Chitera (2009b; 2012) states that most of the language practices in multilingual mathematics classrooms that teachers produce cannot be traced back to their teacher education institutions. In the South African context this practice is manifested twofold: FP student teachers are taught in English, yet after the completion of their studies they will be expected to use mother-tongue instruction. IP student teachers who are also taught in English do not master the language well enough to be competent to handle the transition from mother-tongue to English-medium instruction. The linguistic dilemma faced by FP teachers is beyond the scope of this study; however, there seems to be a linguistic disjuncture between teacher education institutions and classrooms. One of the ways of addressing this gap between the LoLT in primary schools and the LoLT in teacher education institutions would be to acknowledge and enforce linguistic strategies that can improve mathematics instruction in multilingual classrooms during teacher training.

Thus, practices involved in the school classroom and teacher training institutions need to be two-way processes (Chitera, 2016). What happens in schools informs the teacher training practices, while teacher training practices inform the school practices so that student teachers need to graduate from the teacher training institutions better prepared to function effectively when tasked to teach in any environment.

4.8 Hegemony of English in Society

Although there are 11 official languages in South Africa,[12] Afrikaans and English are the only languages with a developed academic literature and in which it is possible to write the external assessments. According to StatsSA (2012), only about 23% of South Africans speak Afrikaans or English as their first language. In order to achieve educational and hence labour market success, the majority of South African learners therefore need to become fluent in either English or Afrikaans as their second language.

In order to achieve educational and hence labour market success, the majority of South African learners therefore need to become fluent in either English or Afrikaans. In reality, the vast majority choose to learn English rather than Afrikaans as the second language, given its status as a global language. English language proficiency therefore influences life chances through its influence on educational success. However, Casale and Posel (2011) demonstrate that English proficiency also improves labour market returns directly. Using a traditional earnings function methodology controlling for an individual's level of education, they find a significant wage premium for black South Africans associated with being able to read and write English fluently.

This situation presents a difficult policy question to countries like South Africa: when and how should the teaching of English be introduced in schools, and when and how should a transition to English as the primary language of instruction in non-language subjects occur? South African legislation and education policy do not prescribe which of the 11 official languages should be used, but leaves the choice of language of instruction to School Governing Bodies (SGB)s, which are comprised of a parent majority as well as the school principal, several staff members and, in the case of secondary schools, learners (DoE, 1997).

Currently, most schools in which the majority of learners are not English- or Afrikaans-speaking opt to use First Language in Grades 1, 2 and 3 and then transition to English as the language of instruction in Grade 4. This approach, though not compulsory in policy, has been encouraged by the national and provincial departments of education. Some schools, however, have chosen to go “straight-for-English” as the language of instruction from the first grade. The Curriculum and Assessment Policy Statements (CAPS) also prescribe English should be introduced and taught from Grade 1 in all schools (DBE, 2011). Consequently, all schools should have some English being taught from the first grade, but for some schools English is also the language of instruction from Grade 1, whereas in most schools this is only the case from the fourth grade. Despite these reasons why mother-tongue education is an educationally sound policy, the

[12] The 11 official languages include nine indigenous languages (isiZulu, isiXhosa, isiNdebele, Sepedi, Setswana, Sesotho, SiSwati, Xitsonga, Tshivenda) and two languages with European roots (English and Afrikaans).

majority of South Africans prefer English and not their home language as LoLT. Reasons perpetuating this belief and practice are explored below.

There is a lack of suitable textbooks and material for the specialised language needs of ELLs (Lemmer, 1995: 92; Chick, 1992: 284; Reagan, 1985: 76; de Wet, 2002). This empirically demonstrated notion is supported by Indigenous African Language (IAL) teachers. In a press interview (Jones, 2001: 1) IAL teachers accused the South African government of not making African language textbooks available. Initiatives to produce texts for learners in IALs have been cautious and have had mixed results. Gough (1994: 10 – 11); however, is of the opinion that the development of learning material in IALs is not an insurmountable problem. In his view, there are piles of IAL learning materials gathering dust somewhere in Department of Education storerooms. He suggests that publishers and teachers should use these textbooks (which probably display the influence of the apartheid era) as a point of departure for preparing new publications.

The lack of IAL learning material does not mean that teachers do not use IAL in their classrooms. African-language-speaking teachers often use their bilingual or multilingual competences as they grapple to interpret a syllabus resourced in English to African-language-speaking children (Bloch & Edwards, 1998: 16).

In the light of the insistence of learners on English as LoLT, cognisance must be taken of de Wet's (202: 119) and Lemmer's (1995: 91) observations that teachers in traditional black schools often lack the English proficiency that is necessary for effective teaching. Teachers do not have the knowledge and skills to support English-language learning and to teach literacy skills across the entire curriculum. A large number of African teachers educate in "an English dialect" (de Wet, 2002: 119) and this may have negative consequences for the learners — learners often imitate their role models' (read teachers') (wrong) pronunciation, grammar and vocabulary.

If the most important stumbling block in the use of IALs as LoLT, namely a lack of educational material, is compared with the problems facing learners who use English, and not their home language as LoLT, the former problem should not be insurmountable.

4.9 International Assessment of Education in South Africa

The education evaluation function in South Africa is regulated in terms of section 4 of the Education Act of 1996, which provides for the national minister to determine national policy, for inter alia, monitoring and evaluation of the wellbeing of the education system (JET, 2010: 6). This provision is given effect in a number of other education policies and programmes.

Examples of these are the WSE, IQMS, Developmental System (DAS) and Assessment Policy for the General Education and Training Band, which provides a systemic evaluation to be conducted on a national representative sample of learners.

The South African education system is characterised by low levels of academic performance on international assessments of education. Table 4.9 indicates the South African education evaluation landscape. Four of the seven programmes are international comparative assessments, while the other three are national programmes implemented at various levels of the system.

Table 4.9: International and national evaluation initiatives in South Africa

	Institutional functionality	Teacher profiles	Teacher knowledge	Teaching Practice	Learner Performance	SES
TIMSS[1]	Yes	Yes	-	-	Yes	Yes
PIRLS[2]	Yes	Yes	-	-	Yes	Yes
SACMEQ[3]	Yes	Yes	-	-	Yes	Yes
MLA[4]	Yes	Yes	-	-	Yes	Yes
Systemic Evaluation	Yes	Yes	-	-	Yes	Yes
WSE / SSE[5]	Yes	-	-	Yes*	-	-
DAS[6]	-	Yes	-	-	-	-
Total	**6**	**6**	**0**	**1**	**5**	**5**

Adapted from JET (2010)

Key:

* Intended but never implemented

** IQMS was omitted as it is comprised of WSE and DAS

1 Trends in International Mathematics and Science Study

2 Progress in International Reading Literacy Study

3 Southern and Eastern Africa Consortium for Monitoring Education Quality

4 Monitoring Learning Achievement Study
5 Whole School Evaluation / School Self Evaluation
6 Developmental Appraisal System

The PIRLS surveys (2006, 2011) as well as the TIMSS (1995, 1999, 2003 and 2011); have perpetually reiterated South Africa as least performing compared to other participating counties. The NAEP revealed that grade ability levels in mathematics and science, reading and writing positioned South Africa at the lowest score among 46 other countries that participated in the tests. TIMSS results drew attention to the lack of academic potential at primary school level contributing to the fact that only 69% of school leavers entering South African Higher education Institutions (HEIs) are prepared to cope with the academic demands of higher education studies (SAUVCA, 2003).

The role of language and access to language skills are critical in ensuring the ability of individuals to realise their full potential to participate in and contribute to the social, cultural, intellectual, economic and political life of South Africa (Ministry of Education, 2002). As such, language can be considered to be a barrier to access and success at all levels of education.

According to Taylor and Coetzee (2013), the extent to which language factors contribute to the low performance is not clear, given the fact that language disadvantages are strongly intertwined with other pre-existing factors such as historical disadvantage, socio-economic status, geography, the quality of school management, as well as the quality of teachers. As that may be the case, there are many South African educationists who are adamant that language, and in particular, the language policy, is a key determinant of education outcomes. Educationists in support of mother-tongue instruction such as Brock-Utne (2007) argue that a later transition to English is necessary, given that learners grapple with understanding the language of learning and teaching. On the other hand, English is widely viewed as a vehicle of upward mobility and this leads to a preference for using English as LoLT from as early as possible.

4.10 Conclusion

This chapter reviewed literature on perspectives of language competency and language as a medium of mathematics instruction. The literature reveals language competence as a predictor of academic performance. A large number of studies that have been carried out globally, in sub-Saharan Africa and in South Africa continuously investigating learner language competence and its relationship to performance on the assumption that the teachers have adequate resources and are working in an environment conducive to supporting the learners. Of significant importance is the lack of international, regional and local studies conducted to specifically investigate the relationship between language competence and mathematics instruction among primary school teachers. This study points out that even fewer studies have been conducted on IP mathematics teachers deployed in the Eastern Cape Province, one of the most poorly resourced provinces in South Africa.

The LoLT used in primary school is one of the most important inputs into the education system. In many African countries the predominant indigenous home language spoken by the majority of learners is not well developed for academic purposes, leading to the adoption of English as the language of instruction from a very early age. This is also the case in South Africa, where some primary schools use African indigenous languages as LoLT for the first three years and then switch to English at the beginning of the fourth year. Thus, most primary schools use English as the LoLT, even though the majority of the learners in the school are ELLs.

Teaching and learning is a two way process, involving both the teachers and the learners; therefore, whichever policy the schools choose to adopt, it is important to simultaneously equip the teachers for the adopted changes in order to provide a constructive balance between language competency and the LoLT. Wolff (in Alidou et al., 2006: 49) sums this up best by stating that "Language is not everything in education, but without language everything is nothing in education" and this study extrapolates Wolff's assertion: **Language is not everything in mathematics education, but without language, everything is nothing in mathematics education**.

CHAPTER 5

RESEARCH DESIGN AND METHODOLOGY

5.1 Introduction

The literature review in the preceding chapters served to illuminate the different perspectives on aspects that pose challenges in the teaching of Intermediate Phase (IP) mathematics using English as language of learning and teaching (LoLT). It provided further details that would assist in answering the central research question: How (if at all) does language competency in the LoLT relate to content delivery by IP mathematics teachers?; as well as realising the aim of the research which is to analyse the relationship between IP teachers' linguistic competencies and mathematics instruction.

This chapter provides a discussion of the research paradigmatic orientation, design, methodology and sampling procedures. The chapter explains the data-collecting techniques, which include questionnaires, language competency and mathematics assessments, interviews and classroom observations. The rationale for using these methods is explained. The chapter further highlights the ethical requirements as well as the limitations and generalisability of the study.

For the purposes of positioning how the researcher's values were inherently embedded in all phases of the research process, the study's paradigmatic orientations are detailed in the section below.

5.2 Paradigmatic Orientations

A paradigm is defined as the entire constellation of beliefs, values and techniques shared by members of a research community (Goduka, 2012: 126). Research paradigms assist with the formation and clarification of epistemological, ontological and methodological dimensions relevant to a particular study (Bahari, 2010; de Jager 2012). Any research should be focused by a philosophy and paradigms embedded in the following list of definitions:

- Epistemology: knowledge and how people come to know it;
- Ontology: nature, reality, feeling, existence or being;
- Logic: acceptable rigour and inference in the development of arguments, judgements or insights; and
- Axiology: fundamental values, consciousness, moral choices, ethics and normative judgements.

McGegor and Murnane, (2010: 421)

Therefore, when conducting research, researchers are expected to take a position regarding their perceptions of how things really are and how things really work (Scotland, 2012: 9). The paradigmatic orientation shaped the application of methodologies in the current study for the purposes of communicating what constitutes reality and the newly created knowledge.

The current study is situated in the interpretivist-constructivist paradigm, which

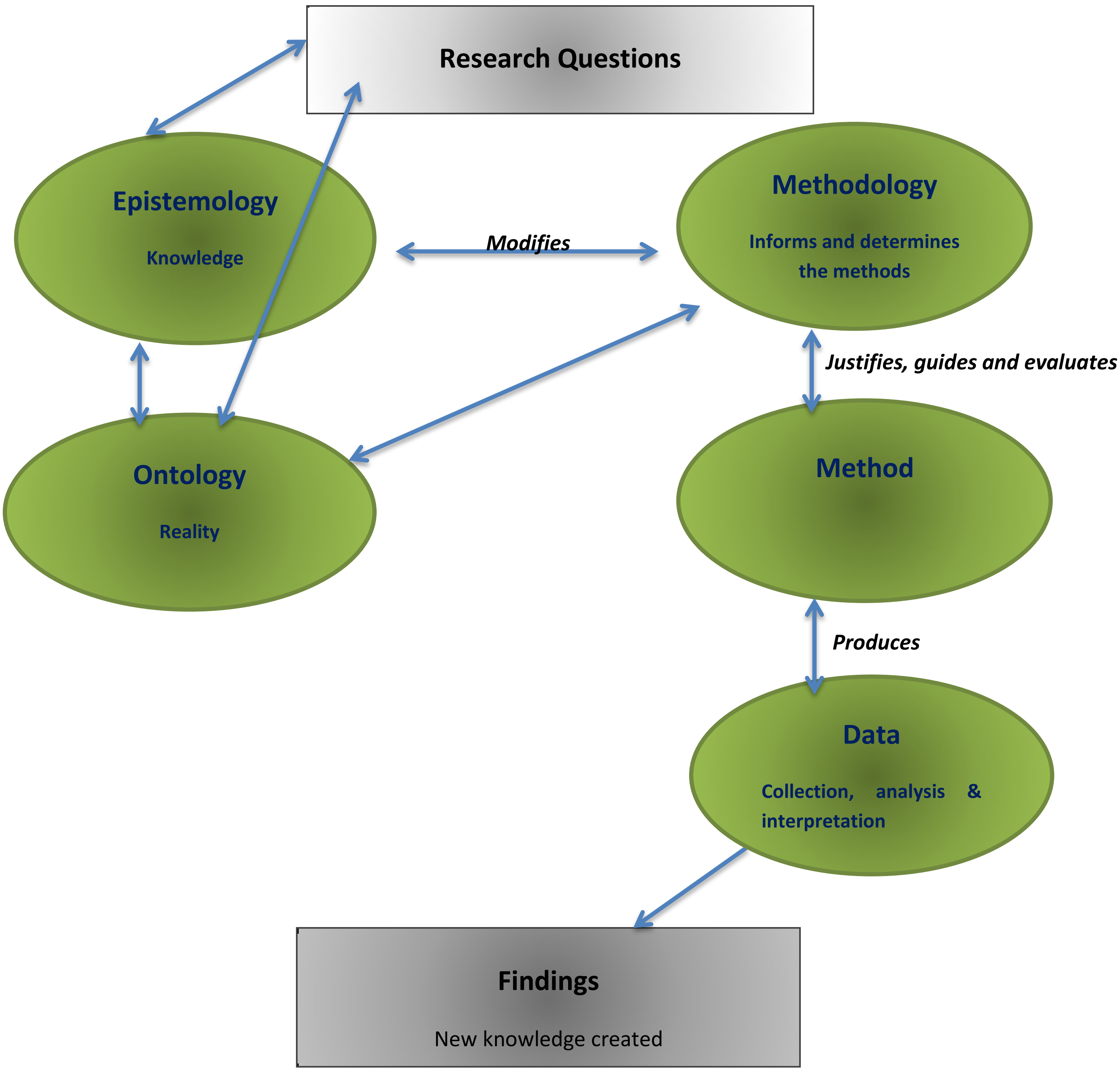
> sees the world as constructed, interpreted and experienced by people in their interactions with each other and with wider social systems, ... the nature of enquiry is interpretive and the purpose is to understand a particular phenomenon, and not to generalise to a population.

Tuli (2010: 100)

The interpretivist-constructivist paradigm is applicable to the current study as it aims to find answers in a naturalistic, real-world, unobtrusive and non-controlling real-world situation (Tuli, 2010: 100). The interpretivist-constructivist paradigm helped this research to understand the phenomenon – *Teacher English-language competencies* – from the data collected (Goduka, 2012: 127) as well as to construct meaning and reality as created in a social context – *the IP mathematics classrooms*.

Mathematics teachers' knowledge and use of the English language, their experiences while using the language in content delivery and the meanings they ascribed to their own classroom practices were interrogated based on the argument that epistemology, the theory of knowledge, is constructed and interpreted through natural interactions in real life situations (Brooks & Brooks, 1993) . In addition, the meanings derived by the researcher in the current study are depicted as a function of the circumstances of the teachers involved and various complex inter-relationships in the situations involved (Saunders, Lewis & Thornhill, 2007). Thus, the teachers' communicative competence in the language prescribed for them to teach in is to a large extent guided by how rigorously they were prepared during their own initial teacher education qualifications, which influences to some extent their own content delivery. Furthermore, the interpretivist-constructivist paradigm reinforces the conceptual frameworks discussed in Chapter 2 of the current study, namely: the Linguistic Threshold Hypothesis; the Framework for Interpreting Language Factors in Mathematics Learning; the Socio-Psycho-Linguistic Model; the Approach for Analysing Errors on Written Mathematical Tasks and the Pedagogical Translanguaging Theory. The alignment of the current study with the interpretivist-constructivist paradigm is illustrated in Figure 5.1.

Figure 5.1: Link between the paradigmatic orientations and the research methodology



Adapted from Carter and Little (2007: 1320)

Epistemology: Data collected from the different methods are interpreted for the purposes of gaining more knowledge in terms of what teachers know (teacher language competencies) and how these competences influence their instruction.

Ontology: Reality is what happens in the sampled classrooms, and it is evident in the teacher's linguistic practices in delivering mathematics content in IP mathematics classrooms.

Methodology: The use of the mixed methods approach, which combines the strengths from both the quantitative and qualitative methodologies, ensured rigour and enhanced the validity of the study.

Methods: The methods employed in the current study – questionnaires, teacher language competency and mathematics word problem assessments, interviews and classroom observations – are congruent with the selected methodology and are deemed relevant in answering the research questions.

Since the study intended to establish how language competency relates to IP mathematics instruction, it was of paramount importance to consider a research design that best yields the desired answers (Creswell, 2010: 78). The section below details the current study design.

5.3 Research Design

A research design is a plan of how one intends conducting the research. According to Mouton (2001), a research design focuses on the end product, formulates a research problem as a point of departure, and focuses on the logic of the research. Thus a research design ensures that there is a structure to the way in which data will be collected and analysed, as well as in the procedure to be followed.

The purpose of the research design is to provide a framework for the collection and analysis of data and to improve the validity of the study by examining the research problem (David & Sutton, 2004: 133; McMillan & Schumacher, 2010: 345). The rationale for the choice of the design allows the researcher to focus closely on the issue at hand. The design used in this study also makes it possible to establish which linguistic aspects of mathematics teaching are problematic in multilingual settings. The study followed a mixed methods approach.

5.3.1 Research Design: Mixed Methods Approach

The field of mixed methods research has been widely accepted only within the last decade, though researchers have long been using multiple methods, just not calling them 'mixed' (Cresswell, 2008). In mathematics education mixed methods studies emerged from 1995, though many previous studies used mixed method designs implicitly (Kelle & Buchholz, 2014; Hart, Smith, Swars & Smith, 2009). Mixed methods research is typically characterised by the use of multiple ways to explore a research question. Mixed methods research is both a method and methodology for conducting research that involves collecting, analysing and integrating quantitative and qualitative research in a single study or a longitudinal programme of inquiry (Cresswell, 2008). The purpose of this form of research is that both qualitative and quantitative research, in combination, provides a better understanding of a research problem or issue than either research approach on its own. Typical situations in which mixed methods are used include:

- comparing results from quantitative and qualitative research;
- using qualitative research to help explain quantitative findings;
- exploring using qualitative research and then generalizing findings to a large population using quantitative research;
- developing an instrument because none is available or useful; and
- augmenting an experiment with qualitative data.

Owing to the fact that mixed methods research is a relatively contemporary research paradigm, mixed methods studies integrating language and mathematics are even fewer in number (Prediger & Wessels, 2013). The background underpinning integrated language and mathematics studies includes the following assumptions: language proficiency is very influential, as language supports the mathematical constructions of meaning; and language used in school is more complex than everyday language, as expounded in Chapter 3 of this study.

This mixed methods study addressed the use of English as the LoLT to teach IP mathematics. A convergent parallel mixed methods design was used; this is a type of design in which qualitative and quantitative data are collected in parallel, analysed separately, and then merged. In this study questionnaires, language proficiency assessments and mathematics word problems were used to establish general patterns linking teacher language competency and mathematics instruction for IP mathematics teachers in the ECDoE. The error analysis interviews, informed non-participant classroom observations and a literature study explored the relationship between language competency and mathematics instruction for IP mathematics teachers in the ECDoE. The reason for collecting both quantitative and qualitative data was to corroborate findings.

5.3.2 Properties of Mixed Methods Research

Mixed methods research designs have specific strengths and weaknesses. To justify the use of mixed methods research, detailed below are the strengths and weaknesses of using this approach, as explained by research methodologist Cresswell (2003: 211).

Strengths

- Words, pictures and narrative can be used to add meaning to numbers;
- Numbers can be used to add precision to words, pictures and narrative;
- Can provide quantitative and qualitative research strengths;
- The researcher can generate and test a grounded theory;
- The method can answer a broader and more complete range of research questions because the researcher is not confined to a single method or approach;
- In a two-stage sequential design, the Stage 1 results can be used to develop and inform the purpose and design of the Stage 2 component;

- A researcher can use the strengths of an additional method to overcome the weaknesses in another method by using both in a research study;
- Can provide stronger evidence for a conclusion through convergence and corroboration of findings;
- Can add insights and understanding that might be missed when only a single method is used;
- Can be used to increase the generalizability of the results; and
- Qualitative and quantitative research used together produce more complete knowledge necessary to inform theory and practice.

Weaknesses

- Can be difficult for a single researcher to carry out both qualitative and quantitative research, especially if two or more approaches are expected to be used concurrently; it may require a research team;
- Researcher has to learn about multiple methods and approaches and understand how to mix them appropriately;
- Methodological purists work within either a qualitative or a quantitative paradigm;
- More expensive;
- More time consuming; and
- Some of the intricate details of mixed research (paradigm mixing, qualitative analyses quantitative data, or interpretation conflicting results) have yet to be clarified by research methodologists.

5.3.3 Mixed Methods Strategies

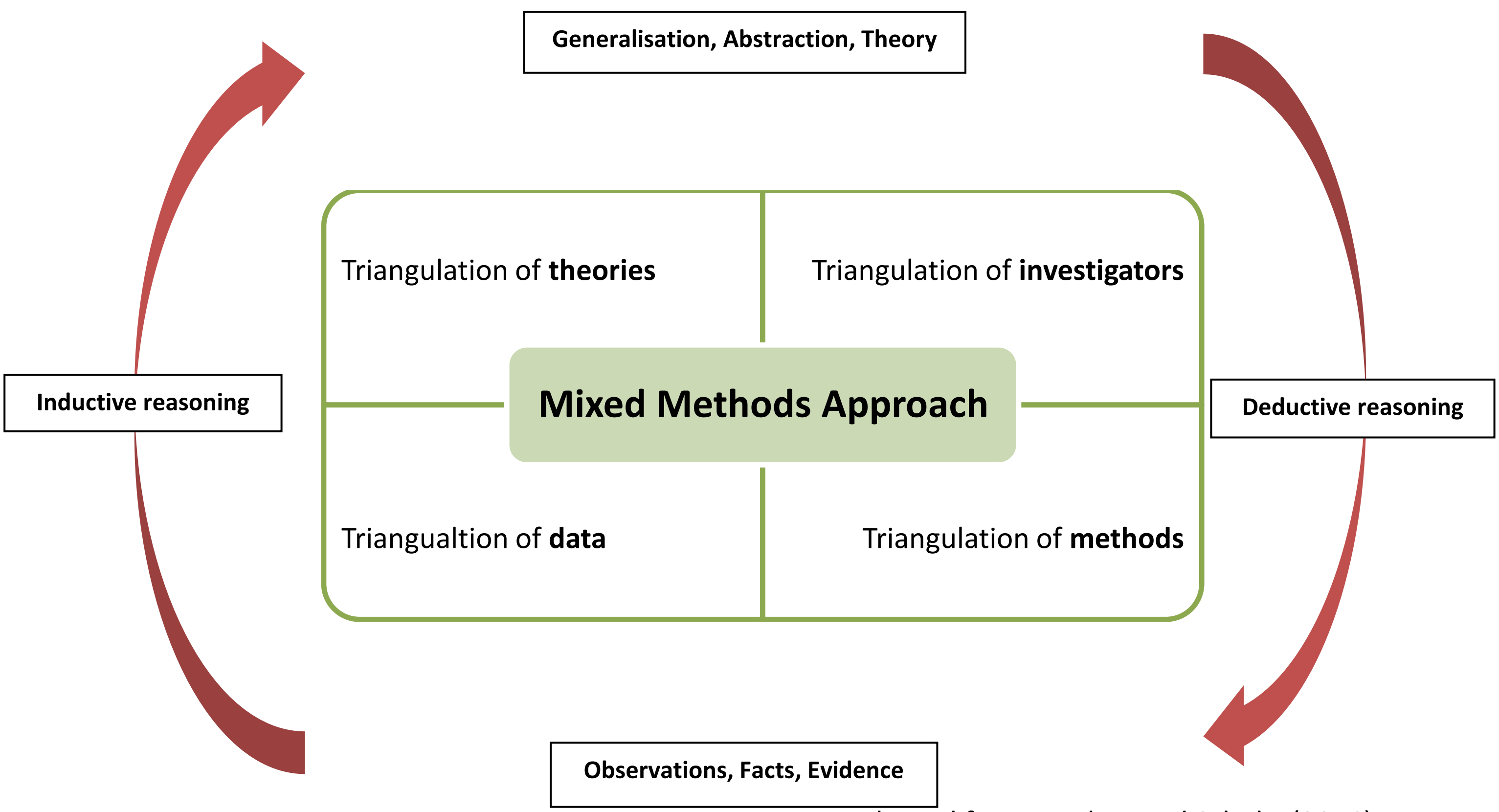
The six mixed methods design strategies suggested by Cresswell, (2003: 211) are sequential explanatory, sequential exploratory, sequential transformative, concurrent triangulation, concurrent nested and concurrent transformative.

The sequential explanatory strategy is characterized by collection and analysis of quantitative data, followed by collection and analysis of qualitative data; its purpose is to use qualitative results to assist in explaining and interpreting the findings of a quantitative study. The sequential explanatory strategy is characterized by an initial phase of qualitative data collection and analysis followed by a phase of quantitative data collection and analysis and its purpose is to explore a phenomenon. This strategy may also be useful when developing and testing a new instrument. The sequential transformative strategy is characterized by collection and analysis of either quantitative or qualitative data first. The results are integrated in the interpretation phase. The purpose of this strategy is to employ the methods that best serve a theoretical perspective.

The concurrent triangulation strategy is characterized by two or more methods used to confirm, cross-validate or corroborate findings within a study. Data collection is concurrent and its purpose is to corroborate both methods. The strategy overcomes the weakness in using one method with the strengths of another. The concurrent nested strategy is characterized by a nested approach that gives priority to one of the methods and guides the project, while another is embedded or “nested” and its purpose is to address a different question from the dominant one, or to seek information from different levels. The concurrent transformative strategy is characterized by the use of a theoretical perspective reflected in the purpose or research questions of the study to guide all methodological choices. The purpose of this strategy is to evaluate a theoretical perspective at different levels of analysis. For the purposes of deepening the understanding of relationships existing between teacher language competency and IP mathematics instruction, this study employed the concurrent triangulation strategy.

The acquisition of scientific knowledge through mixed methods studies systematically links theory to evidence by corroborating the quantitative and quantitative research methods. In mixed methods studies, quantitative data provide universal generalisations, while qualitative data situates the study within social and interactive structures. While quantitative data focus on deduction, theory/hypothesis testing and prediction, qualitative data focus on induction, theory/hypothesis generation and discovery; and the quantitative strands are dominated by numerical data on observable behaviours and statistical analyses while, qualitative strands are dominated by intensive studying of cases and analytic induction (Pellegrino, DiBello & Goldman, 2016; Leuders & Schulz, 2016; Teddlie & Tashakkori, 2009; Hart et al., 2009). The systematic linking of theory to evidence as depicted by these researchers is illustrated in Figure 5.2.

Figure 5.2: Mixed Methods Research – systematically linking theory to evidence



Adapted from Leuders and Schulz, (2016)

Educational research on mathematics learning and teaching should aim to improve education, and researchers must set out to know *if* a particular intervention improves learning, *how* results are achieved and *why* the results can be expected to be replicated (Hart et al., 2009; Chatterji, 2004). To uncover patterns and deepen understandings of relationships between language competency and IP mathematics instruction, this study conformed to the above stipulations by combining more than one research method.

The present research was designed as a **mixed methods study** investigating the linguistic barriers faced by IP mathematics teachers using English as language of instruction, focusing in particular on a peculiar case: the Eastern Cape Province.

5.3.4 Why 'the case of the Eastern Cape Province'?

By virtue of focusing on a particular province, this study has elements of case study research embedded in it. To illustrate how the mixed methods design principles can be applied to improve the quality of research evidence; the properties of a case study are briefly discussed.

A case study is used in order to understand a real-life phenomenon in depth; however, such understanding encompasses important contextual conditions, because they are highly pertinent to the phenomenon of the study (Yin, 2009: 18). Contextual issues in this study would be the teaching environment, especially those multilingual classroom variables that are related to mathematics teaching. The case study was preferred because, as Baker (1999: 321); McMillan and Schumacher (2010: 344) and Creswell (2010: 75) indicate, it could afford the researcher a better understanding of the specific problem in its context.

A case study is an empirical investigation of a particular contemporary phenomenon within its real-life context through the use of multiple sources of evidence. It is a type of research design in which in-depth data are generated relative to a single or a number of individuals, programmes or events in order to learn more about an unknown or poorly understood situation (Blaxter, Hughes & Tight, 2001; Yin, 2003; Leedy & Ormrod, 2005; Nieuwenhuis, 2007). A case study provides a multi-perspective analysis of a phenomenon by providing a platform to incorporate the views of different participants in a situation (Nieuwenhuis, 2007: 75; Holliday, 2010: 99). In this study the views of teachers as well as teacher educators who are the directly involved in mathematics teacher education are incorporated.

In comparison to other designs, the key strength of the case study design is the use of multiple sources and techniques in the data gathering. The use of a variety of data-collection techniques ensures the collection of data from a variety of respondents, which ultimately ensures the balance and representability of data gathered. Data collected from different respondents allow the researcher to cross-check the findings and to view the recurrent themes raised by the different respondents from different perspectives (Bell, 2009: 116).

Data gathering in case study research includes both qualitative and quantitative strands as is the case with the current study. Case study research gathers data through tools like surveys, interviews, documentation reviews, observation, focus group discussions and questionnaires (Blaxter, Hughes & Tight, 2001; Leedy & Ormrod, 2005; Nieuwenhuis, 2007).

Case studies are usually critiqued for their dependence on a single case, results of which may not provide generalizable conclusions. However, case studies allow the researcher to probe deeply and analyse the multifarious phenomena that constitute the life cycle of a single unit with a view to establishing generalisations about the wider population to which that unit belongs. Focus on a single case is usually based on the case's uniqueness and exceptional qualities, as is the case with the Eastern Cape Province in terms of mathematics education. Focusing on a single case can also provide a deeper understanding of the particular case, for the purposes of informing practice on similar or related situations (Silverman, 2000; Blaxter, Hughes & Tight, 2001; Leedy & Ormrod, 2005; Flyvbjerg, 2007; Gobo, 2007). In this study, focusing on the Eastern Cape Province may provide a deeper understanding as well as inform practice on the improvement of IP mathematics instruction in other Provinces such as Limpopo and KwaZulu-Natal, which are part of the wider pool of poorly resourced and underperforming provinces in South Africa.

The strategic choice of a case to be studied significantly influences and augments the generalisability of a case study. But generalisations from a case study must be handled with care, particularly when only one single case is studied. Any generalisation is largely tentative and must be substantiated by other studies (Silverman, 2000; Blaxter, Hughes & Tight, 2001; Leedy & Ormrod, 2005; Flyvbjerg, 2007; Gobo, 2007). Case study research aims to gain greater insight into and understanding of the dynamics of a specific situation (Nieuwenhuis, 2007: 76; Casanave, 2010: 67). To justify the validity and necessity of focusing on a single case, Nieuwenhuis (2007: 76) exemplifies the focus on a single case as "a dewdrop in which the world is reflected". As such, the researcher focuses intensively on the subject of inquiry.

The motivation to approach this study as a case study is to limit the scope of the study. Limiting the scope allows the researcher to identify the unique aspects of the case in order to produce a rich and thick informative description, thereby enhancing the generalisability of other cases falling within the same category as stipulated by Lodico, Spaulding and Voegtle (2006), Holliday (2010) and Casanave (2010).

Critiques of case studies highlight the fact that the key researcher(s) tend to become emotionally involved with the respondents and this may cloud judgement (Nieuwenhuis, 2007: 77). This notion was experienced first-hand by researcher at a presentation of this study at an international conference; one of the comments from the audience implied that the researcher was emotionally attached to the study. Yet there is no way that a researcher cannot become involved, if they are to establish trust and rapport with the respondents. However, for the purposes of objectivity it is crucial to draw boundaries on the extent of involvement. Research in the field of education, and other disciplines concerned with issues of social justice and human emancipation, cannot be regarded as a neutral enterprise (Jankie, 2009: 180).

In order to obtain an insider view of the phenomenon and get as close as possible to the respondents for the purposes of collecting resonant and fertile data calls for the researcher's emotional involvement (Jankie, 2009). Case study data are drawn from people's realistic experiences and practices. By virtue of building on actual experiences and practices, case studies are thus linked to action research – as a subset of a broader action research project – and their insights contribute to change practice (Blaxter, Hughes and Tight, 2001: 73).

In addition, case studies often focus on a limited number of units of analysis such as an individual, a group or institution, which are studied intensively (Welman & Kruger 2001: 105; Creswell, 2010: 75). In this study the units of study are constituted by the 55 IP mathematics teachers in the ECDoE and 10 IP mathematics teacher educators. Based on the Eastern Cape Province's recurrent poor performance in mathematics, this investigation into the relationships between teacher language competencies in the prescribed LoLT and mathematics instruction was designed as a case study in order to zoom into and better understand the situation in the province.

Thus, this mixed methods research has elements of a case study applying mixed methods design principles as described by Chatterji (2004). The following section details the research methodologies employed by the study.

5.4 Research Methodologies: Quantitative and Qualitative Research

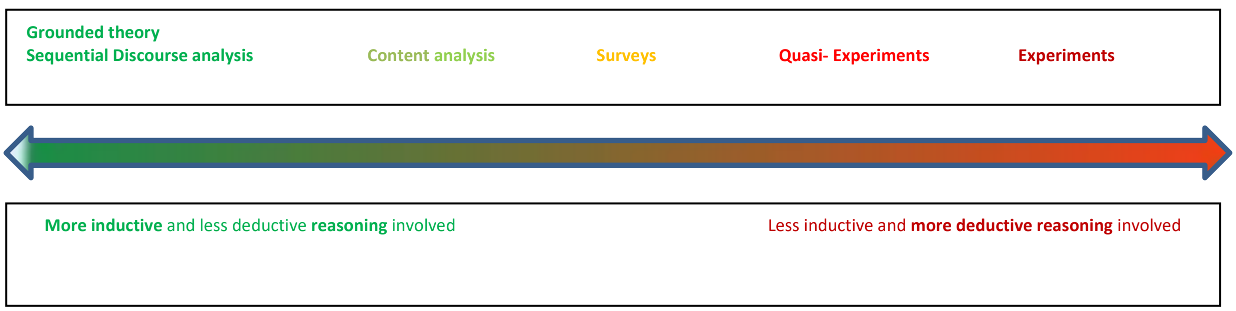
As indicated in the previous section, the mixed method design comprises a combination of the two primary methodologies, the quantitative and the qualitative.

The quantitative methodology is considered as extensive research based on the quantification of data collected (Bahari, 2010: 18). Quantitative methodology is dominated by deductive reasoning (Bahari, 2010: 21). The emphasis on numerical as well as statistical data makes quantitative research the mainstream methodology searching for explanations based on statistical methods (Corrigan, 2014: 52). In this study questionnaires, linguistics needs and mathematics word problem assessments were the focus of the quantitative aspects of the data collected.

The qualitative methodology is a process of understanding a social or human problem, based on building a complex holistic picture formed with words, reporting detailed views of informants and conducted in natural settings (Cresswell, 1994: 2). The natural setting in this study is the under-resourced public school where the teachers are based. It is worth noting that the phenomenon of under-resourced public schools is prevalent in developing countries (*Guardian*, 2013; UNESCO, 2016). The qualitative methodology is used to answer questions about complex phenomena with a purpose of describing and understanding the phenomena from the respondents' point of view (Leedy & Ormrod, 2001: 101). The respondents' point of view was incorporated through the involvement of IP mathematics teachers and teacher educators, who are the immediate participants in mathematics teacher education. The qualitative aspects of this study were highlighted by the use of data collected from classroom observations and interviews.

Research cannot be exclusively inductive or deductive, as such; quantitative and qualitative methods can best be arranged on a continuum (Leuders & Schulz, 2016; Teddlie & Tashakkori, 2009; Maxwell & Loomis, 2003; Reichardt & Cook, 1997), as illustrated in Figure 5.3.

Figure 5.3: A continuum of quantitative and qualitative research methods



Adapted from Leuders and Schulz, (2016)

This study is focused by adopting a pragmatics worldview (Cresswell, 2008). The pragmatic approach requires an awareness of the weaknesses of both the quantitative and qualitative methods. Being aware of the strengths and weaknesses of the two approaches allows the researcher to combine the methods with a view to complementing their strengths (Leuders & Schulz, 2016). Table 5.1 summarises the strengths and weaknesses of quantitative as well as qualitative data as described by Johnson and Onwuegbizie (2009), Kelle (2008), Maxwell and Loomis (2003) and Brewer and Hunter, (1998).

Table 5.1: The strengths and weaknesses of quantitative and qualitative research

Quantitative Research	Qualitative Research
Strengths	***Strengths***
• Testing and validating already constructed theories about how and why phenomena occur. • Testing hypotheses that are constructed before the	• Data are based on the participants' own categories of meaning. • Useful for studying a limited number of cases in depth.

data are collected. Can generalize research findings when the data are based on random samples of sufficient size. • Can generalize a research finding when it has been replicated on many different populations and subpopulations. • Useful for obtaining data that allow quantitative predictions to be made. • Researcher may construct a situation that eliminates the confounding influence of many variables, allowing one to more credibly assess cause-and-effect relationships. • Data collection using some quantitative methods is relatively quick, for example, telephone interviews. • Provides precise, quantitative, numerical data. • Data analysis is relatively less time consuming since statistical software is used. • Research results are relatively independent of the researcher such as effect size or statistical significance. • It may have higher credibility with many people in power such as administrators, politicians or funders. • It is useful for studying large numbers of people.	• Useful for describing complex phenomena. • Provides individual case information. • Can conduct cross- case comparisons and analysis. • Provides understanding and description of people's personal experiences of phenomena. • Can describe, in rich detail, phenomena as they are situated and embedded in local contexts. • Researcher identifies contextual and setting factors as they relate to the phenomenon of interest. • Researcher can study dynamic processes. • Researcher can use the primarily qualitative method of grounded theory to generate inductively a tentative but explanatory theory about a phenomenon. • Can determine how participants interpret constructs like self-esteem or intelligence quotient. • Data are usually collected in naturalistic settings. • Qualitative approaches are responsive to local situations, conditions, and stakeholders' needs. Qualitative researchers are responsive to changes that occur during the conduct of a study and may shift the focus of their studies as a result. • Qualitative data in the words and categories of participants lend themselves to exploring how and why phenomena occur. • One can use an important case to demonstrate vividly a phenomenon to the readers of a report. • Determine idiographic causation.
Weaknesses • The researcher's categories that are used may not reflect local constituencies' understandings. • The researcher's theories that are used may not reflect local constituencies' understandings. • The researcher may miss out on phenomena occurring because of the focus on theory or hypothesis testing rather than on theory or hypothesis generation. • Knowledge produced may be too abstract and general for direct application to specific local situations, contexts, and individuals.	***Weaknesses*** • Knowledge produced may not generalize to other people or other settings, as such; findings may be unique to the relatively few people included in the research study. • It is difficult to make quantitative predictions. • It is more difficult to test hypotheses and theories. • It may have lower credibility with some administrators and commissioners of programs. • It generally takes more time to collect the data when compared to quantitative research. • Data analysis is often time consuming. • The results are more easily influenced by the researcher's personal biases.

Adapted from Leuders and Schulz (2016); Chatterji (2004)

The arrows in Table 5.1 emphasize the point that the strengths of quantitative research may be the weaknesses of qualitative research while the strengths of qualitative research may be weaknesses of quantitative research. A mixed methods approach incorporating both the quantitative and qualitative methods benefits from the strengths of both strands. Both the quantitative and qualitative methodologies were utilised in the study. The following section details the sampling techniques employed by the study.

5.5 Sampling

Sampling is the process of selecting a portion of the population for a study (Creswell, 2010: 79). Sampling refers to the identification and selection of respondents for the study from a selected target population. Sampling implies selecting a section of a population for investigating a topic of interest. McMillan and Schumacher (2010: 129) describe sampling as selecting the group of respondents from whom the data are collected.

A sample selected from a larger group of persons, identified as the population, is studied in an attempt to understand the population from which it was drawn and the researcher's interest lies in describing the sample not primarily as an end in itself, but rather as a means of helping us to explain some facet of the population (de Vos, 2000: 199; Bryman, 2012: 416).

Sampling decisions are made for the purpose of obtaining the richest possible source of information in order to answer the research questions (Creswell, 2010: 82). The major criteria to use to decide on a sample size include the type of study, time, the resources available to the researcher and the extent to which the selected sample is representative of the target population (Bless and Higson-Smith, 2000; Nieuwenhuis, 2007; Flyvbjerg, 2007; Gobo, 2007).

In this study these four factors were considered in deciding the sample size. Being a mixed methods study, the researcher had access to the teacher participants for the collection of quantitative data (questionnaires and teacher assessments) while the teachers attended CPTD courses lectured by the researcher. In addition, the researcher established a rapport with the teachers for the purposes of collecting quantitative data (classroom observations) at the schools where the participants are deployed. The face-to-face interactions between the study sample and the researcher facilitated timeous collection of data. Being a teacher educator, the researcher also had easy access to other teacher educators for the purposes of collecting data to cross-check the information provided by the teachers. The researcher accessed fellow teacher educators during conferences on mathematics teacher education. The fact that the target audience of AIMSSEC CPTD courses are teachers from under-resourced communities enabled the researcher to access teachers who are a representative sample of the target population. Consideration of these factors is detailed further in the sections below.

5.5.1 Types of Sampling

There are two types of sampling namely, probability sampling and non-probability sampling.

A probability sample is selected by using a random selection whereby every member of the population has a chance of being selected. A probability sample can be classified into four categories: simple random sample, systematic sample, stratified random sample, and multi-stage cluster sample. In the simple random sample, the most basic form of probability sampling, everyone in the population stands an equal probability of being included in the sample. In the systematic sample respondents are selected directly from the sampling frame without using a table of random numbers. The stratified random sample is representative of all various elements, while the multi-stage cluster sample involves dividing the population into clusters and then using the probability sampling method to select a sample from among those selected in the clusters (Bryman, 2012: 416).

A non-probability sample implies a selection of a sample not using a random method of selection and some members of the population are more likely to be selected than others. A non-probability sample covers all other kinds of sampling not conducted according to probability sampling. It includes convenience sampling, snowball sampling, quota sampling and purposive sampling. Convenience sampling occurs when the target population is readily available to the researcher. Snowball sampling occurs when the researcher meets or makes contact with a group of people relevant to the topic under research and then uses them to make contact with the specific target population. Quota sampling, which aims to produce a sample reflective of a population's diversity in different categories such as gender, age groups or ethnicity is prevalent in commercial research and rarely takes place in academic social research (Bryman, 2012: 416).

This study is focused by non-probability and purposive sampling rather than probability or random sampling approaches. The sample size is relatively small and is purposefully selected from individuals who have the most experience with the phenomenon under investigation, as suggested by Bless and Higson-Smith (2000), Lodico, Spaulding and Voegtle (2006), Nieuwenhuis (2007), Ivankova, Creswell and Clark (2007), Holliday, (2010), Flyvbjerg (2007) and Gobo, (2007).

Non-probability purposive sampling was chosen for this study, because it would be the most representative way of looking at the target population. For the researcher, this was appropriate because it allowed for the selection of teachers from a specific province. The researcher also considered certain characteristics when selecting this sample, among others, teachers in disadvantaged and poorly performing schools of the Eastern Cape Province. The rationale for the choice of this sampling procedure is explained below.

5.5.2 Purposive Sampling

Respondents for this study were selected using purposive sampling. Purposive sampling means that respondents are selected because of some defining characteristics that make them the bearers of the data needed for the study. Sampling decisions are made for the purpose of obtaining the richest possible source of information in order to answer the research questions.

Purposive sampling decisions are not only restricted to the selection of respondents, but also involve settings, incidents, events and activities to be included for the data collection (Blaxter, Hughes & Tight 2001).

Blaxter, Hughes and Tight (2001: 161) define purposive sampling as a sampling method that involves handpicking supposedly typical or interesting cases. In purposeful sampling, the researcher identifies "information-rich" respondents as they are possibly knowledgeable about the phenomenon under investigation. Purposive sampling also defines a type of sampling that allows the researcher to choose a case because it illustrates certain features in which one is interested (White, 2005: 120; McMillan & Schumacher, 2010: 138). Purposive sampling is based entirely on the judgment of the researcher in that a sample is composed of elements that contain the most characteristics that are representative or typical attributes of the population (de Vos, 2004: 207). This type of sampling selects the respondents of the study among a selected target population, because of some defining characteristics that make them the bearers of the data needed for the study.

For the purpose of this study, the targeted population was IP mathematics teachers in ECDoE and IP mathematics teacher educators from different universities. The defining characteristics of the respondents for this study are discussed below.

5.5.2.1 Purposive Sampling: Teachers

Purposive sampling decisions are not restricted to the selection of respondents, but they also involve the settings, incidents, events and activities to be included for data collection (Nieuwenhuis, 2007: 79).

This sample comprised 55 IP mathematics teachers purposely selected from the ECDoE. These teachers were appropriate for the research because they are based in poorly performing schools in the ECDoE. These were schools known to experience recurrent low performances in GET mathematics and were selected by district officials within the ECDoE to attend professional development courses at AIMSSEC[13] for the purposes of improving their mathematics content knowledge as well as teaching strategies most relevant to poorly resourced schools. The focus was on the Grade 4 – 6 teachers. The teachers were studied not so much for their mathematics content knowledge, but specifically whether they were competent and proficient in using English as the LoLT in mathematics instruction.

5.5.2.2 Purposive Sampling: Teacher Educators

This sample comprised 10 IP mathematics teachers educators purposely selected from the 26 universities in South Africa. These teacher educators were available to the researcher through co-presentation of professional development courses and at national and international

[13] The researcher is an IP mathematics teacher educator at AIMSSEC.

mathematics conferences. The teacher educators ranged from mathematics chairs, professors, senior lecturers, lecturers and didacticians from different Education Departments at the country's universities. The rationale for selecting teacher educators across the different universities that teachers who end up being deployed to the ECDoE could have trained at any university in the country, including universities lying outside the borders of the Eastern Cape Province. The focus was on the IP mathematics teacher educators offering both pre-service and in-service education qualifications and professional development courses. The teacher educators were studied solely to establish the major challenges they often encounter when observing IP mathematics teacher as well as to solicit their suggested strategies for improving the teaching of mathematics using English as LoLT.

The basis for sampling teachers as well as teacher educators as respondents of the study was to get information from the key agents involved in teacher education, namely the teachers and their teacher educators. Pedagogic theory denotes instruction as a two-way process which involves the one who is imparting knowledge, and the one to whom knowledge is being imparted. In teacher education, the focus of this study, the teacher educators impart knowledge and skills, while the teachers receive the knowledge.

5.5.3 Demographic Information of Participants

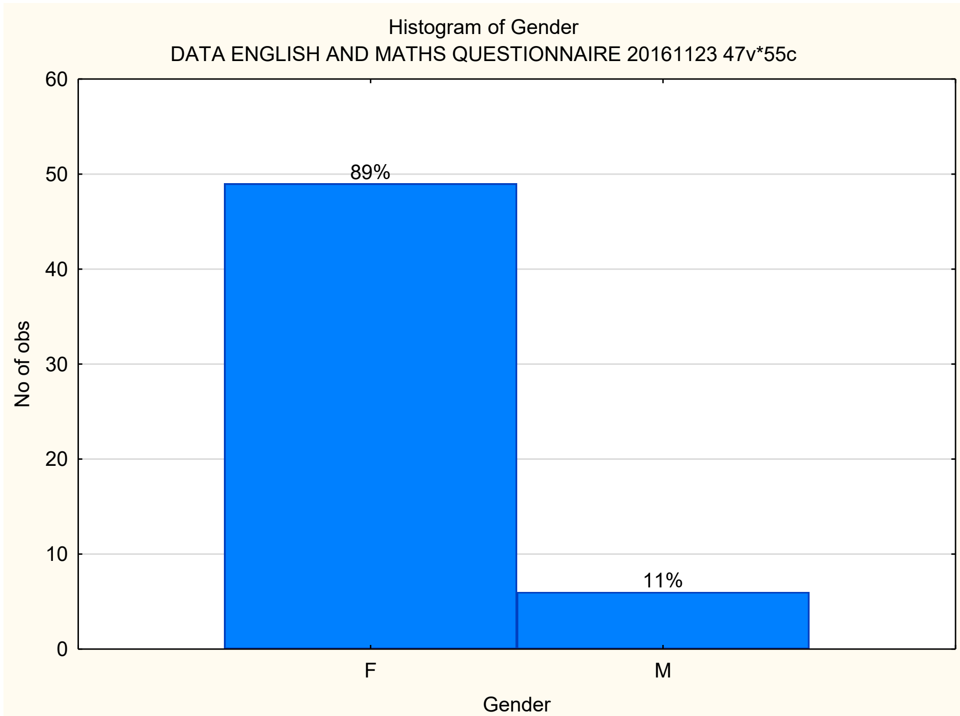
Demographic information presents crucial and factual data relevant in social sciences research, including education. The demographic information collected in this study facilitated a clear understanding of the background and context of the participants necessary for answering the questions posed by this study. Such information provides the essential background information available for analyses and supporting self-contained analyses (Frick, Groh-Samberg & Lohmann, 2008: 2).

Since participants of the study were comprised of teachers and teacher educators, the demographic information for these two groups of participants is presented separately. The first to be presented is the teacher demographic information, followed by the teacher educator demographic information. The section below presents the demographic information of teachers.

5.5.3.1 Demographic Data: Teachers

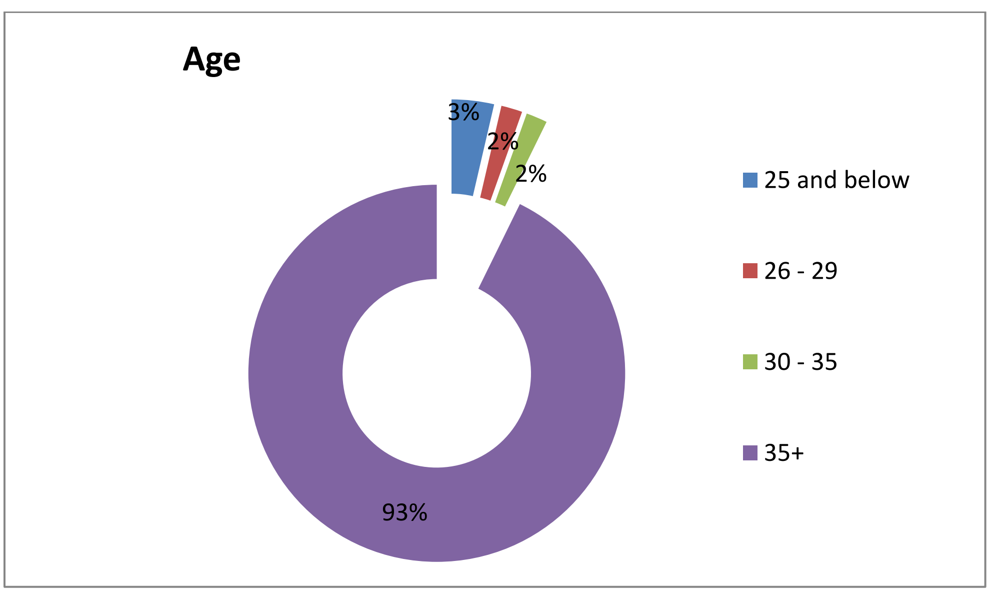
The section below details the teacher participants' demographic information in which the characteristics of the teachers are described in terms of gender, age, race group, education districts, home language(s) spoken, additional languages spoken, university attended, highest qualification obtained, English symbol obtained at matriculation and experience in teaching IP mathematics. Figure 5.4 indicates the distribution of the teachers by gender.

Figure 5.4: Distribution of teachers by gender



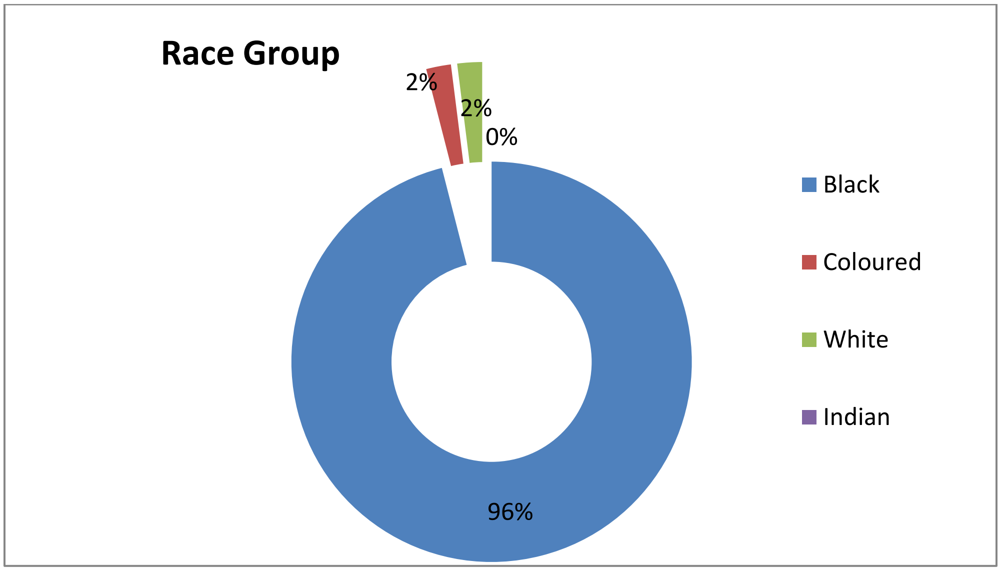
Of the 55 teacher participants, 89% were female and 11% were male as indicated in Figure 5.4. The participants' ages ranged from early twenties to over 35. Two participants (3%) were below the age of 25, only one participant (2%) was between 26 – 29, another one (2%) was between 30 – 34, and the majority (93%) of the participants were above 35 as indicated in Figure 5.5.

Figure 5.5: Distribution of teacher ages



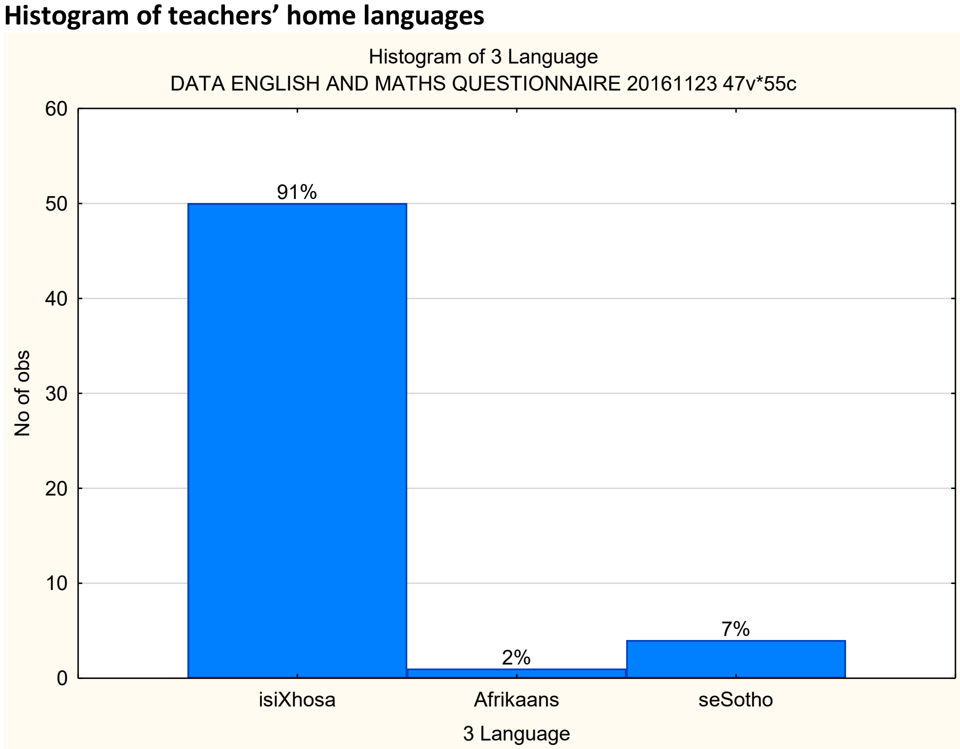
The majority (96 %) of the participants belonged to the black race group, 2% were Coloured, 2% white and none were Indian, as indicated in Figure 5.6.

Figure 5.6: Distribution of teacher race groups



The distribution of participants across race groups is closely related to the participant teachers' home languages. IsiXhosa was home language to 91% of the participants, seSotho to 7% of the participants and Afrikaans to 2% of the participants, as indicated in Figure 5.7.

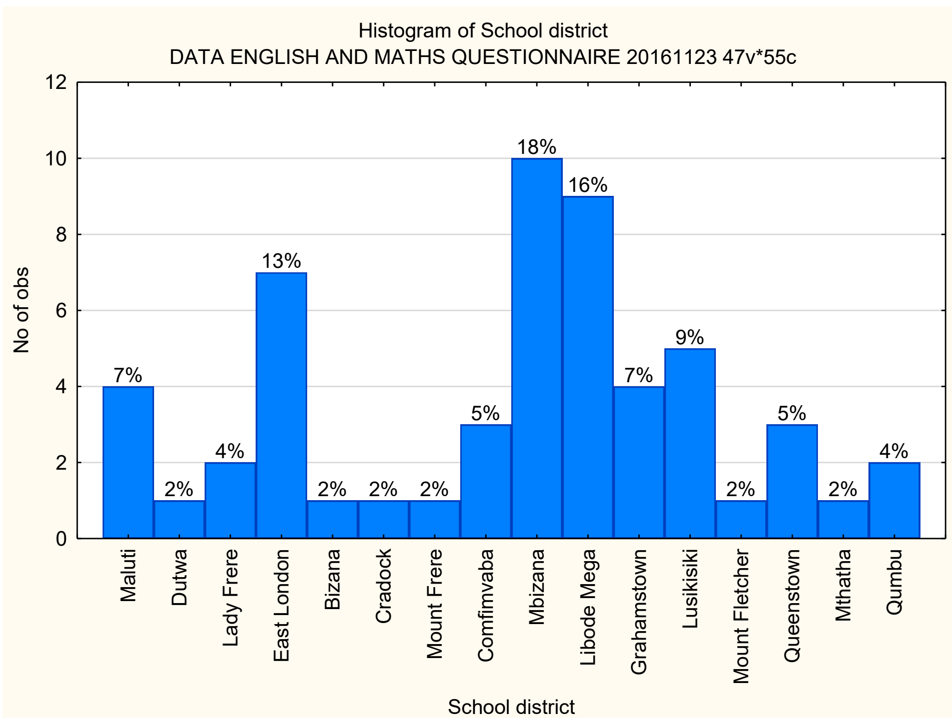
Figure 5.7: Histogram of teachers' home languages



It can be inferred that teachers of the black race group constituted those whose home language is isiXhosa and seSotho, while the participants of the Coloured and white race groups constituted those speaking Afrikaans as their home language.

The Eastern Cape is a relatively large province; it is divided into 24 districts. Information regarding the districts where the participant teachers were deployed was recorded and is indicated in Figure 5.8.

Figure 5.8: Histogram of teacher participants' school districts



The teachers were from only 16 of the 24 education districts in the Eastern Cape Province (the full list of districts: *Bisho, Butterworth, Cofimvaba, Cradock, Dutywa, East London, Fort Beaufort, Graaff-Reinet, Grahamstown, King William's Town, Lady Frere, Libode, Lusikisiki, Maluti, Mbizana, Mt Fletcher, Mt Frere, Mthatha, Ngcobo, Port Elizabeth, Queenstown, Qumbu, Sterkspruit and Uitenhage*).

There are 26 universities[14] spread across South Africa's nine provinces, namely *Cape Peninsula University of Technology (**CPUT**), Central University of Technology (**CUT**), Durban University of Technology (**DUT**), Medical University of Southern Africa (**MEDUNSA**), Mangosuthu University of Technology (**MUT**), Nelson Mandela Metropolitan University (**NMMU**), North West University*

[14] Please refer to page XXIV for a list of the 26 universities in South Africa.

*(**NWU**), Rhodes University (**RU**), Sol Plaatje University (**SPU**), Stellenbosch University (**SU**), Tshwane University of Technology (**TUT**), University of Cape Town (**UCT**), University of Fort Hare (**UFH**), University of the Free State (**UFH**), University of Johannesburg (**UJ**), University of KwaZulu-Natal (**UKZN**), University of Limpopo (**UL**), University of Mpumalanga (**UMP**), University of South Africa (**UNISA**), University of Venda (**Univen**), University of Pretoria (**UP**), University of the Western Cape (**UWC**), University of Zululand (**UZ**), Vaal University of Technology (**VUT**), University of the Witwatersrand (**Wits**) and Walter Sisulu University (**WSU**).* To ascertain the teachers' level of education, information on the universities in which participants completed their Initial Teacher Education (ITE) qualification was recorded and is presented in Table 5.2.

Table 5.2: University at which ITE qualification was completed

Key:[15]

1 = Wits
2 = UNISA
3 = NMMU
4 = WSU
5 = UP
6 = NWU
7 = UJ / RAU
8 = UWC
9 = UZ
10 = UL
11 = Univen
12 = RU
13 = WSU
27 = Teachers' College

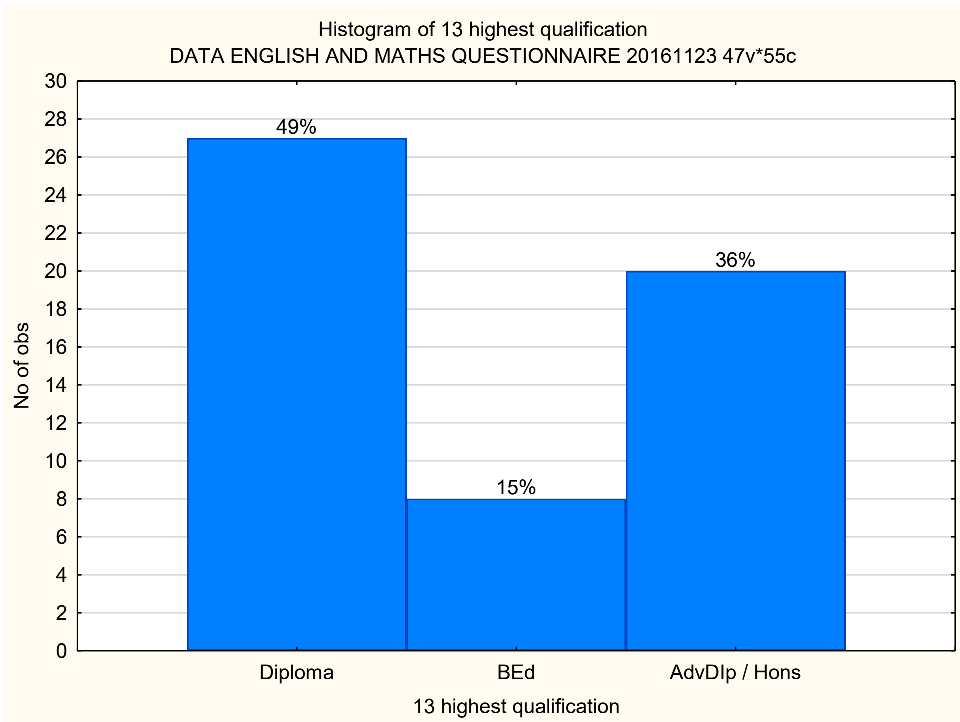
	Frequency table: At which university did you complete y			
Category	Count	Cumulative Count	Percent	Cumulative Percent
1	2	2	3.63636	3.6364
2	14	16	25.45455	29.0909
3	2	18	3.63636	32.7273
4	3	21	5.45455	38.1818
5	6	27	10.90909	49.0909
6	2	29	3.63636	52.7273
7	1	30	1.81818	54.5455
8	1	31	1.81818	56.3636
9	3	34	5.45455	61.8182
10	2	36	3.63636	65.4545
11	1	37	1.81818	67.2727
12	1	38	1.81818	69.0909
13	1	39	1.81818	70.9091
27	15	54	27.27273	98.1818
42517	1	55	1.81818	100.0000

27% of the teachers studied at teachers colleges, which have since been closed after policy changes stipulating that all ITE programmes be offered by the various universities' departments of education; 25% of the teachers studied at UNISA, 10% of the teachers studies at UP while 5% of the teachers studied at UZ. UNISA and NWU are well known for their footprint in offering distance education and it is not surprising that a relatively large number of the teachers had received their qualifications from these two universities.

[15] The numerical coding of the universities is for the current study's data presentation purposes only and does not reflect any ranking of the educational institutions.

For finer details regarding the teachers' level of education, information on their highest qualification obtained in teacher education was captured and coded as follows: {*1=**PreMatric**, (i.e. only passed a standard lower than the Matric level), 2=**Matric** (passed matric but did not attend any tertiary education), 3=**Diploma in Education**, 4=**Bachelor of Education degree** (BEd), 5=**Advanced Diploma / Honours' degree in Education**[16], 6=**Master's degree in Education** and 7=**PhD***}. The results of the teachers' highest qualifications are indicated in Figure 5.9.

Figure 5.9: Histogram of teacher participants' highest qualifications



The majority of teachers (49%) only had a Diploma in Education, 15% had a Bachelor's Degree in Education and 36% had either an Advanced Diploma or an Honours' degree. According to these statistics, all the teachers were qualified; however, the learner performance as detailed in Chapter 1 is significantly low, so there is a gap – one which the education system cannot afford to leave unplugged.

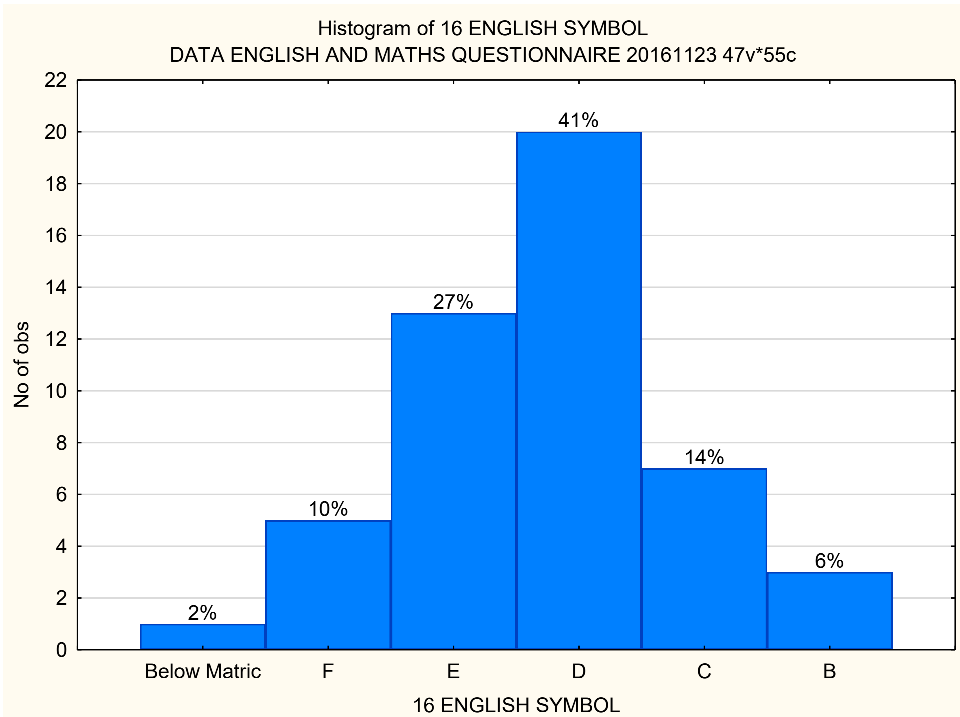
Regarding qualifications, there were two outliers in the teacher participants. One of the participants had initially studied for a National Diploma in Adult Basic Education and Training (ABET) and through correspondence obtained a Diploma in Education and ended up serving as

[16] The two qualifications were equated based on the South African Qualifications Authority (SAQA) framework, which considers them to be on the same level.

an IP mathematics teachers because of the recurrent critical shortage of mathematics teachers; the other participant was in the process of completing a Master's degree in Education.

Since the current study is based on interrogating the teachers' competence in English, the prescribed LoLT in most South African Schools, it was necessary to capture the symbols the teachers had obtained in English at matric[17] / school-leaving level. The matric English symbols are indicated in Figure 5.10.

Figure 5.10: Histogram of English symbols obtained at matriculation

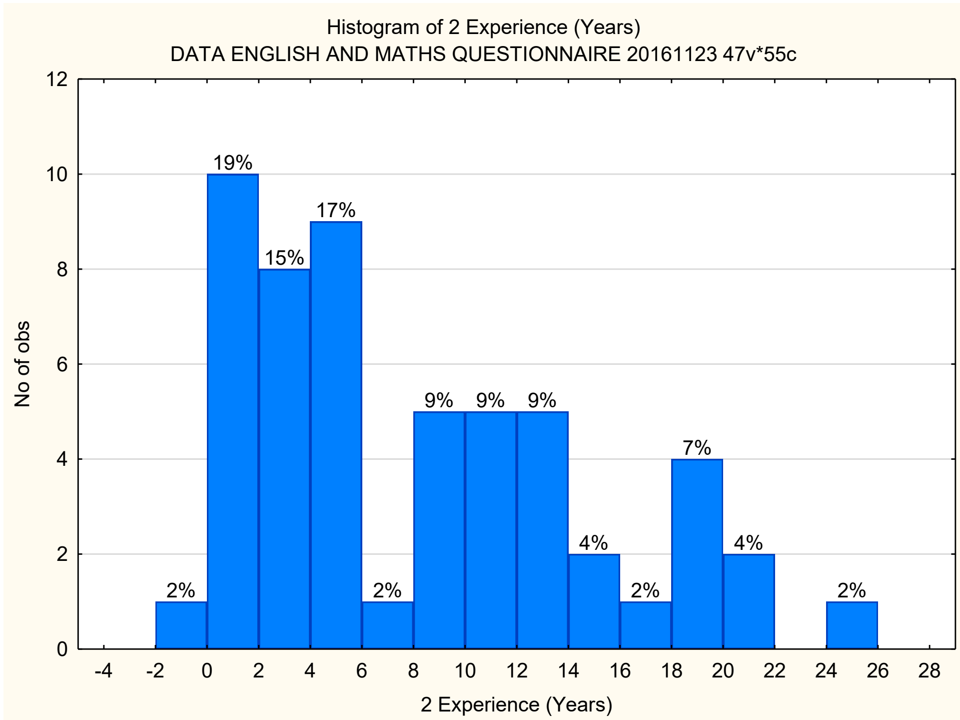


None of the teachers obtained symbol **A**, 6% obtained symbol **B**, 14% obtained symbol **C**, 41% obtained symbol **D**, 27 % obtained symbol **E**, 10% obtained symbol **F**, and 2 % failed matric English. It is noteworthy that the majority of the teachers obtained symbol **D** and below. However, as is the norm, matriculants who settle for teacher education qualifications are usually not the *crème de la crème* and the results above provide information to confirm this attestation.

To ascertain the participants' teaching experience, the number of years they have been practising as IP mathematics teachers was captured and is indicated in Figure 5.11.

[17] A matric certificate is offered after completing the 12th grade of the South African ordinary school system. The issuing of certificates is standardised and quality assured by Umalusi Council in conjunction with the Department of Basic Education, (DBE).

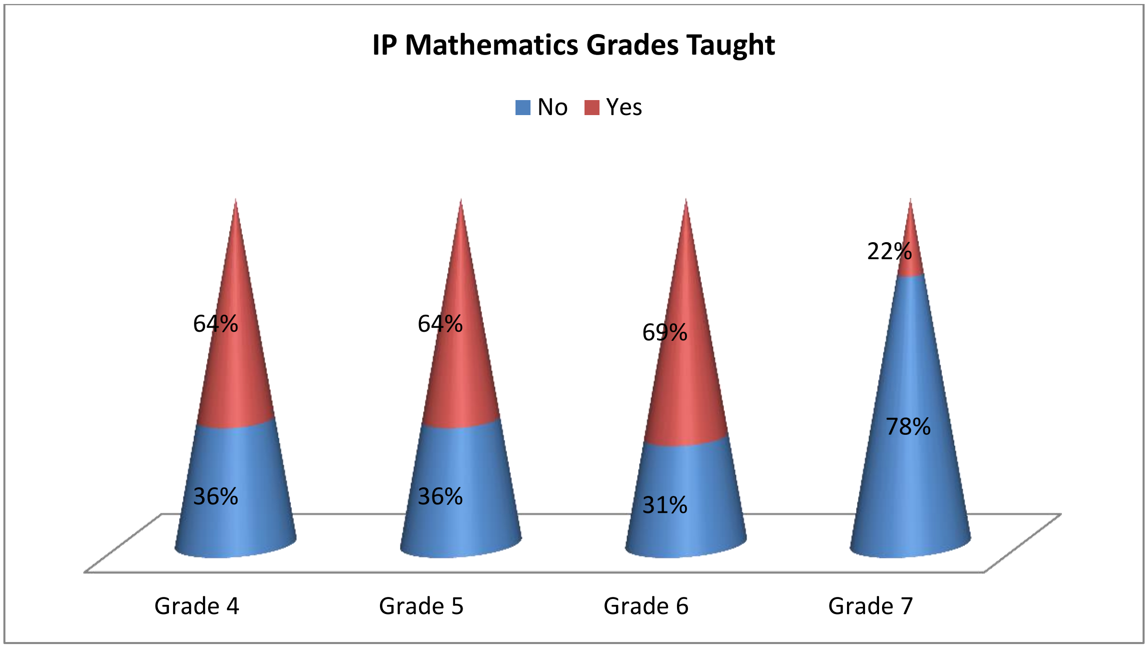
Figure 5.11: Histogram of IP mathematics teachers' teaching experience



As indicated in Figure 5.10, very few participants were outliers, i.e. with very little experience of less than 1 year (2 %), or had extensive experience of teaching IP for 26 years (2%) with a varying distribution ranging from 2 to 22 years. 19% of the of the participants had been teaching IP mathematics for only 2 years; this could be attributed to the fact that some teachers could have been teaching other phases and/or subjects such as Technology and were moved to teaching IP mathematics when their subject specialisations were removed from the curriculum. A total of 32% of the teachers had been teaching IP mathematics for an average of 5 years, while a total of 27% of the participants had been teaching IP mathematics for an average of 12 years, and these could be considered as seasoned IP mathematics teachers.

According to the policy stipulation, the IP phase is comprised of three specific grades: 4, 5 and 6. However, changes in the DBE stipulations resulted in the IP phase including Grade 7 as well to accommodate primary schools that had enrolments ranging from grade R – 7. (As from the beginning of 2015, the DBE began the process of moving Grade 7, 8 and 9 classes housed in primary schools to neighbouring high schools – a process with good intentions but resulting in redeployment of teachers). As such, the information obtained from the teachers about the grades taught ranged from Grades 4 to 7 as indicated in Figure 5.12.

Figure 5.12: Distribution of IP mathematics grades taught



As indicated in Figure 5.11, an average of 66 % of the teachers taught Grade 4, 5 and 6, and only 22% of the teachers taught Grade 7 classes.

The demographic information of both the teachers and the teacher educators was derived from the biographical details section of the questionnaires, which the participants completed in person. Demographic information provided participants' background information, including evidence of their practice.

5.5.3.2 Demographic Data: Teacher Educators

The demographic information of the teacher educators was not deemed as pivotal in the study as much as that of the teachers, because the teacher educators were secondary participants of the study meant to authenticate the information given by the teachers. The only biographical information from the teacher educators that was deemed necessary was gender, position, the official LoLT(s) at their institutions and their experience in years in teaching IP mathematics at university level. The demographic data of the 10 participant teacher educators is indicated in Table 5.3.

Table 5.3: Demographic information: Teacher educators

	Gender	Race Group	Position	Question	
				What is the official LoLT at your institution?	***For how many years have you offered in-service IP mathematics education?***
TE1	M	Indian	Senior Lecturer	English and Afrikaans	0 – 3 years
TE2	M	Black	Lecturer	English	More than 10 years
TE3	F	White	Lecturer	English	4 – 6 years
TE4	M	Black	Lecturer	English	0 – 3 years
TE5	F	White	Senior Research Fellow	English	More than 10 years
TE6	M	White	Director Maths Project	English	More than 10 years
TE7	F	Indian	Professor/Numeracy Chair	English	More than 10 years
TE8	F	White	Lecturer	English and Afrikaans	7 – 10 years
TE9	F	White	Professor/Numeracy Chair	English	More than 10 Years
TE10	M	Black	Lecturer	English	0 -3 years
Totals % where applicable	M (5) 50% F (5) 50%	Black (3) 30% Coloured (0) 0% White (5) 50% Indian (2) 20 %	Lecturer (5) 50% Senior Lecturer (1) 10% Senior Research Fellow (2) 20 % Professor/Numeracy Chair (2) 20%	English (8) 80% English and Afrikaans (2) 20%	0 – 3 (3) 30% 4 – 6 (1) 10% 7 – 10 (1) 10% More than 10 years (5) 50%

Key:

TE = Teacher Educator
M = Male
F = Female

The teacher educator participants were distributed equally between male and female. The participants held various positions in their universities ranging from lecturers (50%), Senior Lecturers (10%), Senior Research Fellows in Mathematics Education (20%) and Professors (20%), who are currently holding South African Numeracy Chair positions. This variety of positions enabled the participants to provide well-balanced information, based on their experiences and expertise regarding the language of instruction in primary mathematics education. 50% of the participants had held teacher educator positions for more than 10 years, while the rest had been in mathematics teacher education for between 0 and 10 years. Since this study is focused on language of instruction, it was crucial to determine the official medium of instruction in the participants' universities; English was the LoLT in 80% of the institutions, while English and Afrikaans were used as LoLTs in 20% of the institutions. It is noteworthy that 50% of the teacher educator participants are white, 30% black and 20% Indian. Thus, a cumulative of 70% of the teacher educators possess native fluency in English in contrast to 96% of the teacher participants (as illustrated in earlier sections of this chapter) to whom English is second, third or even fourth language.

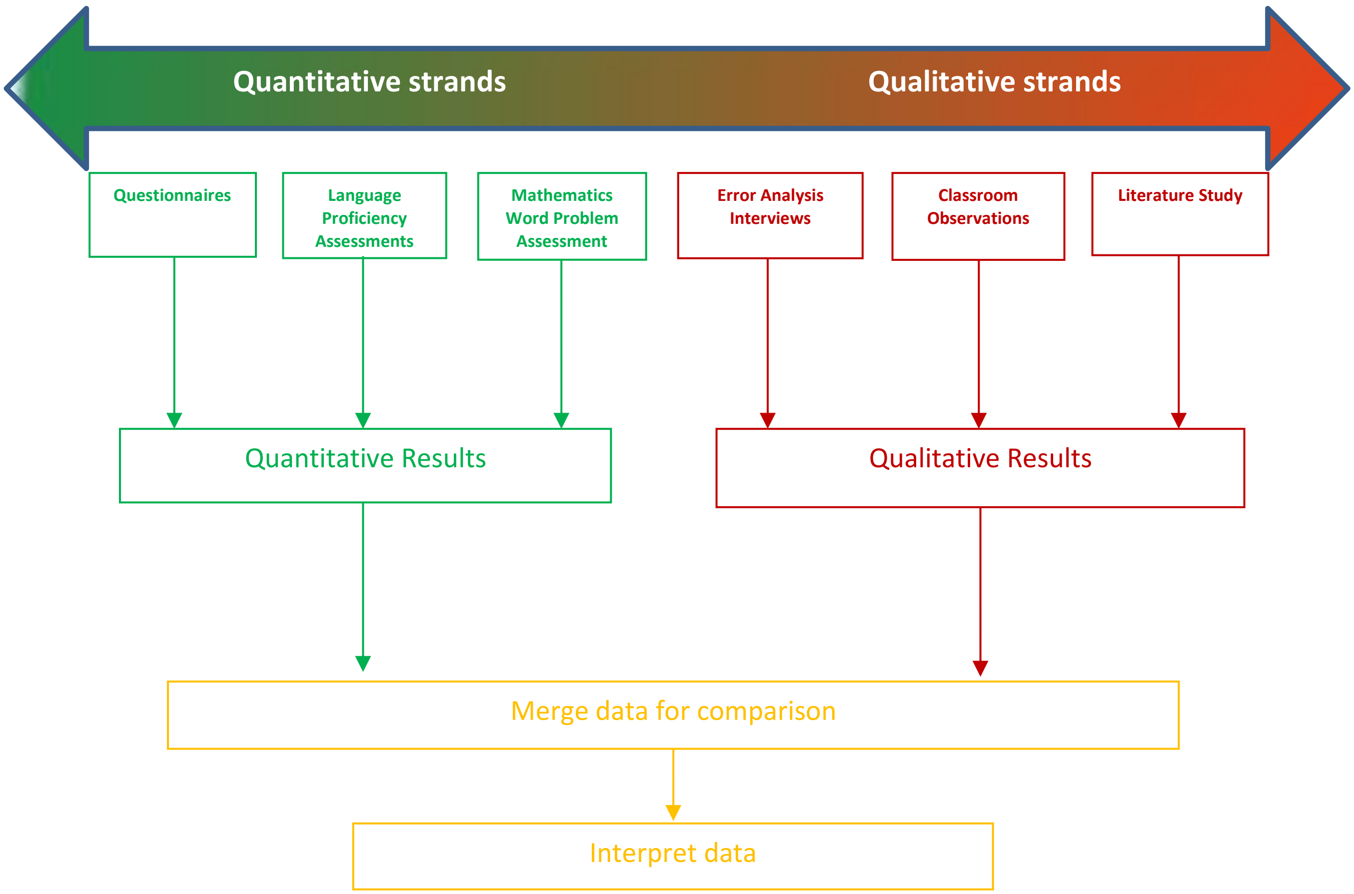
5.6 Data-Collection Techniques

In order to carry out this investigation, the researcher identified and selected data sources relevant to this research (White, 2005: 186). The researcher was the main data-collection instrument and collected data over a period of time while respondents attended professional development courses as well as at the setting of the school site, in line with what Creswell, (2010: 78) suggests.

Primary research methods focused on respondents involved in IP mathematics education, falling within the scope of this research, namely school teachers based in the ECDoE and teacher educators based in different universities. The mathematics teachers were involved as participants in the research to gain a deeper and balanced understanding of their proficiency in English as well as how they overcome language barriers in teaching IP mathematics. The teacher educators were involved in the research to provide a deeper understanding of the extent to which teacher are trained in using English as the LoLT.

Data for this study were gathered through questionnaires, language proficiency and mathematics word problem assessment, semi-structured interviews, non-participant class observations, and documentary analysis based on a mixed methods process as indicated in Figure 5.13.

Figure 5.13: A mixed methods research process model



Based on Wittink et al. (2006)

Figure 5.13 shows the fundamental framework adopted for this study. It depicts the convergent parallel mixed method design which combines both the qualitative and quantitative methodologies (Cresswell, 2012: 540).

A review of secondary sources was also undertaken. The combination of these data-gathering techniques complemented the data gathered through different methods and from different respondents to ensure that the researcher obtained rich data in a way which is not possible through one method.

The use of a multi-method approach helped the researcher to validate and cross-check findings and to confirm or challenge the findings. The multi-method approach, which also entails triangulation, enables cross-checking certain phenomena and the veracity of individual accounts by gathering data from a number of different informants and sources and subsequently comparing and contrasting one account with another to produce a comprehensive and balanced study (Leedy & Ormrod, 2005; Lodico, Spaulding & Voegtle, 2006; Nieuwenhuis, 2007; Gobo, 2007; Flyvbjerg, 2007; Bell, 2009).

Questions used during the different data-gathering techniques were derived from the analytical frameworks of the study. These frameworks guided and informed data collection and analysis. Questions in the different data-gathering techniques helped the researcher to establish whether the teachers were sufficiently trained in using English as a LoLT during the initial teacher education programmes offered by the various universities.

The convergent parallel mixed method research design shown in Figure 5.13 represents the structure, methodologies and methods of data collection which are discussed separately below.

5.6.1 Questionnaires

Questionnaires are one of the most widely used social research techniques. A questionnaire enables the researcher to organise the questions and receive replies without actually having to talk to every respondent. Questionnaires are a relatively economical method of gathering data in terms of cost and time to solicit data from a large number of people. Respondents can also take time to check facts, leading to more thought – out and accurate information (Walliman, 2001: 236 – 237; Wagner, 2010: 26). Questionnaires can be delivered personally, or by post or email or through research assistants. Postal and email surveys are likely to have lower response rates and possibly inadequate answers because the respondents have no one available to clarify any queries, but they may allow a larger number of people to be surveyed.

Postal and email surveys are useful in cases where the postal services are affordable, reliable and fast and where the respondents have access to the internet and are computer literate. Delivering the questionnaires personally helps respondents to overcome difficulties with questions that might need clarification, but such concerns should be minimised to ensure that the questionnaire is as user-friendly and accessible as possible and can be completed without the help of the researcher. Delivering questionnaires in person also offers the possibility of checking on responses if they seem incomplete or odd, and this generally leads to a higher response rate and better results (Blaxter, Hughes & Tight, 2001: 179; Wagner, 2010: 30). Considering that in this study the researcher had access to the respondents during face-to-face contact sessions, there was ample time to help the teachers with questions if clarity was sought.

While questionnaires are relatively cheap and effective in preventing the personality of the interviewer having an impact on the results, they do have limitations. Questionnaires are not suitable for questions which require probing, as they should only contain simple, one-stage questions and are often affected by restrictions of space not allowing expanded responses. The data obtained from questionnaires are mainly superficial accounts of complex constructs such as language ideologies, which need to be unpacked further and complemented with information from other data-collection instruments. In this study information obtained from the questionnaires was further unpacked through language competency and word problem assessments, interviews and classroom observations, which provided rich in-depth data (Wagner, 2010: 26). In addition, questionnaires are also associated with problems of failing to gain the required response from the complete sample, because the questionnaires tend to be returned by the more literate sections of the population (Walliman, 2001: 238). In this study this meant that respondents with a higher level of English proficiency provided more detailed answers compared to those with lower proficiency, the very notion under investigation in the study.

Two different questionnaires were used in this study, one for teachers (**Appendix A**) and another for teacher educators (**Appendix B**).

5.6.2 Needs Assessments

A needs assessment is a systematic process for determining and addressing needs or gaps between current and desired conditions. The discrepancy between the current and desired conditions must be measured to appropriately identify the need (AL-Qahtani, 2015). In this study the current condition is established by the teacher performances in the assessments and measured against the desired condition, which is the level at which the teachers are expected to be performing. Since the study focuses on the IP level, the expected performance is thus pegged at Grade 7 level, one year beyond the exit point of IP. A needs assessment is a tool that can be used in strategic planning. This study used assessments in order to identify the needs of IP mathematics teachers for the teachers' professional development and to clarify the linguistic challenges faced by the teachers in content delivery.

Two forms of teacher assessments were used in this study, namely an English Language Proficiency Assessment and a Mathematics Word Problem Assessment. The two assessments were provided by JET educational services; they are standardised teacher assessments, conforming to the South African context and piloted in five different university teacher education departments in the country. The frameworks for the two assessments are explained below.

5.6.2.1 English Language Proficiency Assessment

The proficiency assessment is primarily based on the National Curriculum Statement (NCS) home language level assessment standards for Grade 7. The rationale used is that teachers, at the absolute minimum, need to show a proficiency in a language that is two years beyond that of their learners. The test is made up of 47 items and covers a range of topics. Topic areas include comprehension, text structures, words, grammar and writing. Test items consist of open-ended questions or multiple-choice questions and the framework of the test items is given in Table 5.4.

Table 5.4: English language proficiency assessment framework

Area	Item number	Type of question	Topics covered	Total Marks	% of total score
Comprehension	1,2,4,9,12,13, 25,26,27,28, 33,34,35	MCQ	Literal and inferential comprehension	16	20%
Text Structures	3,8,18,19,20, 21,22,32,37	MCQ, OEQ	Features of non-fiction texts: interviews, autobiographies, dictionaries and advertisements	12	15%
Words	5e,10,11,24,30	OEQ	Homonyms, vocabulary, synonyms/antonyms, word roots	8	10%
Grammar	5a,5b,5c,5d, 6a,6b,15a,15b, 15c,16a,16b, 16c,16d,23, 29,36	OEQ	Interrogative words, tenses, apostrophe, word order, adjectives, verbs, subject, subject-verb agreement, adverbs, inverted commas, phrase/clause, punctuation	22	28%
Writing	7,17,31,38	OEQ	Expresses and supports an opinion, writes a description, writes comparative statements	22	28%
Total				**80**	**100%**

KEY:
MCQ = Multiple Choice Question
OEQ = Open-Ended Question

JET, (2015a)

5.6.2.2 Mathematics Word Problem Assessment

The mathematics word problem assessment was based on a framework that considered broad mathematics content area, the domains of knowledge, level of difficulty and school phase. The assessment contained various question types: multiple choice, short answer, written answer. The framework used for the development of the assessment is shown in Table 5.5.

Table 5.5: Mathematics word problem assessment framework

Category		Description of category / rationale
Broad mathematics content area	Number and operations	These are the broad content areas into which mathematical content in primary school in South Africa is divided. Number and operations are most heavily weighted in the primary curriculum followed by geometry and measurement and then patterns, functions and algebra, with data handling having only a small weighting. These categories were used to check that all these areas were covered, but with the relative emphasis of these content areas borne in mind.
	Patterns, functions, algebra	
	Geometry and measurement	
	Data Handling and probability	
Domains of knowledge	Lower cognitive demand subject knowledge	Knowledge of mathematics that is of low cognitive demand, e.g. recall of facts, execution of routine procedures.
	Higher cognitive demand subject knowledge	Knowledge of mathematics that is of high cognitive demand, e.g. execution of non-routine procedures, interpretation of mathematics in context, problem-solving, work that requires deep understanding of the concepts involved.
	Application of subject and pedagogical knowledge in a teaching environment	Application of knowledge of mathematics as well as pedagogical knowledge in a teaching environment, e.g. understanding learner thinking about a particular topic or task, selection and design of appropriate tasks, appropriate choice of teaching strategy for teaching a particular topic.
Level of difficulty	Easy	These are questions which should be easy for the respondents to answer correctly.
	Moderate	These are questions which should be moderately difficult for the respondents to answer correctly.
	Difficult	These are questions that which should be difficult for the respondents to answer correctly.
School phase	Intermediate phase	This indicates the content tested in the question is encountered in the current South African Mathematics Curriculum (CAPS)[18] in the Intermediate Phase (Grades 4 – 7).
Question type	Restricted response	The answer is either correct or incorrect and is a number or mathematical expression or shape.
	Open-ended response	The answer is open-ended and will be given in writing.
	Multiple-choice question	The answer is selected from a set of possible answers.

JET, (2015b)

[18] CAPS – Curriculum Assessment Policy Statements

The mathematics word problem assessment was developed using already existing tests, including Wits Maths Connect Project, Mathematics Knowledge for Teaching Measures, Annual National Assessments (ANA)[19] question papers 2009 – 2013 and Southern and Eastern African Consortium for Monitoring Educational Quality (SACMEQ) Mathematics test for teachers 2007. Where items from the test are in the public domain, or where there is a need for permission to replicate questions from the test, questions were adapted for use in the test and indicated thus. The distribution of marks to categories is indicated in Table 5.6

Table 5.6: Distribution of marks in mathematics word problem assessment

	Lower Cognitive Demand	Higher Cognitive Demand	Pedagogy	Total
Number	13	15	18	**46**
Patterns, functions and algebra	3	7	2	**12**
Geometry and measurement	9	5	3	**17**
Data handling and percentages	1	1	3	**5**
Total	**26**	**28**	**26**	**80**

JET (2015b)

The distribution of marks according to content areas took into consideration the weighting and importance of those topic areas at IP level.

5.6.2.3 Performance Scales

The level of these tests is quite low, as they are trying to establish absolute minimum standards for teachers. The pass rate was thus set at 70% for the two assessments. The following scale can be applied:

- **70% and above:** satisfied requirements
- **50% – 69%:** cause for some concern
- **Below 50%:** cause for serious concern

5.6.2.4 Assessment Administration

The researcher was the sole assessment administrator; however, this was not a challenge as the study is triangulated. Assessments were administered anonymously through the use of alpha numerical codes. Teachers were given 90 minutes in which to complete the test. On average, teachers spent 75 minutes to complete the proficiency test. No teacher required the full amount of time to finish any of the tests. The English Language Proficiency Assessment is

[19] ANAs were phased out in 2015.

attached as **Appendix C**, while the Mathematics Word Problem Assessment is attached as **Appendix D**. The detailed framework of the English Language Proficiency Assessment is attached as **Appendix C1**, while the detailed framework of the Mathematics Word Problem Assessment is attached as **Appendix D1**.

Although language proficiency and mathematics word problem assessments were used to collect data for the current study, the use of the two instruments does not in any way make the study a needs analysis; the study is a relational analysis between language competency and IP mathematics instruction. The mixed methods design informing this study necessitated the use of needs assessments as components of data-collection procedures.

5.6.3 Interviews

Nieuwenhuis (2007: 87) defines an interview as a two-way communication in which the interviewer asks the respondents questions to collect data and to learn about their ideas, beliefs, views, opinions, practices and behaviours. In qualitative research interviews help the researcher to see the world through the eyes of the participant. The aim is always to obtain rich descriptive data that will help the researcher understand the participant's construction of knowledge and social reality. Interviews are useful for collecting data which would probably not be accessible using techniques such as documentary analysis, observation or questionnaires. Unlike documentary analysis, observations and questionnaires, interviews, especially unstructured and semi-structured interviews, allow room for in-depth probing or clarifications, since they involve questioning and discussing issues with people (Blaxter, Hughes & Tight, 2001; Bell, 2009; Wagner, 2010).

Interviews offer opportunities to follow up ideas, probe responses and investigate motives and feelings which the questionnaire can never do. The way in which a response is given, for example, the tone of voice, facial expression or hesitation can provide information that a written response would conceal. Interviews allow the researcher to reassure and encourage the respondent to be full in his/her answers. Visual signs such as nods or smiles are valuable tools for promoting complete responses. However, the personality of the interviewer can have some effects on the results (Walliman, 2001: 239; Bell, 2009: 157).

While interviewing is suitable for quantitative data collection, it is particularly useful when qualitative data are required, hence their use for the qualitative strands of this study. For this study the researcher conducted face-to-face interviews because of their advantage over telephone and on-line interviews. In face-to-face interviews the researcher is in a good position to judge the quality of the responses of the participants, since they can even look at the non-verbal forms of communication that also help ascertain the participant's inner feelings about the subject. The researcher is able to notice if a question is properly understood and to reassure and encourage the participant through their body language and appreciation of the responses, which are all valuable tools in promoting complete responses (Walliman, 2001: 238). Face-to-face interviews are also relatively cheaper compared to telephone and on-line interviews and are the only option available in areas with poor telephone and cell phone network coverage and internet connections.

In qualitative research interviews are classified as unstructured or semi-structured or structured (Walliman, 2001; Leedy & Ormrod, 2005; Davies, 2007; Nieuwenhuis, 2007; Rugg & Petre, 2007).

5.6.3.1 Unstructured Interviews

Unstructured interviews often take the form of a conversation with the intention that the researcher explores with the participant their views, ideas, beliefs and attitudes about certain events or phenomena (Nieuwenhuis, 2007: 87). In unstructured interviews respondents may propose solutions or provide insight into events or phenomena being studied.

5.6.3.2 Semi-Structured Interviews

Semi-structured interviews are commonly used in research projects to corroborate data emerging from other data sources. In this study semi-structured interviews were used to corroborate data gathered through questionnaires and language competency and mathematics word problem assessments. Semi-structured interviews require the participant to answer a set of predetermined questions with a defined line of enquiry. They are organised around areas of particular interest, while still allowing considerable flexibility in scope and depth from respondents. While conducting a semi-structured interview, the interviewer needs to be attentive to the responses of the participants so that they can identify new emerging lines of inquiry that are directly related to the issues under investigation, and explore and probe these. Semi-structured interviews are usually preferred because they allow for the probing and clarification of answers; in addition, they are flexible and more likely to yield the information that the researcher had not planned to ask for (Leedy & Ormrod, 2005; Nieuwenhuis, 2007; Wagner, 2010).

Semi-structured interviews are also referred to as reflective interviews. They use prompt sheets, such as Newman's Error Analysis in Written Mathematical Tasks approach, which contains carefully selected lists of topics. Questions used in semi-structured interviews do not solicit simple yes or no answers, but stimulate reflection and exploration of ideas and issues. They are often concerned with people's feelings (Davies, 2007: 29). The semi-structured nature of such interviews leave some space for following-up interesting topics when they arise, allowing for an in-depth probing and exploration of the subject in question. Semi-structured interviews also allow the researcher to explore the concepts under investigation in depth, allowing for the unpredictable emergence of information.

5.6.3.3 Structured Interviews

Structured interview questions are detailed and developed in advance. Structured interviews are frequently used in multiple case studies or larger sample groups to ensure consistency. However, if they are overly structured, they inhibit probing (Leedy & Ormrod, 2005: 146). Structured interviews can be viewed as a form of a spoken questionnaire (Rugg & Petre, 2007: 138). Being structured leaves the interviews with limited room for probing and seeking clarity on emergent topics. Structured interviews only allow a limited set of responses, usually the yes or no kind of answers. Since this study aims to stimulate reflection and exploration of ideas and issues related to the relationship between language competency and mathematics instruction, the researcher used semi-structured interviews to gather data from IP mathematics teachers and teacher educators.

This study opted for semi-structured interviews as they could help to explain in detail what approach teachers use when they teach specialised mathematical vocabulary in IP mathematics. The intention was also to find clarity on the challenges related to linguistic practices encountered during mathematics instruction. The researcher conducted individual face-to-face semi-structured interviews with the respondents.

During the process the researcher tape recorded the interviews with IP teachers and teacher educators and then transcribed them verbatim. The researcher listened to the tapes several times, perused the transcriptions a number of times too, in order to establish meaning and context. The researcher also looked at the respondents' reactions collectively to each question. Inductive analysis means that categories and patterns emerge from the data rather than being imposed on data prior to data collection.

During the interview the respondents were probed to provide further information and the researcher took field notes regarding the interview interactions (verbal and non-verbal communication) between the researcher and the respondents, as well as the researcher's reflections on the interchange (Leedy & Ormond, 2005; Creswell, 2010). After the completion of the interviews, the researcher asked all respondents if they had any questions they would like to ask in case the researcher left something out. The researcher thanked all the respondents for their time, their contribution, and for agreeing to take part in this research.

Interview guides were used during the interview and the interviews were conducted in English. The transcribed data from the interviews were saved on a computer locked by a secret pass word and accessible only to the researcher. An interview guide was employed in accordance with the principles stipulated by Hollway and Jefferson (2001) and Creswell (2010). In this study interviews were used to enhance the study. Two different sets of interviews were conducted: one for the teachers and another for the teacher educators.

Teacher Interviews

The Newman hierarchy of error causes for written mathematical tasks was incorporated to interview 10% of the sampled IP teachers after the administration of the mathematics word problems.

Since 1977, when an Australian-based mathematics teacher, Anne Newman, published data based on a system she had developed for analysing errors made on written tasks, a steady stream of research papers has been published in which data from many countries have been reported and analysed along the lines suggested by Newman (1977), Casey (1978), Clarkson (1980, 1982, 1991), Clements (1980, 1982), Marinas and Clements (1990) and Watson (1980).

The findings of these studies were sufficiently different from those produced by other error analysis procedures to attract considerable attention from both the international body of mathematics education researchers (Dickson, Brown & Gibson, 1984; Mellin-Olsen, 1987; Zepp, 1989) as well as mathematics teachers. In particular, analyses of data based on the Newman procedure have drawn special attention to:

- the influence of language factors on mathematics learning; and
- the inappropriateness of many 'remedial' mathematics programmes in schools in which there is an over-emphasis on the revision of standard algorithms.

(Clarke, 1989)

According to Newman (1977, 1983) a person wishing to obtain a correct solution to a one-step word problem such as "***The marked price of a book was R20. However, at a sale, 20% discount was given. How much discount was this?***" must ultimately proceed according to the following hierarchy:

1. Read the problem;
2. Explain what is read;
3. Carry out a mental transformation from the words of the question to the selection of an appropriate mathematical strategy;
4. Explain the process skills required by the selected strategy; and
5. Record the answer in an acceptable written form.

Newman used the word hierarchy based on the reasoning that failure at any level of the above sequence prevents problem solvers from obtaining satisfactory solutions, unless they arrive at correct solutions by chance through faulty reasoning.

Usually, problem solvers often return to lower stages of the hierarchy when attempting to solve problems (Casey, 1978). (For example, in the middle of a complicated calculation someone might decide to reread the question to check whether all relevant information has been taken into account.) However, even if some of the steps are revisited during the problem-solving process, the Newman hierarchy provides a fundamental framework for the sequencing of essential steps.

A diagrammatic illustration of the Newman technique is provided in Chapter 2 (Figure 2.3). According to Clements (1980: 4), errors due to the form of the question are essentially different from those in the other categories, because the source of the difficulty resides fundamentally in the question itself rather than in the interaction between the problem solver and the question. This distinction is represented in Figure 2.3 by the category labelled "Question Form" being placed beside the five-stage hierarchy. Two other categories – *carelessness* and *motivation* – have also been shown separately on the hierarchy. Although as indicated, these types of errors can occur at any stage of the problem-solving process. A careless error, for example, could be a reading error or a comprehension error. Similarly, someone who had read, comprehended and worked out an appropriate strategy for solving a problem might decline to proceed further in the hierarchy because of a lack of motivation. For example, a problem-solver might exclaim: "What a trivial problem. It's not worth going any further."

The complete teacher interview guide is attached (**Appendix E**). The extracts below from the interview illustrate how the Newman technique informed the teacher interview guide:

5. The following questions are based on the **JET mathematics word problem assessment** you solved earlier: **(Choose only one question from Questions 13 or 14 or 15).**

13ai) *Solve the word problem, showing all working clearly: I want to divide 3 pizzas between two children fairly. How much pizza will each child get?*

____
____
____

13aii) *Would the word problem "I want to divide 3 pizzas between two children fairly. How much pizza will each child get?" be a good word problem to illustrate 3 divided by ½? Explain why you say so.*

____
____
____

13bi) *Solve the word problem, showing all working clearly: A child has 3 chocolates. The number of chocolates the child has is doubled. How many chocolates will the child have now?*

____
____
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13bii) *Would the word problem "A child has 3 chocolates. The number of chocolates the child has is doubled. How many chocolates will the child have now?" be a good word problem to illustrate 3 divided by ½? Explain why you say so.*

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13ci) *Solve the word problem, showing all working clearly: I have 3 metres of ribbon. I am making* *bows that each require ½ metre of ribbon. How many ribbons will I be able to make?*

____
____
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13cii) *Would the word problem " I have 3 metres of ribbon. I am making bows that each require ½ metre of ribbon. How many ribbons will I be able to make? " be a good word problem to illustrate 3 divided by ½? Explain why you say so.*

____
____
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Extracted from JET (2015b)

Answer ***all*** of the following based on the question you have chosen:

a) Read the question. (***Reading / Decoding***)
b) What is the question asking you to do? *(**Comprehension**)*
c) Suggest a method that can be used to find an answer to the question. *(**Transformation / Mathematising**)*
d) Explain how you worked out the answer. *(**Processing**)*
e) Write down the answer to the question. *(**Encoding**)*

This type of interview was used instead of an ordinary interview, because it solicited responses better suited to answer the research questions based on its likelihood of establishing IP mathematics teachers' language competency in the prescribed LoLT.

Teacher Educator Interviews

The purpose of the interview was to verify the information collected through the questionnaires. The teacher educator interview guide (**Appendix F**) was used to interview 10% of the sampled IP teacher educators after the administration of the questionnaire.

While flexibility and adaptability are great advantages of personal interviews, they are costly and time consuming (Welman & Kruger, 2001). Personal interviews could also not be conducted anonymously and researchers must thus take care not to say anything that could be construed as a desired response, but must rather use open-ended questions. Some advantages of personal interviewing identified by Welman and Kruger (2001) include control over responses and the respondents' response rate. They emphasise the control of the researcher in the interview situation through personal interaction, whereby they may gain the confidence of evasive respondents, record their answers, and follow up on incomplete or vague responses, and so obtain rich data. The researcher's physical presence may reduce elusive responses during a direct encounter and respondents may be more willing to talk about their experiences in an interview; yet the researcher's presence may also have the opposite effect.

White (2005: 143) outlines the following advantages of interviews:

- ***Flexibility***: when the participant indicates that they have not understood the question, the researcher can repeat and probe for more specific answers;
- ***Response rate:*** Participants who are unable to read and write could still answer questions in an interview;
- ***Control over the environment:*** The researcher can standardise the interview environment and conduct it in a quiet and private place;
- ***Non-verbal behaviour***: the presence of a researcher enables the observation of non-verbal behaviour and assessment of the validity of the interviewee's response;
- ***Question order:*** the researcher can ensure that participants answer questions in order;
- ***Spontaneity***: immediate answers may be more informative than answers about which a participant has had time to think over;
- ***Respondent alone could answer***: the researcher obtains immediate answers as the participant is not able to cheat;
- ***Completeness***: the researcher is able to ensure that all questions are answered.

5.6.3.4 Recording Interviews

Recording an interview must be done in a meticulous manner. Most people are very uncomfortable about being recorded and they fear that the recording can be used to identify them and they feel it compromises confidentiality. They also feel that once they are recorded verbatim, the chances of remaining anonymous are very low. Tape recording makes some respondents anxious and less likely to reveal confidential information (Blaxter, Hughes & Tight, 2001). To avoid situations where respondents felt uncomfortable about stating their views, the researcher clearly explained the purpose of the study before the discussions and interviews, guaranteed confidentiality, anonymity and also sought the consent of the respondents to record and explained why recording was preferred to note taking.

Tape recording helps the researcher focus on the process of the interview, i.e. focus attention on the interviewee, giving the interviewee appropriate eye contact and non-verbal communication, and offers the researcher a verbatim record of the whole interview. Based on this advantage of tape recording, the researcher chose to record and take notes while interviewing respondents. Note taking gave the researcher an instant record of the key points of the interview. Note taking also assisted in ensuring that both data collection and analysis were on-going, cyclical, non-linear and interactive, which is a quality of qualitative research (Blaxter, Hughes & Tight, 2001: 173). All the interviews were audio recorded for subsequent and repetitive listening and evaluation. These were transcribed by the researcher before the final analysis, and analysed and discussed through content analysis using inductive and deductive approaches.

5.6.4 Classroom Observations

In qualitative research the techniques that are normally employed are observation, individual interviews and document analysis. Since this research follows the mixed method approach involving some qualitative strands, the researcher used all three techniques.

Observation is a systematic process of recording the behavioural patterns of respondents, objects and occurrence without necessarily communicating with them. It is an everyday activity whereby the senses of sight, hearing, touching, smelling and tasting, as well as intuition, are used to gather bits of data. Observation is used to describe the data that are collected, regardless of the technique employed in the study (Creswell, 2010: 83; McMillan & Schumacher, 2010: 208).

Observational research methods also refer to a more specific method of collecting information that is very different from interviews or questionnaires, relying on a researcher's seeing and hearing things and recording these observations, rather than relying on subjects' self-reported responses to questions or statements. Observation is a typical approach to data collection. In the observation the emphasis is thus both on one's own participation and the participation of others. Researchers observe both human activities and physical settings in which such activities take place (Denzin & Lincoln, 2000: 673; de Vos, 2002: 278).

Observation is used to describe the data that are collected, regardless of the technique used in the study. For this study the classroom observations formed a crucial component of the data collection because they enabled the researcher to witness the intricacies involved when using English as LoLT to teach mathematics in a natural setting (McMillan & Schumacher, 2010: 208).

There are four forms of observation that are used in qualitative research. The types of observation are classified according to the role assumed by the researcher in the observation. The researcher can be a complete observer, a participant, the respondent being an observer, or be a complete participant (Creswell, 2010: 83).

When the researcher is a complete observer, he or she is a non-participant observer who looks at a situation from a distance. This is the least obtrusive type of observation. When the researcher is a participant he or she gets involved in the situation without influencing the dynamics of the setting. When the respondent is an observer, a characteristic of action research projects, the observer becomes part of the research process. The researcher works with the respondents in the situation under observation and may intervene in the activity and even attempt to change it. When the researcher is a complete participant, he or she becomes totally immersed in the situation so that those involved do not even notice that they are being observed. This may sometimes raise grave ethical concerns when those being observed were not asked for their consent (Creswell, 2010).

In this study the researcher was a non-participant observer throughout the data collection process – from the administration of the tests to the classroom observations which were conducted at the schools of the sampled teachers. In order to explore the linguistic practices teachers engaged in while teaching IP mathematics, the researcher sat at the back of the classroom taking field notes describing the classroom activities using an observation guide (**Appendix G**).

The advantages of observation include the fact that the observer is actively engaged in activities at the research site, where there is first-hand involvement and immersion in a natural and social setting (Lewins & Silver, 2007: 10 – 11). During observation the researcher gains insight into the views of the respondents more readily, develops a relationship with them, and hears, sees and begins to experience reality as the respondents do. The researcher does not stand aside as an outsider. Observations give a comprehensive perspective on the problem under investigation. The researcher also learns from his or her own experience and reflections, which form part of the emerging analysis. Data are gathered directly and are not of a retrospective nature.

After the classroom observations, the researcher held short discussions with the teachers observed. The discussions were semi-structured and allowed the teachers to further explain any decisions and actions they had taken during the lesson. These discussions were conducted at the earliest convenient time after the lesson or at break time to avoid disturbing the teachers' schedule, as stipulated by the ECDoE's approval to collect data in schools. The researcher requested the respondents for permission to audio tape the discussions as it was not possible for her to capture all the discussions otherwise.

5.6.5 Documentary Analysis

Documents are printed or written records of past plans and events (McMillan & Schumacher, 2010: 452). In this study, documentary analysis focused on all types of written communication that may shed light on the factors affecting the choice of English as LoLT. Documentary analysis involved the analysis of documentary sources, which shed light on the Language in Education Policy (LiEP) and material relevant to a particular set of policy decisions in the South African LiEP, generally and specifically for the choice of LoLT in primary schools. These documents included sources such as policy documents, acts, the Constitution of South Africa, statutory instruments, language-in-education policy circulars, curriculum policies, and ANA Grade 6 public examination pass rate reports on the LoLT in mathematics, DBE/ECDoE bulletins and press releases on LoLT in Science, Technology, Engineering and Mathematics (STEM) education, newspaper articles on LoLT, evaluation reports on IP mathematics initial teacher education programmes offered in South African universities as well as in-service professional development courses on language competency for IP teachers offered by both public universities and private institutions.

The documents were analysed and integrated with the evidence obtained through the questionnaires, language proficiency and word problem assessment, error analysis interviews and classroom observations in order to enrich and support the information collected. These documents (official and unofficial) were analysed in order to gain further insight into the research and to improve the trustworthiness of this study. The purpose of analysing these specific documents was to establish an understanding of the teachers' and relevant stakeholders' practices with regards to DBE LiEP and the interpretation of them.

Document analysis is suitable for this study because it afforded the researcher an opportunity to view the documents, policies and teacher education programmes in relation to language competency in IP mathematics instruction. As such, the documentary analysis formed a subset of the literature study. Documents constitute a useful and valuable source of evidence (Henning, Van Rensberg & Smit, 2004: 99; McMillan & Schumacher, 2010: 360). In the following section, the secondary sources of data employed in the study are discussed.

5.6.6 Secondary Sources

Secondary sources are useful in that they shed light on, or complement, the primary data gathered. They are valuable for confirming, modifying or contradicting research findings. Furthermore, it is always good and appropriate to consider what has already been done for the purposes of building on it in the process of adding new knowledge. This was also meant to equip the researcher with theoretical perspectives and previous research findings related to the subject at hand. Secondary sources were also used to acquire insights and arguments as well as to help shape and consolidate the researcher's arguments.

The use of secondary sources involved a review of literature on the link between language and mathematics teaching and learning generally, and the use of English as a language of learning and teaching mathematics for English-language learners specifically. It also involved a review of literature on second-language learning and the theoretical frameworks of the study. In addition to this body of literature, the researcher reviewed literature on research design and methodology to identify the best research design and methodology of the study to address the research problem. Insights gained from secondary sources also proved useful in the deductive and inductive analysis of the data.

5.7 Phases of Data Collection

The data collection was conducted in five phases between January and December 2016. Teacher questionnaires were administered first, followed by the teacher educator questionnaires. Teacher needs assessments were administered followed by error analysis interviews, classroom observations and finally teacher educator interviews. The literature review was conducted throughout the duration of the study. Documentary analysis was incorporated into the literature review. Teacher questionnaires and needs assessments were conducted at Stellenbosch, while classroom observations were conducted at the sampled teachers' schools. The time frames for the phases of educator data collection in this study are shown in Table 5.7.

Table 5.7: Data collection timeframe

Phase		Date											
		Jan 2016	Feb 2016	Mar 2016	Apr 2016	May 2016	Jun 2016	Jul 2016	Aug 2016	Sep 2016	Oct 2016	Nov 2016	Dec 2016
Literature Review													
Teacher Educator	Questionnaire			9 Mar									
	Interviews												9 Dec
Teacher	Questionnaire	3 Jan											
	Language Proficiency Assessment							4 Jul					
	Mathematics Word Problem Assessment							13 Jul					
	Error Analysis Interview							14 Jul					
	Classroom Observation									12 – 16 Sep			

	S1	S2	S3	S4	S5
	12 September 2016	**13** September 2016	**14** September 2016	**15** September 2016	**16** September 2016

Key: S1 = School 1

Classroom observations were conducted for five days at all the schools where the sampled IP mathematics teachers are based. During this phase the researcher carried out observation with the aim of getting a clear picture of what approaches teachers used in the teaching of mathematics, how they interacted with the learners and also how the learners participated during mathematics teaching. The major aspect of the observation entailed active listening. The researcher sat at the back of the classroom taking field notes describing the classroom environment and the teachers' and learners' linguistic practices during the mathematics lesson using an observation guide. The researcher observed 3 mathematics lessons at each school: one class at the entry level (Grade 4), one class in the middle (Grade 5 or 6) and one class at the exit level (Grade 7) of IP.

Teacher educator questionnaires were administered at a National Symposium on Primary Literacy and Primary Mathematics Teacher Education hosted by the Department of Higher Education and Training (DHET)'s Teaching and Learning Development Capacity Improvement Programme (TLDCIP), in which the researcher was a participant. Collection of completed questionnaires and interview administration on the teacher educator respondents spanned the entire 12-month period determined by the availability of the sampled teacher educators.

To ensure confidentiality during the different phases of data collection and presentation schools, teachers, teacher educators and documents were coded as follows:

School = **S** Teacher = **T** Teacher Educator = **TE**

KEY: The **55** Teachers who participated in the study are coded as **T1** – **T55**

The **10** Teacher Educators who participated in the study are coded as **TE1** – **TE10**

The **5** Schools where classroom observations for the study were conducted are coded as **S1** – **S5**

5.7.1 Data Analysis

Data analysis is an interpretive task, involving the categorizing of findings. Since the purpose of the study is to explore the relationships between English language competency and IP mathematics instruction, the interpretive paradigm allows the researcher to explore and develop a deeper understanding of the respondents' perceptions, experiences and opinions in relation to the approaches teachers use to deal with language barriers in their classroom practice. The aim of data analysis is to reduce and synthesise information to make sense of it and allow inferences about the population, while the aim of interpretation is to combine the results of data analysis with the value statements, criteria and standards in order to produce conclusions, judgments and recommendations (Mertler & Charles, 2008: 153; White, 2005: 104). The quantitative and qualitative data sets of the study were analysed separately before they were merged.

5.7.1.1 Analysis of Quantitative Data

Quantitative data (questionnaires, English-language proficiency and Mathematics word problem assessments) were analysed by Stellenbosch University's Centre for Statistical Consultation (CSC), housed in the Department of Statistics and Actuarial Sciences. In addition to

Stellenbosch University CSC's analyses, data from the English Language Proficiency and Mathematics Word Problem Assessments were analysed by JET's Data Unit Statisticians.

The researcher captured the quantitative data using MS Excel and Stellenbosch University's CSC analysed the data using STATISTICA version 13 (Dell Inc. (2015). Dell STATISTICA (*data analysis software system*), version 13. software.dell.com.), while JET conducted descriptive analyses of the quantitative data. Patterns emerging from the two independent analyses of the quantitative data are presented, compared and discussed in detail in Chapter 6 of this study.

5.7.1.2 Analysis of Qualitative Data

Qualitative data analysis is an ongoing process through which a researcher tries to find out how respondents are making meaning regarding a specific phenomenon. The researcher analyses their feelings, attitudes, values, knowledge, understanding, perceptions and experiences in an endeavour to approximate their construction of the phenomenon (Creswell, 2010: 99; McMillan & Schumacher, 2010: 367).

The researcher, who was the sole transcriber of all the qualitative data, read the transcribed data and field notes several times in order to get the initial sense of the data. The reason for reading the data repeatedly was to vicariously enter into the lives of respondents, feel what they are experiencing and listen to what they are saying for the purposes of better understanding the information provided (Corbin & Strauss, 2007). The researcher analysed the data after every interview and classroom observation. This reduced the volume of raw information and assisted in sifting significant data from trivia and identifying significant patterns communicating the essence of what the data reveal (de Vos 2006: 333). This enabled the researcher to sift through the data and collect information deemed relevant for the study.

Finally, during data analysis summaries of each individual interview and classroom observation were written down, incorporating the themes that had been elicited from the data. The themes were coded using open and axial coding. The qualitative data (Error Analysis Interviews and Classroom Observations) were analysed by the researcher and are presented in Chapter 7 of this study.

5.8 Trustworthiness

The researcher employed the following strategies to ensure the trustworthiness of the data used in this study: member checking, triangulation and peer debriefing.

- **Member checking**

After the collection of data, the data were transcribed, arranged into cases and analysed. The researcher went back to the respondents with the cases in order to verify that the researcher had captured them well. The cases that were found to contain inaccuracies or misunderstandings were rectified.

- **Triangulation**

The instruments of data collection were tested on fellow teacher educators and educators involved in other research projects at AIMSSEC before the actual data collection processes. In order to validate the data collected, one of the methods used was triangulation. Triangulation is defined as the use of more than one data-collection method (White, 2005: 89).

- **Peer debriefing**

The researcher shared the data with a colleague who is a seasoned educational research fellow at AIMSSEC and received feedback which helped to clarify information. As mentioned earlier, the data were presented and critiqued at different local, regional and international literacy and mathematics education conferences in South Africa, Senegal and Germany. In addition, findings from the study were developed into two book chapters and a journal paper. For more information on the peer-reviewed publications and presentations emanating from this study, see page ix.

The next section, the ethical considerations, provides a brief review of the data collection and analysis process and discusses the validity of the study.

5.9 Ethical Considerations

The word “ethics” is derived from the Greek word “ethos”, meaning one’s character. It is related to the term “morality”. A moral issue is concerned with whether behaviour is right or wrong, whereas an ethical issue is concerned with whether the behaviour conforms to a set of principles (Bless 2006: 139).

Before the process of data-collection commenced, the respondents in the research have the right to be informed that they are being researched and about the nature of the research (Punch, 1994). The researcher respected the rights of all respondents in this study by seeking permission from the authorities concerned and informing the respondents of what the research entailed. Permission to gain access to the school respondents was sought in writing from the ECDoE (**Appendix K**) and from the principals heading the schools where the sampled respondents were based. Furthermore, consent forms were sent to participating IP mathematics teacher educators in the various South African universities requesting their participation in the study without coercion or intimidation. In addition, the purpose and focus areas of this research were clearly explained to all the respondents verbally before the signing of the consent forms.

There were no letters to seek consent from parents because all respondents (teachers and teacher educators) were adults (over 18 years of age) and capable of making informed decisions. In South Africa the legal age of majority is 18 years and by the time teachers complete their initial teacher education or any form of tertiary education, they would have attained the legal age of majority.

Ethical issues are integral to the research process and therefore need to be carefully considered before the research process is finalised (Cresswell, 2010; Bless, 2006). An essential ethical aspect is the issue of the confidentiality of the results and findings of the study, and the protection of the identities of the respondents. Creswell (2010: 42) further mentions that obtaining letters of consent, obtaining permission to be interviewed and undertaking to destroy audiotapes should be included in the ethical principles. The ethical issues observed in this study are outlined below.

5.9.1 Permission to conduct research

To conduct research in the ECDoE schools was sought from the provincial Director of Strategic Planning Policy Research and Secretariat Services, the school principals and the sampled IP teachers to carry out the proposed investigation. The researcher also submitted the project outline to the heads of institutions where the research was conducted so as to avoid deception and betrayal, and to ensure anonymity, confidentiality and honesty about the purpose of the study and the conditions of the research. The questionnaires, language proficiency and mathematics word problem assessment, and the error analysis interviews were conducted in Stellenbosch, while the respondents were attending contact sessions for their profession development courses. The classroom observations were conducted at the sampled teachers' schools in Eastern Cape Province. The following section describes how the researcher acquired permission to conduct research in the ECDoE schools.

5.9.2 Permission to access ECDoE Schools

The researcher telephoned the principals of all the sampled schools and scheduled appointments with them. The telephonic conversations were followed up by emails to confirm the agreed appointment dates for the purpose of the classroom observations.

Upon arrival at the school, the researcher explained the purpose of the visit, before requesting the principals to sign a letter requesting permission to conduct research at their schools with the approval of Stellenbosch University's Research Ethics Committee and the ECDoE. The researcher requested a meeting with the sampled IP mathematics teachers at the school and further explained the role of the teacher in the study. The researcher also handed the teachers a consent form (**Appendix J**) requesting to observe their IP mathematics classes in session.

The researcher thanked the principals and the sampled teachers for agreeing to participate in the study and assured them that their identities and that of the schools will be protected and that all the data gathered from the school will be kept confidential and destroyed after the completion of the study. The following section describes how the researcher gained informed consent from the respondents.

5.9.2.1 Informed Consent

Respondents were informed about the purpose of the research, the classroom observation process and the transcriptions, and were assured of confidentiality. The researcher explained to the respondents they were not going to be remunerated for participating in the study and that they had the right to decline participation at any stage of the data collection and, if they chose to do so, they were not going to face any penalties. Bless (2002: 143) asserts that the researcher should explain to respondents what the study entails and what is required of them in terms of participation. Each participant was asked to sign an informed consent form, which is an indication that they indeed understood what had been explained to them. The researcher invited respondents to seek clarity by asking questions pertaining to the study and their participation.

Confidentiality entails protecting the privacy (identities, names and specific roles) of the respondents and holding in confidence what they share (Rossman and Rallis, 2003). Bulmer (1982) notes that, to protect privacy and the identity of the research respondents, locations of individuals and places are concealed in published results, data collected are held in anonymous form, and all data are kept securely and confidentially. To ensure that the data collected was of high quality, it was crucial for the researcher to protect the respondents' identities and assure the respondents of confidentiality. Apart from protecting their identities, the researcher also ensured that the information they provided remained confidential. A tape recorder was used during data collection. The use of the audio recorder was negotiated with the respondents and they had to agree voluntarily. The section below details how confidentiality as well as anonymity of data and respondents was maintained in this study.

- **Confidentiality**: To promote confidentiality, information provided by the respondents, particularly personal information, was protected and not made available to third parties. Respondents were allocated codes to protect their identities and to ensure confidentiality. The researcher reassured the respondents that their real names would be revealed and all data gathered would be kept confidential and anonymous.
- **Data anonymity:** The data collected from the respondents was kept under secure conditions at all times, saved on a computer locked with a secret password and only accessible to the researcher. The transcribed raw data did not contain the names of

respondents, the learners, or the school names. Alpha-numeric codes were used for labelling the data.

- **Participant Anonymity**: Creswell (2010) notes that a participant's data must not be associated with his or her name or any identifier; rather, the researcher may assign a number or alpha symbol to a participant's data to ensure that the data remain anonymous.
- **Discontinuance**: To accommodate discontinuance, respondents were given every assurance that they were free to discontinue their participation at any time without being required to give an explanation (Creswell, 2010).
- **Appointments**: The researcher first telephoned, then emailed the letters to the principals of each selected school, and telephoned again to ascertain that the letters had been received. Through the telephonic conversations, the researcher, the school principals and the sampled teachers arranged appointments to conduct classroom observations.
- **Research Ethics ECDoE**: Boundaries for data collection are influenced by the general research methods pertaining to the study and the proposed research questions. The specific parameters for data collection in this study include the choice of the province and the selection of the respondents. In this study the researcher telephoned the ECDoE Provincial Head Office, located at Steve Vukile Tshwete Complex in Bisho, King Williams Town, requesting permission to conduct research in schools whose mathematics teachers had been recommended by the district officials to attend AIMSSEC teacher professional development courses. The researcher was requested to complete an application for conducting research in the ECDoE. An approval letter to conduct research within the ECDoE is attached as **Appendix K**.
- **Scientific Ethics Stellenbosch University**: Mouton (2001) refers to unethical behaviour referred to as scientific misconduct, which includes research fraud and plagiarism; fraud occurs when a researcher falsifies the data or the methods of data collection, and also includes significant departures from the generally accepted practices of the scientific community for conducting or reporting research (Mouton, 2001). Research institutes and universities have policies and procedures to detect misconduct, to report to the scientific community and to penalise the researcher who engages in it. Throughout this study the researcher was continually under the supervision of the study supervisor and abided by the rules and regulations of Stellenbosch University as stipulated by the University's Ethics Research Committee. An approval letter to conduct the study from Stellenbosch University's Research Ethics Committee is attached as **Appendix L**.

Permission and the confidentiality of respondents' names and information gathered in the process of data collection were therefore guaranteed. Confidentiality of information gathered in the school was also assured, respecting the wishes of the sampled respondents, who had voluntarily given the information about themselves, their schools and the way they conduct their IP mathematics classes.

5.9.3 Validity, Reliability and Generalisations

To permit analysis and reporting, data that were collected were transformed from their original raw state into a form of representation that is suitable for manipulation and producing analytical insights. Therefore results from the quantitative data, i.e. language proficiency assessments, mathematics word problems and questionnaires, were itemised and recorded 'question by question' on an Excel spreadsheet. The lesson observations and interviews conducted in this study were recorded and transcribed. The representation of all the data was recorded in a manner that ensures validity and reliability.

5.9.4 Validity

Validity, according to Hitchcock and Hughes (1989) and Maxwell (1992), refers to the degree to which the findings described by the researcher are the real representation of the data collected. Lupton (1992) suggests several ways of validating one's assertions.

These include the inclusion of actual data in a report or paper, which provides the opportunity for others to assess the researcher's interpretation and follow the reasoning process, which should have been explained thoroughly. Replicating the methods of researchers ensures validity (Redwood, 1999; Roberts & Sarangi, 2005). Furthermore, the researchers emphasise on analysis that is sound, well-grounded on principles or evidence, able to withstand criticism or objection, effective, effectual, cogent.

Warranting claims must fulfil the criteria of trustworthiness, soundness, coherence, plausibility and fruitfulness (Nixon & Power, 2007). Trustworthiness seeks to achieve procedures that are simultaneously open-ended and rigorous, and do justice to the complexity of the social setting under study (Janesick, 2000). Trustworthiness deals with how one persuades the audience that the findings of an inquiry are worth paying attention to (Lincoln & Guba, 1985). This includes elements such as credibility and replicability; a feature of the current research that is supported by validity and reliability.

5.9.5 Credibility

Five processes that ensure credibility of a study include activities that increase the likelihood of producing credible findings and interpretations; provide an external check on the inquiry process; enable checking of preliminary findings and interpretations against archived raw data and provide for a direct test of the finding and interpretations with the human sources from which they have come (Lincoln & Guba, 1985).

Throughout the study peer consultations were held with colleagues. Issues such as the sample identification and size, methodology, methods, the conceptual framing of the study were discussed in order to enhance credibility through pooled judgement.

Another activity undertaken to ensure credibility was collecting data from a range of sources. Carson, Gilmore, Perry and Gronhaug (2001), and Erlandson, Harris, Skipper and Allen (1993) argue that such an approach helps to test the reliability and credibility of the findings through cross-referencing of accounts. In this study mathematics teacher educators from public South African Universities with different cultural backgrounds (including both the formerly white and the historically disadvantaged institutions) were involved. These universities cut across the spectrum of the three types of universities in South Africa, namely traditional universities, which offer theoretically-oriented university degrees; universities of technology, which offer vocational oriented diplomas and degrees; and comprehensive universities, which offer a combination of both types of qualification (Department of Higher Education and Training (DHET), (2014). However, because participants were based in the ECDoE, the population group and cultural background of the participant teachers did not vary much.

The study provided a clear and defensible link for each step of the research from the raw data to the reported findings. Through the analysis of the data, the information is coherently presented and interpreted in the light of the empirical information in the study (Merriam, 1998). The study also presents a detailed description of how data were collected and analysed.

5.9.6 Limitations and Generalisability

This study is interested in investigating the relationships between language competence and IP mathematics instruction in the Eastern Cape Province of South Africa, as exhibited by teachers attending CPTD courses at AIMSSEC. The study is based on a mixed methods approach, incorporating questionnaires, language competency tests, mathematics word problems, interviews and classroom observations all administered and conducted by the researcher. Possible limitations of this research are indicated and acknowledged below.

Coordinating a mixed methods study produced voluminous amounts of data and selecting the data contributing to the answering of the research questions was a huge task to be undertaken by one person. Although the quantitative data collected were analysed by Stellenbosch University's Centre for Statistical Consultation (CSC) led by Professor Dan Nel, a team of researchers would have done greater justice to the study.

Participants for the study were 55 IP mathematics teachers based in the ECDoE and 10 Teacher Educators from different universities in South Africa. The study focused on only one province in the country, the Eastern Cape, yet there are other similar poorly performing provinces in the country, such as Limpopo and KwaZulu-Natal. Thus the study focused on one province of one country, yet ELLs make up a greater population of the Sub-Saharan region in Africa and other developing countries worldwide. Although this may raise questions of validity as well as reliability, the study can act as a guide for investigating other elements or aspects pertaining to the relationship between primary school teacher language competence in the prescribed LoLT and mathematics instruction.

There were also other unforeseen circumstances, such as the financial constraints which meant that the researcher could not conduct classroom observations in Mount Frere District, the poorest performing district in South Africa (DBE, 2015) and had to settle for the neighbouring Qumbu and Mthatha Districts instead. Nonetheless, the change of schools for one classroom observation during data collection did not in any way impair the central line of argument in this study.

5.10 Conclusion

This chapter outlined the research design and methodology and explained the research approach, the design, the data-collection techniques as well as the research process of this study. For a detailed description of the sample, participants' demographic information was also presented in this chapter. The chapter outlined how ethical considerations were observed and briefly explained how the collected data will be analysed in the next two chapters.

The methods used are conceptually informed by five frameworks: the theshold hypothesis, a framework for interpreting language factors in mathematics learning, the socio-psycho-linguistic model, error analysis on written mathematical tasks, and pedagogical translanguaging; the mixed methods approach was adopted to answer the research questions. Since the procedure was both quantitative and qualitative in nature, the methods of data collection were consistent with the dictates of both quantitative and qualitative research, combining the strengths of both. Issues pertaining to the reliability and validity of this research as well as ethical considerations that guided the research process were also discussed, including the limitations and generalisability of this research.

The next two chapters will provide a description of the data analysis employed in this study and the presentation, analyses and discussion of the data. Since the collection of quantitative data preceded that of qualitative data, the presentation of the data also follows the same sequence: Chapter 6 details the quantitative data analyses, while Chapter 7 details the qualitative data analyses.

CHAPTER 6

QUANTITATIVE DATA PRESENTATION, ANALYSIS AND DISCUSSION

6.1 Introduction

The congruent parallel mixed method research design was used to achieve the aims and objectives of the study; thus, both quantitative and qualitative data were collected and analysed independently and then merged for interpretation. As mentioned in Chapter 5, this chapter focuses on quantitative data presentation, analysis and discussion. Quantitative data analysis was both statistical and descriptive. The first part of this chapter provides the statistical presentation, analysis and discussion of data gathered through teacher and teacher educator questionnaires, as well as the teacher English-language proficiency and mathematics word problem assessments. The chapter concludes with a descriptive presentation, analyses and discussion of teacher assessments, and merges data from the different analyses of quantitative data used in the study.

6.2 Quantitative Data Analysis

The researcher captured the quantitative data using MS Excel and the Centre for Statistical Consultation (CSC) Stellenbosch University analysed the data using STATISTICA version 13 (Dell Inc. (2015).

Summary statistics were used to describe the variables. Distributions of variables were presented with histograms and-or frequency tables. Medians or means were used as the measures of central location for ordinal and continuous responses and standard deviations, and quartiles as indicators of spread.

Relationships between two continuous variables were analysed with regression analysis and the strength of the relationship measured with Pearson correlation or Spearman correlation, if the continuous variables were not normally distributed. If one continuous response variable was related to several other continuous input variables, multiple regression analysis was used and the strength of the relationship measured with multiple correlation.

The relationships between continuous response variables and nominal input variables were analysed using appropriate analysis of variance (ANOVA) and appropriate repeated measures analysis of variance (RMANOVA) when responses were repeated on the same respondent. To account for possible confounding variables, these variables were included as covariates in appropriate analysis of covariance (ANACOVA).

When ordinal response variables were compared versus a nominal input variable, non-parametric ANOVA methods were used. For completely randomized designs the Mann-Whitney test or the Kruskal-Wallis test was used and for repeated measures designs the Wilcoxon or Friedman tests were used. The relation between nominal variables was investigated with contingency tables and appropriate chi-square tests such as the likelihood ratio chi-square test or the McNemar test. A p-value of $p < 0.05$ represented statistical significance in hypothesis testing and 95% confidence intervals were used to describe the estimation of unknown parameters.

6.3 Quantitative Data Presentation

The following sections present the quantitative data collected in this study. Since the collection of quantitative data through questionnaires preceded that of teacher English-language proficiency and mathematics word problem assessments, the presentation of the data also follows the same sequence.

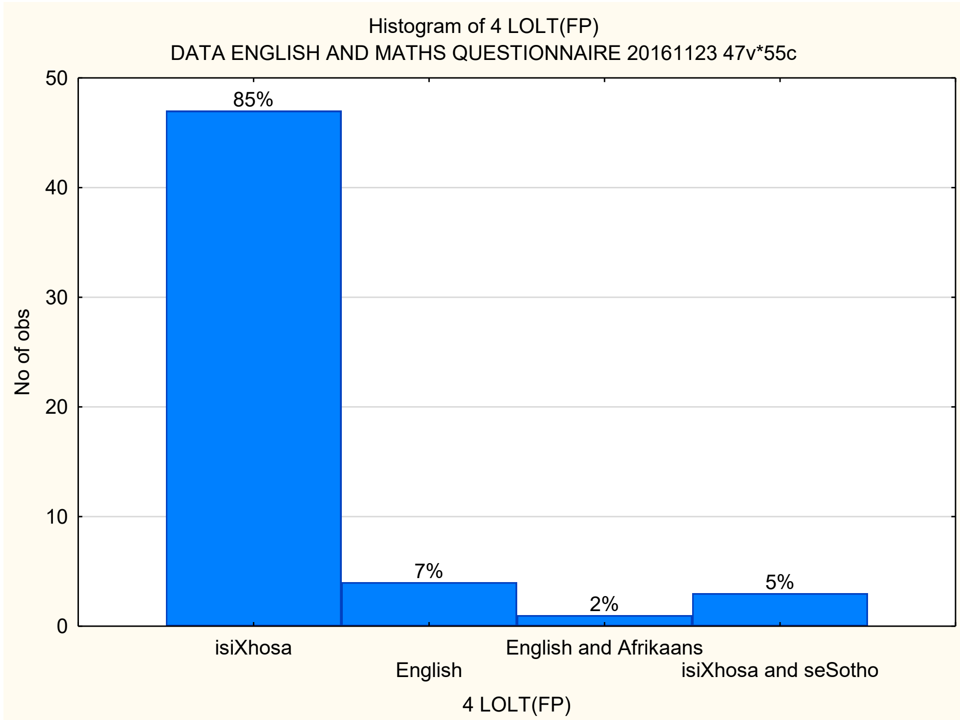
6.3.1 Questionnaires

The first quantitative data-collection technique to be administered was the questionnaire. The questionnaire sought to determine the context and current practices used by both teachers and teacher educators to deal with linguistic barriers in the classroom. There were two different questionnaires administered in this study, one for the teachers and the other for the teacher educators. The section below presents analyses and discusses data gathered through the teacher questionnaires.

6.3.1.1 Questionnaires: Teachers

To establish baselines of what languages were used as the language of learning and teaching (LoLT) in the respondents' schools, it was necessary to provide information on the official LoLT at the schools' Foundation Phase (FP) level. The information provided is illustrated in Figure 6.1.

Figure 6.1: Histogram of official LoLT at FP level

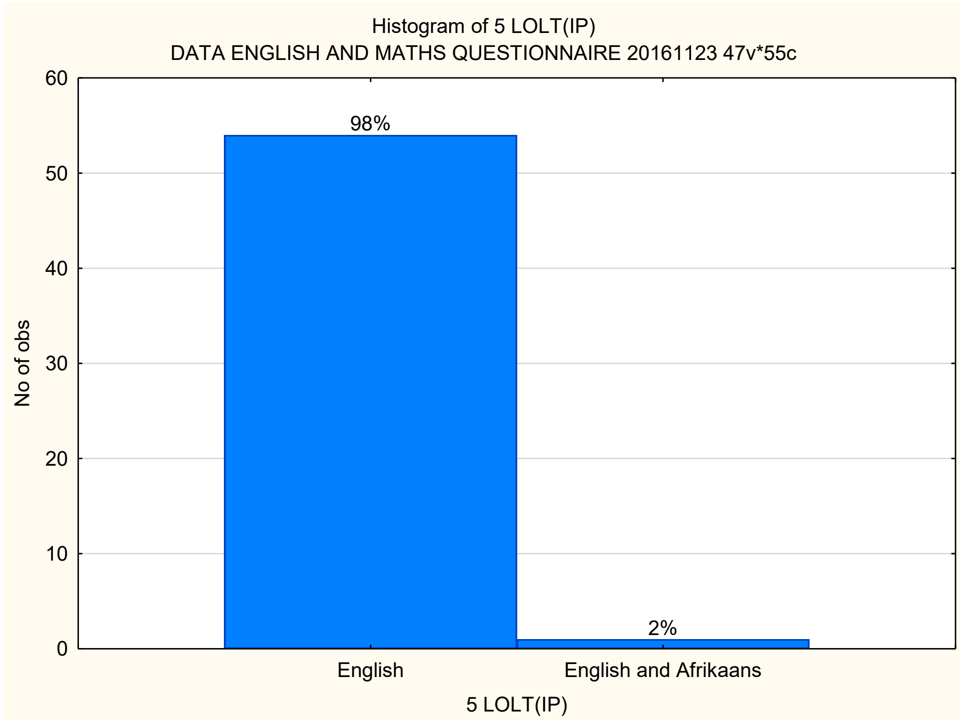


The majority of the teachers (85%) indicated that the LoLT for the FP is isiXhosa, 7% indicated English; 2% indicated the use of both English and Afrikaans, while 5% indicated the use of both isiXhosa and seSotho. The results are consistent with the current South African Language in Education Policy (LiEP), which stipulates that the mother tongue should be the language of instruction at FP level, and since the participants are from the Eastern Cape, a predominantly Xhosa-speaking province, there is no deviation from the norm. For the participants who indicated the use of two languages of instruction in the FP, the implication is that the schools have adopted a dual medium of instruction; thus, if the two languages are equally predominant in the communities around the schools, the SGB committee which is mandated with the choice of language of instruction may choose the use of the two languages to accommodate learners from the different households.

In addition, the participants who indicated the use of English as the language of instruction imply that their SGBs have adopted this for the immersion programme where learners begin their formal schooling in English without having to switch to English at the IP level, and continue right through the ordinary school education system using English as the language of instruction.

Having established the LoLT at FP level, it was thus necessary to establish the LoLT at the Intermediate Phase (IP) level; the results obtained from the participants are illustrated in Figure 6.2.

Figure 6.2: Histogram of official LoLT at IP level

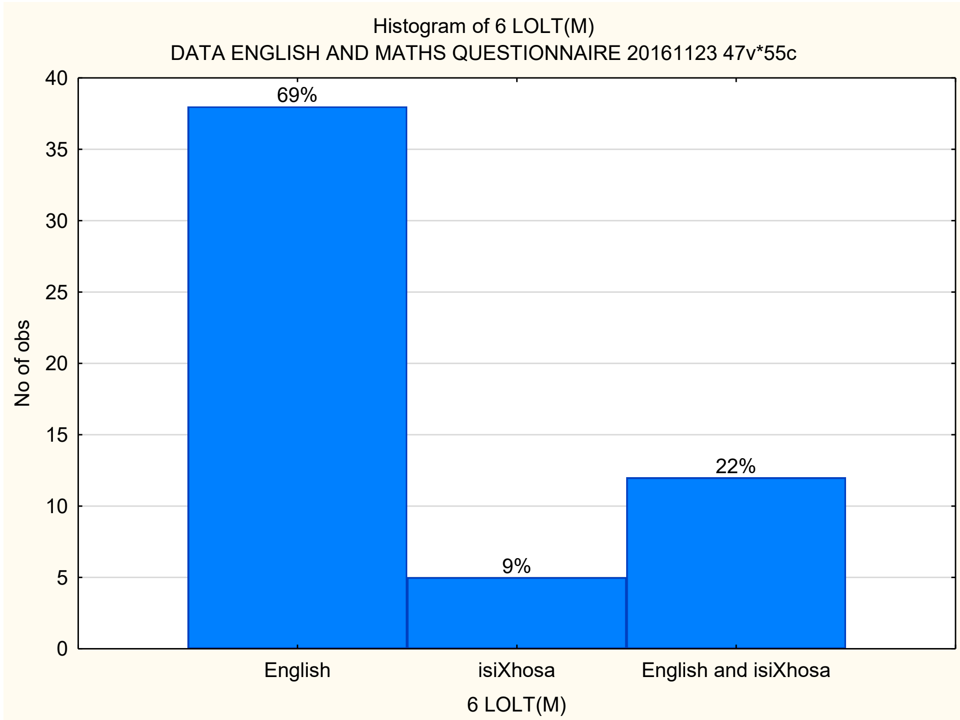


The majority of the teachers (98%) indicated that the language of instruction at the IP level is English. Again, this is in line with LiEP policy as stated above. What is of interest here is that all the participants who indicated that their schools used an African language as the LoLT at FP then switch to English at IP level. Thus, these schools now fall within the same category as those that chose the immersion option of commencing the FP level in English.

It worth noting that the schools that chose the dual medium of instruction that uses both English and Afrikaans from the FP (2%) continue with the same mode even at IP, recorded as 2%.

Having established the language of instruction used at IP level, it was necessary to establish how often the participants used the prescribed language of instruction; results obtained are illustrated in Figure 6.3.

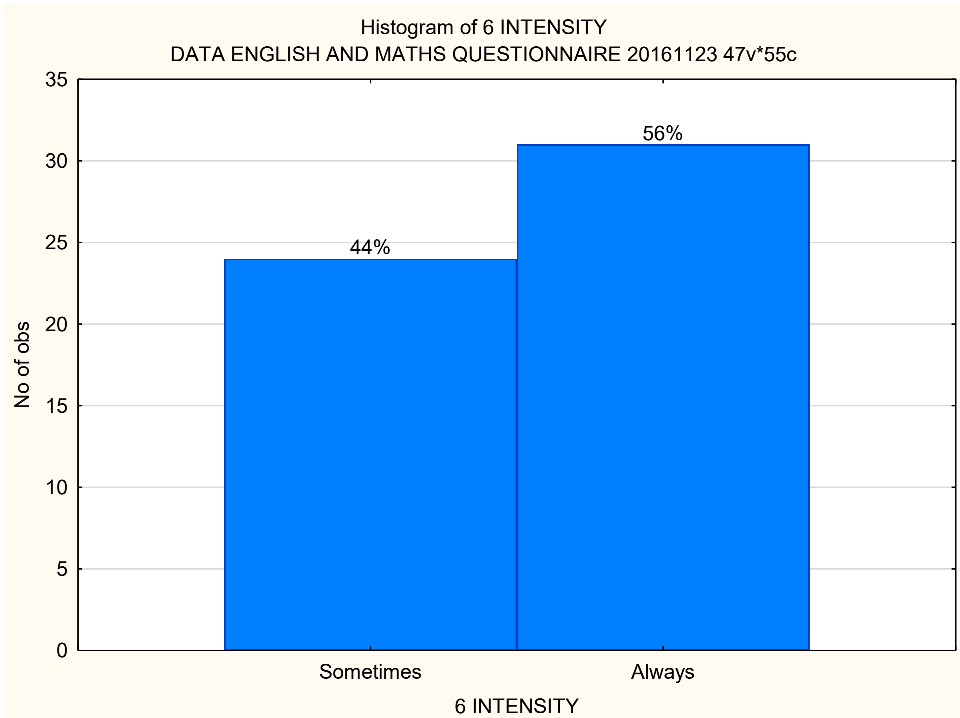
Figure 6.3: Histogram of languages frequently used as LoLT



As illustrated in Figure 6.3, 69% of the teachers indicated that they always use English, 9% indicated that they always use isiXhosa, and 22% indicated that they always use both English and isiXhosa in IP mathematics lessons.

Regarding the intensity of the use of the English language, teachers were requested to rate their use of the language according to the following scales: always, sometimes, never; results are illustrated in Figure 6.4.

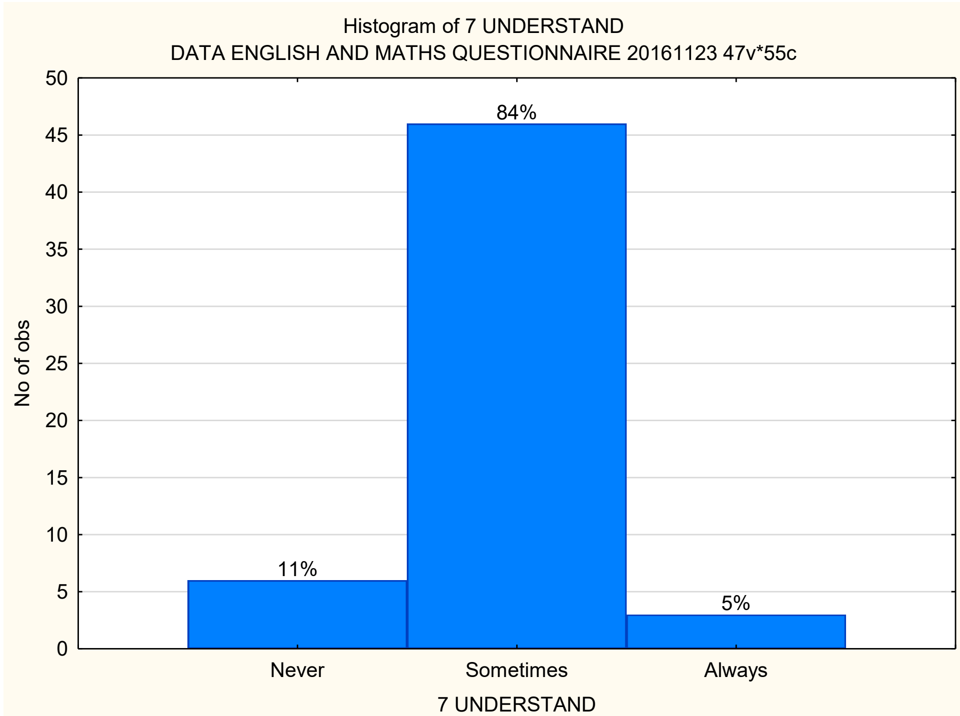
Figure 6.4: Histogram of intensity of using English in IP mathematics classrooms



Of the teachers who indicated that they always use English as the language of instruction in their IP mathematics lessons, 56% rated their use as 'always', while 44% rated their use as 'sometimes'.

Teachers were also required to rate whether their learners understood the language they used as a medium of instruction according to the scales: always, sometimes, never; the results are indicated in Figure 6.5.

Figure 6.5: Histogram of level of understanding when English is exclusively used as LoLT



In the classrooms where English is always used as the medium of instruction, 11% of the teachers indicated that the learners never understand the mathematics concepts, 84% of the teachers indicated that the learners sometimes understand the concepts, while only 5% of the teachers indicated that the learners always understand the concepts.

The open-ended part of the question allowed teachers to provide reasons for their choices and the following reasons were cited as factors affecting the learners' ability to understanding concepts when English is always used in IP mathematics classrooms as indicated in Table 6.1.

Table 6.1: Frequency table on factors affecting learners' understanding when English is used as LoLT

	Frequency table: 7 UNDERSTAND # (DATA ENGLISH AND MATHS			
Category	Count	Cumulative Count	Percent	Cumulative Percent
Express themselves	23	23	43.39623	43.3962
Code switching	4	27	7.54717	50.9434
Change from FP to IP	14	41	26.41509	77.3585
Difficult to understand abstract	2	43	3.77358	81.1321
Learners prefer to use their home language	1	44	1.88679	83.0189
Learners obtain better marks when using isiXhosa in tests	1	45	1.88679	84.9057
Using simple language helps the learners to understand	1	46	1.88679	86.7925
Learners are responding well to being taught in English	1	47	1.88679	88.6792
Abiding by policy stipulations	4	51	7.54717	96.2264
Active participation from learners	1	52	1.88679	98.1132
School language policy stipulates the use of English throughout the curriculum in all grades	1	53	1.88679	100.0000

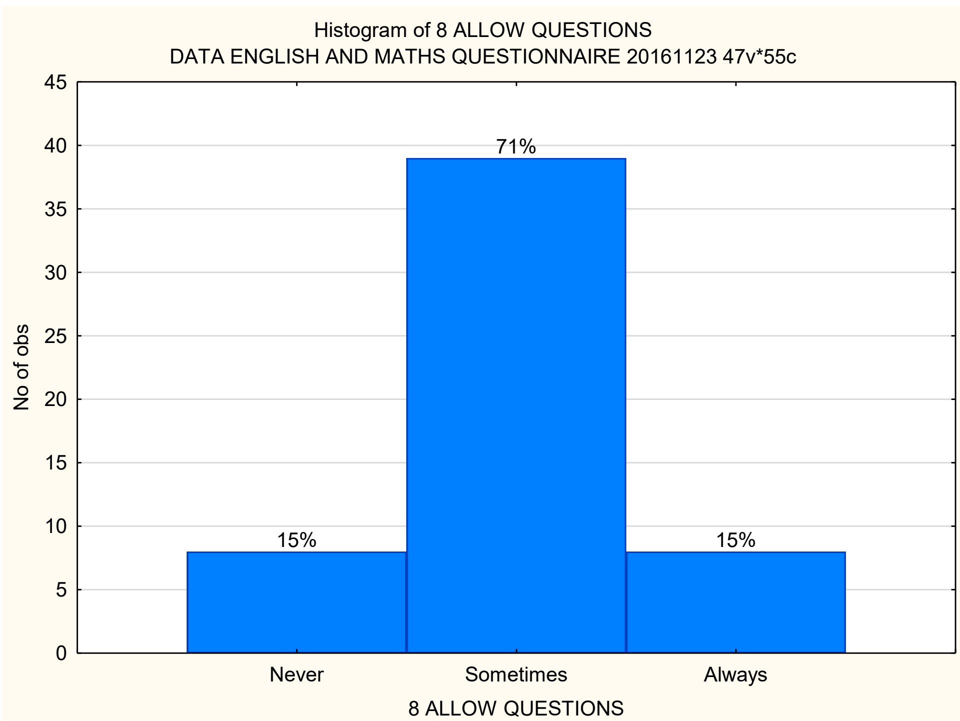
The majority (43%) of the teachers stated that learners struggle to express themselves in English; 26% stated that the learners grapple with the change of language of instruction from FP to the IP; 7% stated that learners have difficulty in coping with code switching; another 7%

stated that the teachers have to stick to using English in abiding by the schools' LiEP policies and 4% cited that learners find it difficult to understand abstract mathematical terms explained only in English. Other reasons cited by the minority of the teachers include the fact that "learners are responding well to being taught in English" from the respondent whose school uses English as the language of instruction from FP to IP level.

For an in-depth enquiry into the teachers' current practices in dealing with language barriers in mathematics classrooms, it was crucial to establish what the teachers usually do to accommodate the learners who never understood and those who sometimes understood the concepts. Teachers were thus required to rate how often they allowed their learners to ask or respond to questions using their home language during mathematics lessons; they also had to provide explanations on what they usually did when they realised that learners did not understand the language used in mathematics lessons.

Results from the question on how often the teachers allowed learners to ask and respond to questions using their home language are indicated in Figure 6.6.

Figure 6.6: Histogram of frequency of questions in home language during IP mathematics instruction

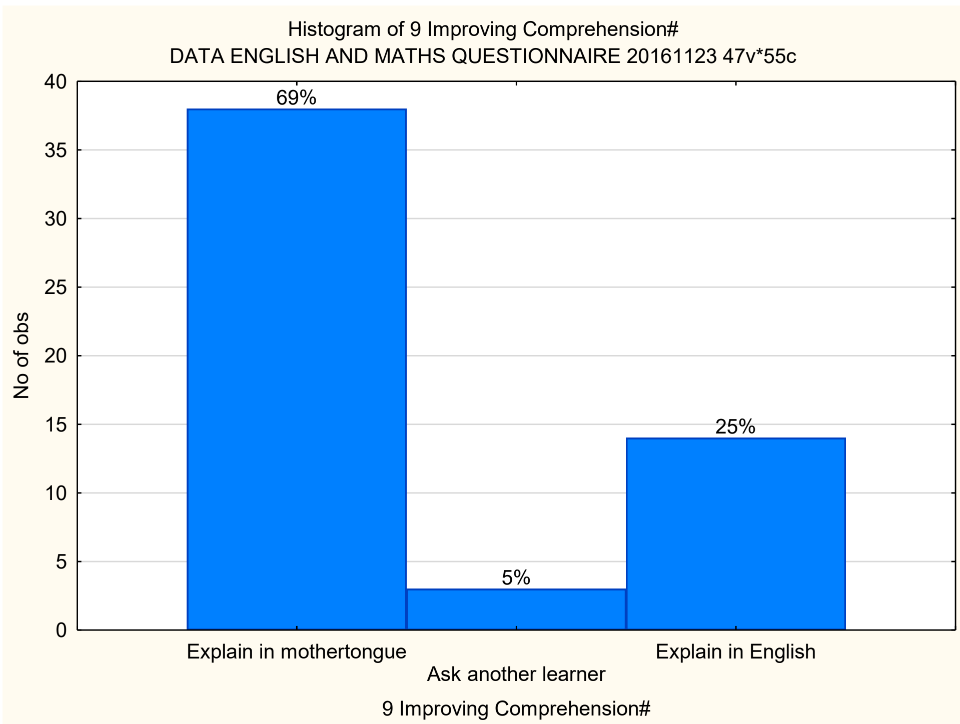


Using the codes (never, sometimes, always), 15% of the teachers indicated that they never allowed learners to use their home language to ask or respond to questions; 71% of the teachers indicated that they sometimes allowed their learners to ask or respond to questions in their mother tongue, while 15% of the teachers indicated that they always allowed learners to ask or respond to questions in their mother tongue during mathematics lessons.

What is of interest from these results is that fact that the majority (86%) of the teachers who chose the 'always' and 'sometimes' options, actually conform to the practices of code switching and pedagogical translanguaging, which are detailed in Chapters 2 and 3 of this study.

Results obtained from the question on what the teachers did to improve comprehension among learners on realising that the learners did not understand the language of instruction used in the mathematics classroom are indicated in Figure 6.7.

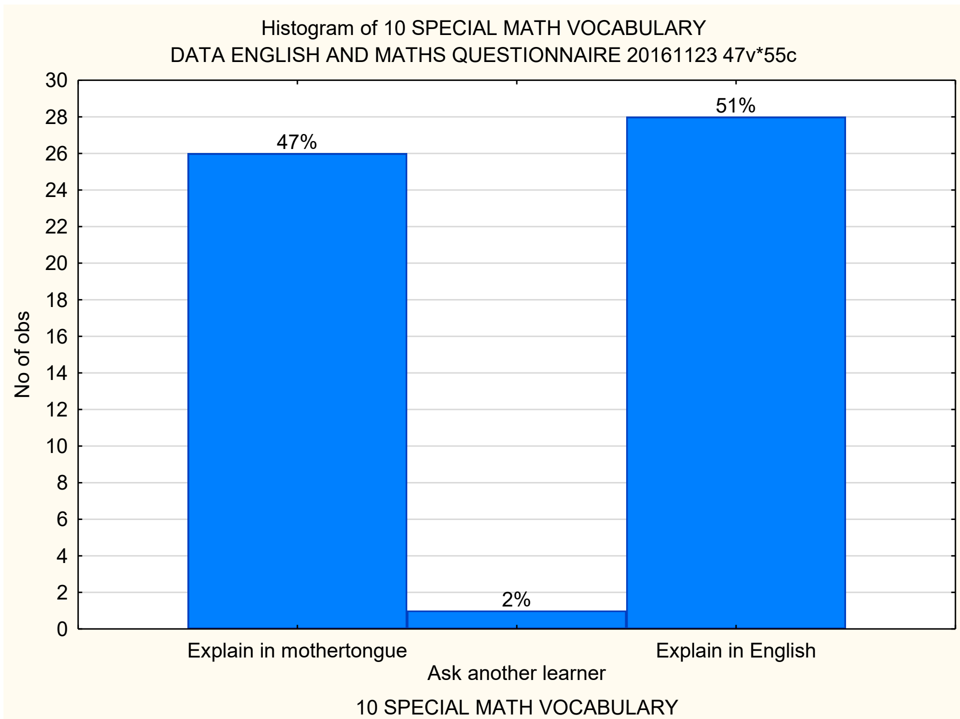
Figure 6.7: Histogram of strategies used to improve comprehension



For guidance in answering this question, the questionnaire provided teachers with three options to choose from: explain differently in English, explain in the learners' mother tongue, and ask another learner to explain. The second part of the question was open-ended and it allowed teachers to provide explanations on any other actions they engaged in to enhance comprehension among learners. As indicated in Figure 6.7, 69% of the teachers indicated that they explained the concepts in the mother tongue; 5% indicated that they asked another learner to explain to the rest of the class; and 25% indicated that they explained the concept differently in English. These results are further confirmation of teachers engaging in code switching and translanguaging in IP mathematics classrooms. The added dimension to the practice is engaging a learner to do the code switching and translanguaging to fellow learners in order to improve on comprehension.

To provide supporting evidence on teachers' current practices when dealing with linguistic barriers in mathematics classrooms, teachers were also requested to rate how they often teach specialised mathematical vocabulary (mathematics register, as detailed in Chapter 3 of this study) using the codes: explaining differently in English, explaining in mother tongue, and asking another learner to explain. Just as in the previous question, there were provisions to indicate other ways of explaining mathematical register in the open-ended section of the question. The participants' responses are indicated in Figure 6.8.

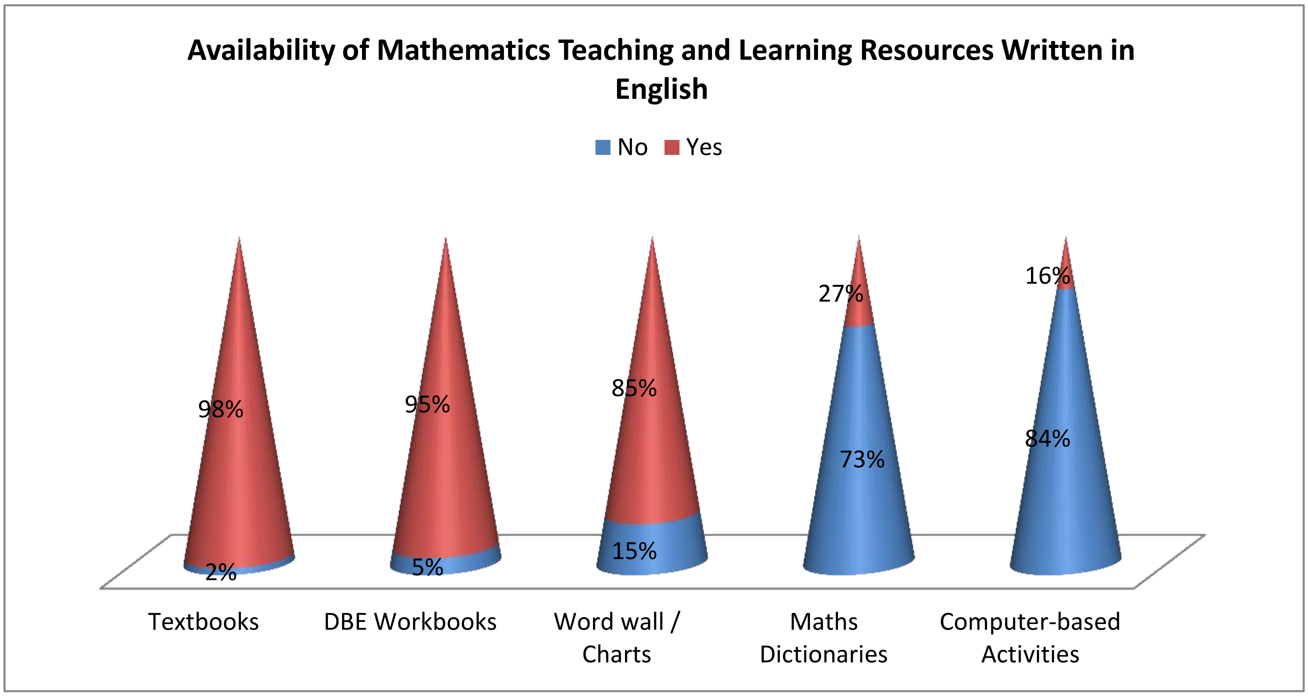
Figure 6.8: Histogram of strategies used in teaching specialised mathematical vocabulary



As illustrated in Figure 6.8, 47% of the teachers explain the mathematics register in the mother tongue; 2% of the teachers ask another learner to explain, and 51% of the teachers explain in English. These results indicate that the percentage of teachers who rely on English to explain specialised mathematics vocabulary is relatively high compared to the percentage of teachers who resort to English to explain general concepts. The percentage of teachers who explain specialised mathematical vocabulary in the mother tongue is relatively lower than the percentage of those who explain general concepts in the mother tongue. These results could be attributed to the fact that the home language referred in this case, isiXhosa, has yet to be developed sufficiently to support the teaching and learning of mathematical concepts. These results echo Kasule and Mapolelo (2013), who denote the inadequacy of local languages to convey mathematical thought.

To establish the availability of mathematics teaching and learning resources written in English at the participants' schools, they were requested to indicate availability based on the following selections: workbooks provided by the Department of Basic Education (DBE), textbooks, mathematics dictionaries, computer-based activities and word walls/charts. The responses on the availability of teaching and learning material are indicated in Figure 6.9.

Figure 6.9: Availability of teaching and learning resources written in English



The majority of the teachers indicated that they had textbooks (98%), DBE workbooks (95%), as well as word walls/charts (85%), with only very few indicating that they did not have access to them. However, the majority of the teachers indicated that they did not have mathematics dictionaries (73%) or access to computer-based activities (84%) that they could use in their IP mathematics lessons.

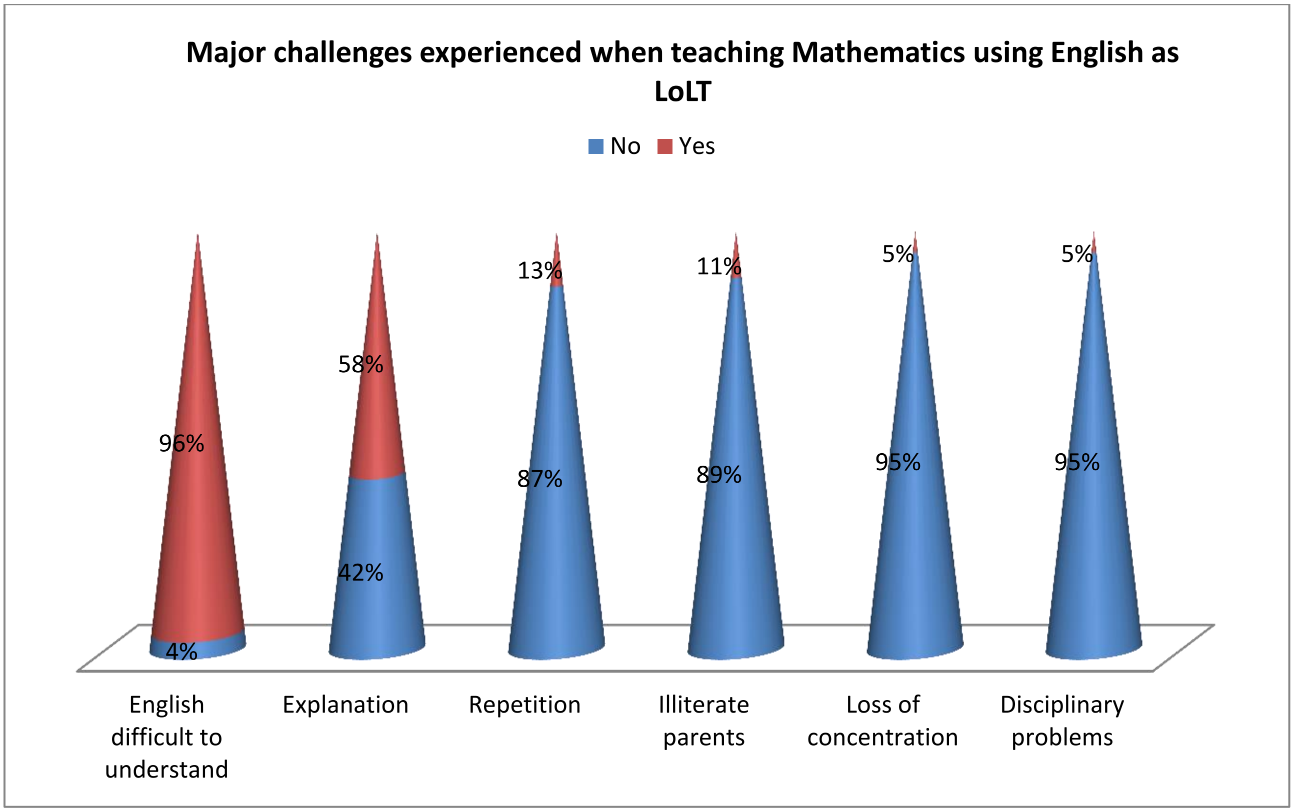
The fact that the percentage of participants without charts and word walls is as high as 15% is disturbing considering the fact that sample charts are usually donated to schools by stationery suppliers as a strategy to market their brands when teachers attend professional development courses. In the event that these are not available, the teachers can make their own charts for the different topics taught, and these charts may be used year in and year out when teaching different classes. In addition, readily available charts can be made by the learners (in groups or as individuals) and laminated to ensure durability of the charts. In this case, the learners' involvement in the making of charts helps them to understand the concepts better and to engage with the content learnt outside of the teaching time. Asking learners to make the charts provides additional benefits such as lightening the load of the teacher and boosting the learners' confidence. Learners enjoy having their work celebrated and IP teachers can mitigate the unavailability of charts by delegating the task to the learners.

Unavailability of computer-based mathematics activities written in English is not surprising, based on the fact that the sample is typically rural and under-resourced schools grappling sometimes to acquire basic needs such as running water and electricity. However, the unavailability of mathematics dictionaries is a serious cause for concern, especially if the school has other textbooks. This may mean that when schools place textbook orders with the DBE, they need to start including mathematics dictionaries in their orders so that these become available when learners need to find the meanings of abstract mathematical terms. In consideration of the fact that there are various multilingual dictionaries available on the market, it would be advisable to have different copies in the IP classrooms which will promote discussion of mathematical concepts when learners compare and contrast the definitions provided by the different dictionaries. If resources do not permit the purchasing of dictionaries, the IP teacher may assist learners to compile their own 'learner-made dictionaries'.

An open-ended section of the above question also requested teachers to indicate if they had any other material not listed in the questionnaire: 2 out of the 55 respondents indicated that they had mathematics kits; however, they both indicated that the kits were donated to their schools and they had not received comprehensive training on how to use them. While the intricate details of provision of mathematics kits to schools and teacher professional development regarding the use of the kits falls beyond the scope of this study, provision of a mathematics dictionary (mono- or multilingual) in these kits would make the kits a valuable teaching and learning resource to their recipients – both teachers and learners alike.

An open-ended question was used to obtain a deeper understanding of the linguistic challenges faced by teachers when teaching IP mathematics. The most significant themes which emerged from the teachers' responses are summarised in Figure 6.10.

Figure 6.10: Challenges experienced when teaching Mathematics using English as LoLT



Key:
English: English is difficult to understand
Explanations: It is time consuming to explain mathematical concepts in simpler English terms
Repetition: The teacher has to repeat the instructions several times for learners to improve comprehension
Illiterate Parents: Illiterate parents cannot help learners with homework
Loss of concentration: Learners loose concentration if they do not understand the English terms
Disciplinary problems: Learners behave inappropriately when the teacher continuously communicates in English

96% of the respondents acknowledged that learners find it difficult to understand English and mathematical concepts and procedures explained in English as a result of their poor reasoning skills in a second language, leading to the following problems:

- poor learner participation – '*learners are reluctant to speak in English, they are shy due to poor mastery of the language';*
- poor comprehension caused by an inability to follow instructions;
- poor communication between the teacher and the learners; and
- lack of creativity.

Acknowledging difficulty in understanding English is commendable; however, it is only the first step and more needs to be done beyond the acknowledgement.

58% of the respondents cited challenges directly linked to the classroom environment and expressed the view that they usually find themselves over-relying on the mother tongue, because it is a shared language with learners. The over-reliance on the use of the mother tongue instead of the stipulated LoLT was attributed to the fact that there is no guidance provided on how to manage the language transition from FP to IP. In addition, teachers expressed the view that it is time consuming to explain concepts to learners in simple English terms. Closely related to this challenge is the fact that 13% of the respondents felt that having to repeat instructions several times so that the learners understand the instructions and concepts is a daunting task.

11% of the respondents cited challenges external to the mathematics classroom, including the fact that learners have no access to English outside of the school premises; moreover, learners' illiterate parents cannot help with homework. In a study of 10-year-old primary school learners in Finland Vilenius-Tuohimaa, Aunola and Nurm (2008) identified several factors linking performance in mathematical word problems and performance in reading comprehension, and parental education levels emerged as a key factor. In a similar study conducted by Prinsloo and Rogers (2013) one of the key findings was that the higher the level of education of learners' parents or caregivers, the better they performed. Du Plessis (2014) indicated that parents in rural areas are less likely to be educated themselves and thus have less capacity in mathematics to provide support for their children. Although investigation of parental education levels falls beyond the scope of the current study, the challenge for primary school learners using an additional language as LoLT is coping with the reading requirements in word based mathematical problems; which is a huge task for ELLs, whose reading skills are still developing (Kasule & Mapolelo, 2013).

5% of the respondents felt that learners have a negative attitude towards English, which leads not only to poor concentration when English is used continuously, but also to disciplinary problems. Although 'disciplinary problems' seem to be a weak link to the use of English as LoLT, this factor could be prevalent and compounded in schools where there are very large classes as in the response '*Extremely large class of 120 learners*' from one respondent.

On the other hand, a respondent from a school that practises total immersion expressed the following sentiment:

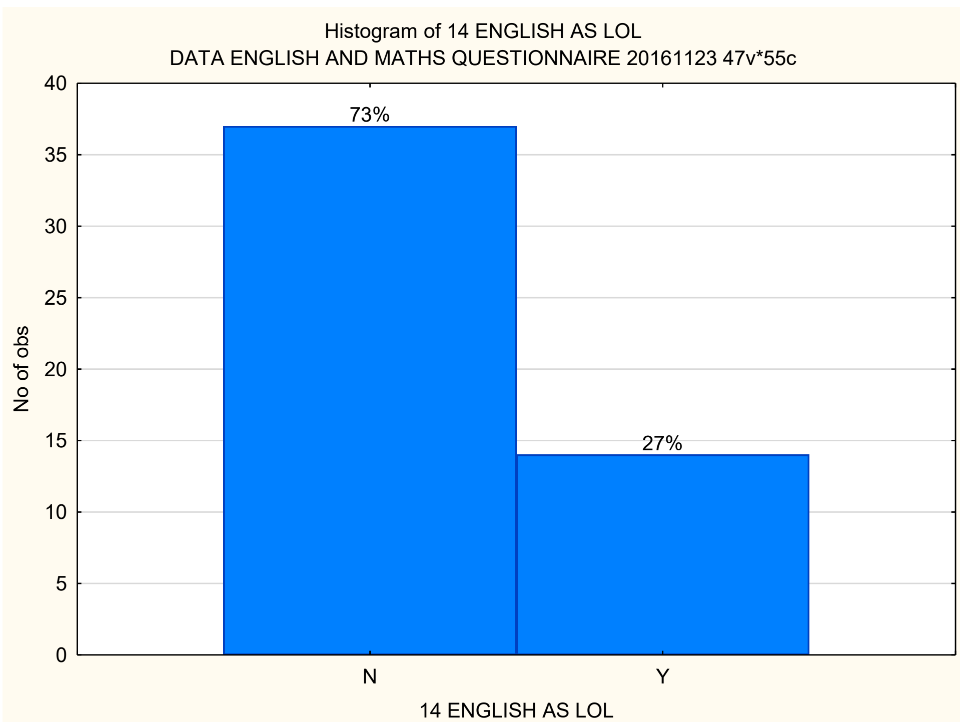
> '*Teacher has very few challenges when teaching using English as LoLT, because all learners and teachers in the school pride themselves in using English as LoLT*'.

This sentiment indicates that the teacher experiences minimal linguistic challenges when teaching IP mathematics, and this confirms findings from a study conducted by Prinsloo and Rogers (2013). Their study analysed trends in the South African Mathematics and Science Survey (TIMSS), focusing on the language skills crucial in mathematics and science education. One of the key findings in the study is that learners who switch at some point from their home language to a different language at school appear to experience greater challenges to perform well in mathematics and science. However, the circumstances at the respondent's school are not the prevailing norm among ECDoE schools. However, it would have been interesting to find out if the respondent ever uses the learners' home language as a resource in the classroom, as indicated by the principles of the translanguaging theory explained in Chapter 2 of this study.

Worth noting is the fact that most of the suggestions provided (except '*lack of guidance to manage transition from mother-tongue instruction to using English as LoLT*') find anomalies with the learner aptitudes and attitudes, classroom environment and the poverty index of the school and community, and the suggestions do not comment on the teachers' own language competencies.

Having established the linguistic challenges faced by the teachers in IP mathematics instruction, it was imperative to determine the extent to which teachers are upskilled in using English as LoLT. Figure 6.11 illustrates teachers' responses on whether their initial teacher education qualifications included a module focusing on using English as LoLT.

Figure 6.11: Histogram of Initial Teacher Education modules focusing on English as LoLT



The majority of the teachers (73%) indicated that that none of their initial teacher education qualification modules had a focus on using English as LoLT, while 27 % indicated that they had had some modules containing aspects on communication skills. Of the 27% respondents who had undertaken modules focusing on communication skills, 12% of these could not remember the names of the modules. The rest listed the names of the modules as follows:

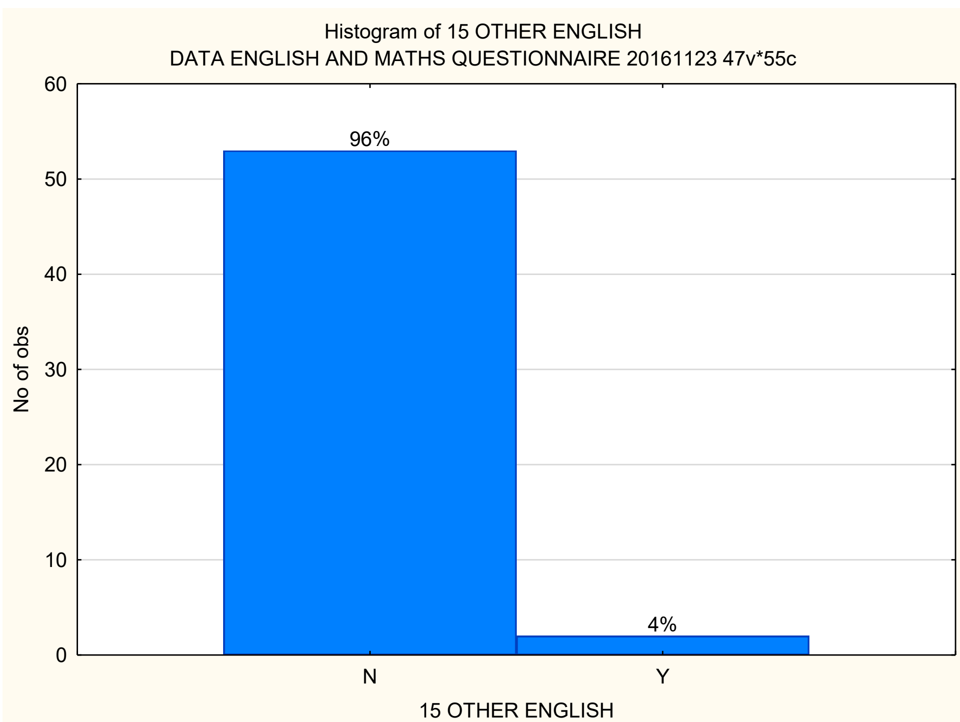
- ***English in Context***
- ***Maths and Science Reasoning***
- ***Communication Skills***
- ***English Didactics***

- ***Language for professional purposes***
- ***English Communication***

The fact that different names were listed for the modules may imply that the contents of the modules were relatively different and this fact is supported by the overarching notion that these modules were provided by different teacher education institutions. Nevertheless, the fact that there are some teacher education institutions (no matter how few) that equip teachers with communication skills is laudable. What remained unestablished is the duration of the modules, the content covered, the depth and particular focus on using English as LoLT in mathematics instruction as well as the focus on the IP level, where the transition from mother tongue to instruction in English in the majority of the public schools takes place. In addition, it is of paramount importance to establish whether the above-mentioned modules were compulsory or elective modules.

A follow-up question aimed at establishing other forms of in-service professional development courses focusing on using English as LoLT the respondents had received. Results of the follow-up question are indicated in Figure 6.12.

Figure 6.12: Histogram of teacher education courses focusing on English as LoLT



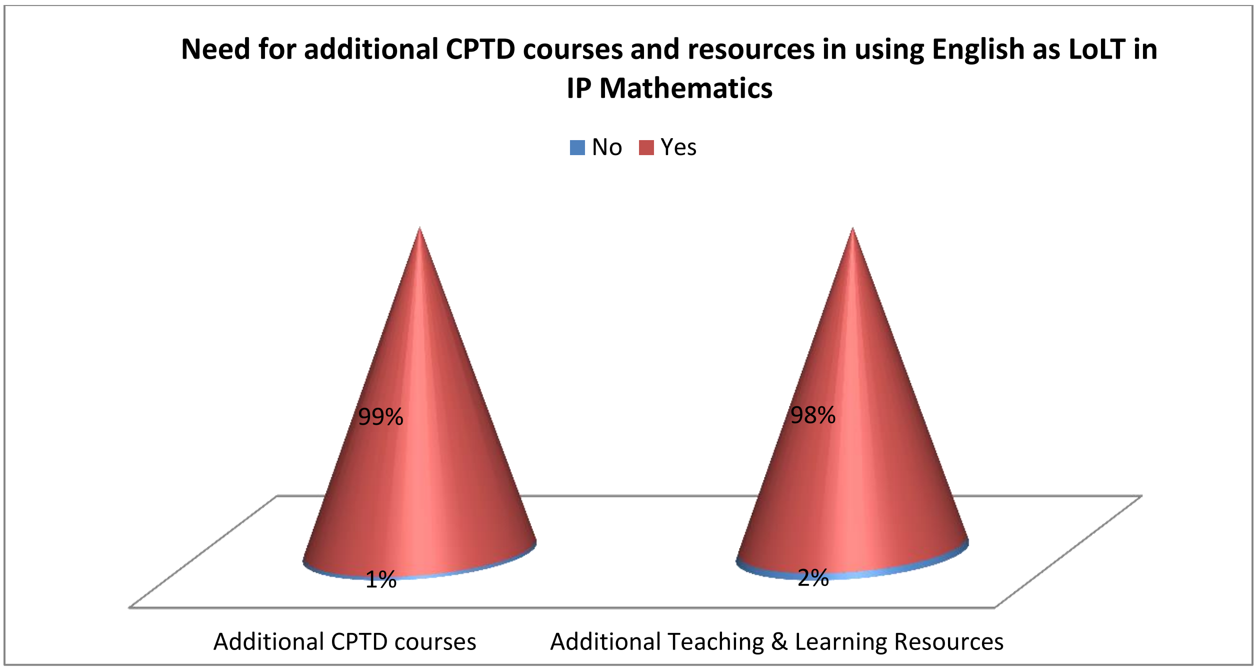
As illustrated in Figure 6.12, only 4% of the respondent had received other in-service professional development courses focusing on using English as LoLT, while 96% had not received any.

The moment teachers complete their initial teacher education, they become candidates for courses offered for in-service professional development. Based on the information illustrated in

Figure 6.12, the fact that there are some teachers who had received any in-service professional development courses focusing on English as a language of instruction indicates that there are some teacher education institutions that offer these courses; however, the fact that such institutions are *very few* is a cause for serious concern. An interpretation of the two strands of information reveals there is a gap in equipping teachers with linguistic skills to overcome language barriers. The gap emerges right from ITE and widens as ones moves into in-service teacher education.

Responses presented in Figure 6.13 are intended to establish the respondents' perceived needs regarding additional continuous professional teacher development (CPTD) courses and teaching and learning resources in using English as a language of instruction in IP mathematics.

Figure 6.13: Histogram of additional CPTD courses and teaching resources needed

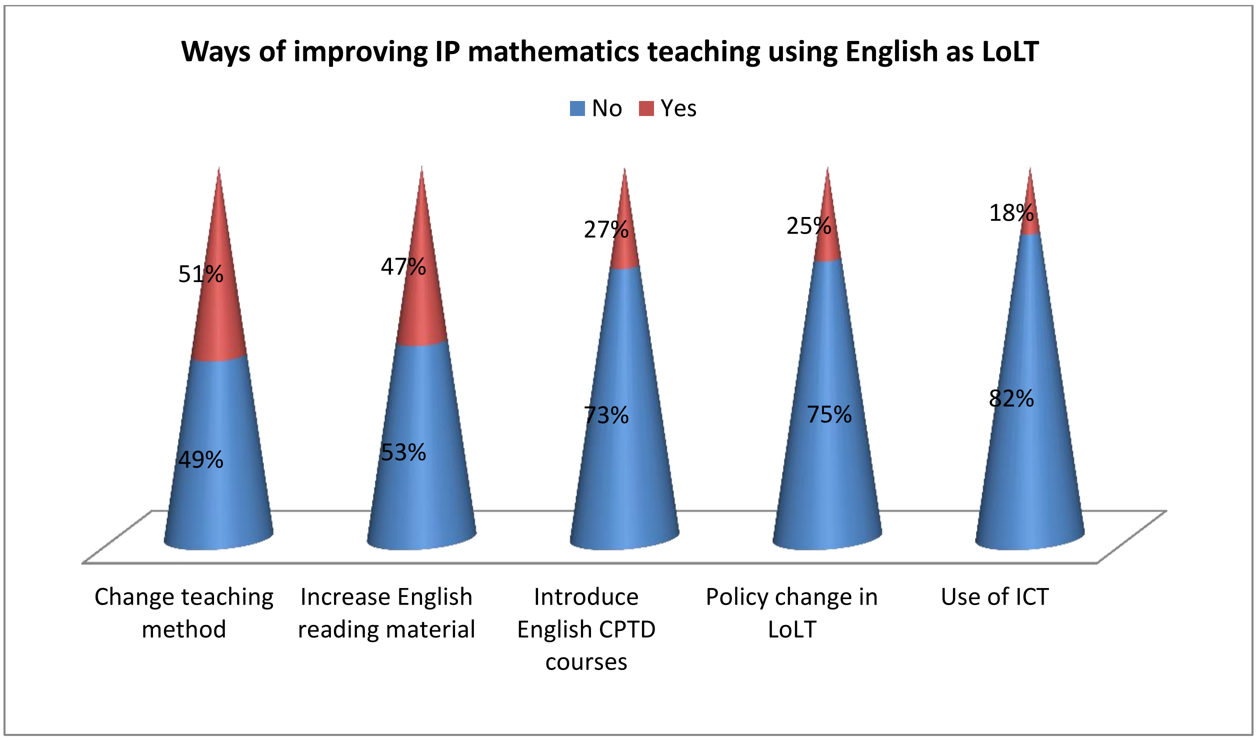


As illustrated in Figure 6.13, the majority of the respondents indicated the need to have additional CPTD courses as well as teaching and learning resources that would support the use of English as the language of instruction in IP mathematics; 99% of the teachers indicated that they would need additional CPTD courses, while 98% of the respondents indicated that they would need additional teaching and learning resources. In as much as these statistics may reflect a 'perceived' need compared to the 'actual' need, the inference is that the teachers would welcome the additional CPTD courses and resources if they were offered to them. Based on the fact that the respondents are practising teachers who have gone through initial teacher education and have been exposed to the realistic challenges of using English as LoLT in real classroom situations, this perceived need could be an indication of a need to review the teacher education curriculum during and after initial teacher education regarding the use of English as language of instruction.

The researcher acknowledges that in 2016, (during the course of the current study) the Department of Higher Education Training (DHET) launched a 5-year programme called the Teaching and Learning Development Capacity Improvement Programme (TLDCIP), which mobilises teacher educators in all higher education Institutions in South Africa for the purposes of reviewing the current teacher education curriculum specifically for primary schools. Therefore, the teachers' perceived need for courses focusing on the use of English as LoLT as established in Figure 6.13 above would contribute greatly to this current review, considering that these respondents are practising teachers and their need has a direct bearing on the quality of their IP mathematics instruction.

Considering that the respondents were practicing teachers, the concluding question on the teacher questionnaire requested suggestions of improving IP mathematics teaching using English as LoLT. Themes emerging from the respondents are summarised in Figure 6.14.

Figure 6.14: Ways of improving IP mathematics teaching using English as LoLT



51% of the teachers suggested that there is a need to change the current teaching methods used to teaching mathematics using English as LoLT. The following changes were suggested in support of this notion:

- *Teachers should always use English when teaching*
- *Simplify the terms used in mathematics*
- *Change style of teaching mathematics*
- *Improve English aural skills*
- *Use quizzes to improve language competency*
- *Rewarding learners who perform better in English*

- *Learners must practise speaking English*
- *Giving more homework and aftercare classes*

Setati and Adler (2001) reported teachers being torn between the exclusive use of English and jeopardizing learner understanding as opposed to the use of the learners' home language and forsaking learners' development in proficiently using the English of mathematics (mathematics register). Responses to the above question confirm this dilemma with about half (51%) of the teachers advocating for the exclusive use of English, while the other half (49%) disagree. What would have added more value to this open-ended response would have been to probe and find out the perspectives of those teachers who were in disagreement about the exclusive use of English as LoLT. Could it be the teachers are in favour of contemporary methods such as translanguaging or discouraged methods such as code switching, or are the teachers not sure what any change in the current teaching methods should incorporate?

47% of the teachers suggested that there is a need to increase English reading material at the IP level to enable learners to have increased access to the LoLT. The following were suggested in support of this notion:

- *Use of dictionaries*
- *DBE must provide dictionaries*
- *Access to resources in English for use in class*
- *Promote reading among learners*

27% of the teachers suggested that there is a need for CPTD courses to upskill teachers in the use of English as LoLT in mathematics. The following changes were suggested in support of this notion:

- *To be trained on how to use English as LoLT*
- *DBE must provide teachers with bursaries to further their studies and become competent*
- *Teachers to take part in language competency competitions*
- *Improve teachers' English language skills*
- *Provision of professional development courses for teachers*

25% of the teachers suggested that there is a need to change the current LiEP so that English is used as the LoLT right from FP level instead of waiting until the IP level. These responses loosely echo earlier findings by Setati (2008), Barwell (2012) and Kasule and Mapolelo (2005, 2013), who state that English is viewed as the undisputed language in which mathematics must be communicated. Setati (2008) notes this view is strongly supported by both the learners and the experienced teachers. If English "is seen as more suitable for mathematics teaching and learning due to its socio-political value" (Barwell 2012: 326), this study contends that this conversation needs to be taken beyond mere awareness levels to implementation levels by equipping mathematics teachers with the necessary linguistic skills to use English as LoLT.

18% of the teachers suggested that there is a need to introduce computer-based mathematics programmes that will enable learners to engage further with the language of instruction. The following changes were suggested in support of this notion:

- *Allow learners to discover*
- *Use games to improve language competency*
- *Use of ICT to improve language competency*
- *Use ICT for teaching*

The suggestions regarding the use of information communication technology (ICT) programs can be regarded as a subset of the suggestion to change teaching methods. Although these are two noble suggestions, they may lack immediate practicality based on the context within which the schools are situated. The suggestions require capital investments which the schools may not be in a position to provide, unless the programmes are funded by other education development stakeholders, investments which would include both the installation of the infrastructure as well as the training of the teacher in the use of the installed ICT programs.

All the suggestions given above are directly linked to the day-today teaching and learning process of IP mathematics. In addition to these, below are a few more suggestions indirectly linked to the teaching and learning process:

- *Mathematics teachers must specialise and not teach other subjects*
- *Improve support from district education officials regarding the use of English as LoLT*
- *Learners should improve school attendance*
- *Parents should help learners with homework*

Although *these* suggestions are only indirectly linked to what happens every day in an IP mathematics classroom, they seem very important. The first one implies that IP mathematics teachers become specialized instead of being generalists. The second one, which implies that district education officials need to provide more support than they are currently providing, assumes that the district officials are better quipped in providing such support, a notion which would need further investigation but falls beyond the scope of this study. The third one implies that there is a high absenteeism rate among learners which, if reduced, could improve the teaching and learning situation. Although this factor may not affect the majority of the under-resourced schools, it is worth looking into. The last one implies that parents need to be involved in helping learners with their school work; however, data from earlier sections of this chapter, supported by research, suggest that not all parents are in a position to help with school work considering the illiteracy levels of the parents or guardians (Vilenius-Tuohimaa, Aunola & Nurm, 2008; Prinsloo & Rogers, 2013; Du Plessis, 2014). The social aspect impeding this suggestion is that in under-resourced communities rural-urban migration is rife, which means that the learners' parents seek employment in the cities and leave the grandparents in charge of upbringing children.

Since there were two different questionnaires administered in this study (one for the teachers and one for the teacher educators), the section above presented, analysed and discussed data gathered through the teacher questionnaires. The section below presents analyses and discusses data gathered through the teacher educator questionnaires.

6.3.1.2 Questionnaires: Teacher Educators

The preceding sections of this chapter presented, analysed and discussed quantitative data gathered through the 55 teacher questionnaires. Although the information from the teacher educator questionnaires also forms part of the quantitative data, it is analysed thematically based on the relatively small number of the teacher educators sampled. Hence the main focus in this section is establishing common themes emanating from the teacher educators' responses. The section below presents, analyses and discusses data gathered from the 10 teacher educator participants of the study.

For an overview of the teacher education programmes offered at the different institutions where the sampled teacher educators are based, it was crucial to establish the IP mathematics education qualifications offered by their institutions. Responses in this regard are indicated in Table 6.2.

Table 6.2: IP Mathematics qualifications offered at universities

	Question: What in-service IP mathematics qualification(s) does your institution offer?		
	Duration (years)	**Name of degree / diploma / certificate**	**Inclusion of methodology modules Yes / No**
TE1	**4**	**BEd Intermediate Phase Mathematics**	X
	2	**PGCE**	X
TE2	**4**	**BEd Intermediate Phase Mathematics**	✓
TE3	**2**	**ACT**	✓
TE4	**2**	**ACT**	X
	2	**BEd Honours**	**No, some students research on it in their projects**
TE5	***None***		
TE6	**3**	**BEd**	✓
TE7	**2**	**ACE**	✓
TE8	**3**	**NPDE**	✓
	2	**ACE**	✓
	2	**ACT**	✓
	2	**BEd Honours**	X
TE9	***None***		
TE10	**Not for IP courses, but for Masters and Honours courses**		

Key:		None

All the institutions surveyed indicated that they offered some pre-service qualifications in IP mathematics education; however, only 70% of these institutions offered these qualifications to in-service teachers. A number of reasons could explain this, such as capacity whereby the in-service courses are offered at other levels such as the FET and SP bands, but not to the IP level. It was also noted that in some institutions the in-service courses were offered by specialised units of the university, running parallel to the pre-service qualifications. The majority of the institutions offering IP courses had some module focusing on methodology; however, at one institution methodology was an elective module which some students pursued in their research projects. Clarity on these modules and their contents would have been sought through a content analysis of the module outlines of the different universities, but that falls beyond the scope of the current study.

The data deemed crucial in this study were whether the institutions offered any short courses focusing on language, specifically English, as a medium of instruction in IP mathematics during or after initial teacher education. Responses in this regard are illustrated in Table 6.3.

Table 6.3: Prevalence of IP mathematics modules focusing on English as medium of instruction

	Question: What other in-service short courses in methodology of teaching IP mathematics does your institution offer?			
	Years	**Months**	**Name of Diploma / Certificate**	**Inclusion of English LoLT modules Yes / No**
TE1	***None***			
TE2	***None***			
TE3	***None***			
TE4	***None***			
TE5	***None***			
TE6	***None***			
TE7		**20 days**	**Maths Primary Project Course**	**Integrated content and methodology**
TE8	***None***			
TE9	***None***			
TE10			**Expressing Mathematics**	

			Language and Communication in Mathematics	
			Key:	**None**

Out of the 10 participating teacher educators sampled from the 26 South African universities, only 2 respondents revealed that their institutions offer modules sensitising teachers on how to teach specialised mathematics vocabulary to IP mathematics student teachers during initial teacher education. One institution that offered a comprehensive module *'Language and Communication in Mathematics'* offered it only at Master's level, a level which most of the teachers would not have attained by the time they are deployed to teach in schools. None of the institutions offered short courses to in-service teachers. One institution offered some in-service programmes focusing on IP mathematics methodology in general, but these were not accredited. This information strongly tallies with the information provided by IP teacher participants in the sense that the departments of teacher education in which they had their initial teacher education did not offer specialised modules focusing on the use of the English language as a medium of instruction for IP mathematics.

In was necessary to establish the teacher educators' views on how they teach or present specialised mathematical vocabulary in their lectures. Establishing this information would determine whether the teacher educators modelled 'good practice' to their students, so that the student teachers may adapt these strategies for use in their own classrooms. Teacher educator responses on strategies used to teach specialised mathematical vocabulary are compiled in Table 6.4.

Table 6.4: Teacher educator strategies for teaching specialised mathematical vocabulary

	Question: How do you teach specialised mathematical vocabulary in your lectures?
TE1	a) I 'integrate' the vocabulary by emphasising the many meanings that mathematical symbols symbolise. b) I thus emphasise many representations of a single mathematical symbol or word. These representations are numerical, geometrical, visual and 'in words' i.e. semantic.
TE2	a) Building experiences and descriptions in which the specialised vocabulary is used. b) Use gestures and manipulatives. c) Use maths dictionary.
TE3	a) Key words displayed on the classroom wall. b) Discussion in groups of meaning of keywords. c) Games and activities to familiarise learners with keywords and phrases Vocabulary jotter. d) Both languages used in teaching material until the learners can cope in English alone.
TE4	a) The teaching of specialised mathematical vocabulary is infused into the teaching of mathematics content.
TE5	
TE6	a) Mathematical vocabulary is part of one of the modules called curriculum studies/mathematics Education. During this time students have to create a list of mathematics vocabulary words together with meanings and submit this as a short assignment. Terms like volume which are shared with everyday English; sound alike terms within maths and English, examples of mathematical terms that are related, but have distinct meanings which are confused by learners are submitted by each student. b) Students are sensitised also to a number of readings on language from local and international journals and part of this aspect includes the language of mathematics. c) Students also compile a mathematics dictionary for the class that they teach not only Intermediate Phase students but Foundation Phase, Senior Phase and FET students as well. The dictionary comprises words and the correct meaning of the words in Mathematics. d) Students also make a set of flashcards with the mathematical vocabulary words written on them which then gets displayed on their classroom walls. All specialised mathematical vocabulary is identified, highlighted and explained during lectures. e) Students also have to submit an assignment on the language of mathematics and have to critically discuss mathematical vocabulary as part of their assignment.
TE7	a) Emphasis on teacher talk, use of representations and explanations is central to the 20-day course. b) Feedback on written assignments includes attention to mathematical precision.
TE8	a) I believe that teacher-students need to "know" the basics and fundamental principles of the mathematics they are going to teach. The teacher-students should feel capable and empowered to do their thing in the math class. The way I go about it is to emphasize the correct use of mathematical terms at all times. While I am teaching content, I would give examples of typical mistakes learners and math users make with respect to the language of math. I also encourage the students to compile their own math vocabulary-list as they are teaching and working through the course.

TE9	
TE10	a) Talk about the mathematics register: 'What is it about the mathematics register that makes it special?' b) Discuss the informal use of mathematics c) Show the students how the lack of register can hump understanding d) Show the students how different language forms can be interchanged
Key: [orange] None	

80% of the teacher educators shared valuable strategies and the rest left the section incomplete. A number of strategies are cited by the teacher educators on how to teach specialised mathematics vocabulary in IP classrooms. These strategies include integration of vocabulary into content teaching and learning, using mathematics dictionaries and freely available software, keeping word walls and promoting discussions on the use of formal and informal use of mathematics register.

For detailed information, teacher educators were requested to share the resources they recommended for use in addressing the language-based mathematical problems. The responses are compiled in Table 6.5.

Table 6.5: Teaching and learning resources recommended by teacher educators for addressing language-based mathematical problems

	Question. What teaching resources do you recommend for use by in-service teachers to address language based mathematical problems?					
	a	***b***	***c***	***d***	***e***	***Other***
TE1	✓	✓	✓	✓	✓	
TE2	✓	✓	✓	✓	✓	
TE3	✓	✓	✓	✓	✓	
TE4	X	✓	✓	X	✓	
TE5	✓	✓	✓	X	✓	- Physical resources such as egg boxes, beads, Cuisenaire rods and Lego
TE6	X	✓	✓	✓	✓	- There are many errors on the GDE workbooks - Textbooks written in isiXhosa for teachers might help. They will help teachers to code switch precisely and consistently.

TE7	X	X	X	X	X	- We use the Beckmann text on Mathematics for primary teachers, not specifically for language but for integrated attention to explanations and representations of mathematical ideas.
TE8	✓	✓	✓	✓	✓	- I advise teachers to use everything they can get hold of. Extra to the list above are the many mathematics interactives which they can engage in for free on the internet. These give so many ideas and support for the struggling teacher.
TE9	X	X	X	X	X	- We design our own resources and give them freely and put them on the website – including homework books, fraction charts, dice games and booklets.
TE10	X	✓	✓	X	✓	- The GDE workbooks have a lot of errors; therefore I do not recommend them. - Multilingual dictionaries would be a useful tool if they were standardised.
Totals **% where applicable**	**50%**	**80%**	**80%**	**50%**	**80%**	
Key: *a* = DBE Workbooks *b* = Textbooks *c* = Mathematics dictionaries *d* = Computer based activities *e* = Word walls / charts **Key:** [orange] **None**						

Textbooks, mathematics dictionaries and word wall/charts were recommended by 80% of the teacher educators for use in addressing language-based IP mathematical problems, while GDE workbooks and computer-based activities were recommended by 50% of the teacher educators. Recommended textbooks which have been evaluated by the DBE are listed on the 'national catalogue' and schools order the books for use in their classrooms. As such, the textbooks used in different schools may vary; however, the common fact is that the DBE's assessment of the textbooks includes checking whether the books comply with the CAPS requirements. One of the teacher educators suggested the use of isiXhosa textbooks for assisting teachers with precise and consistent code switching.

'Textbooks written in isiXhosa for teachers might help. They will help teachers to code switch precisely and consistently.'

Interestingly, this statement suggests that the textbooks alone may be insufficient without formal instruction on how precisely and consistently code switching should be done during initial teacher education. In addition, the fact that teaching and learning material available in indigenous languages is still being developed is a significant factor. The use of mathematics dictionaries for addressing language-based mathematical problems is re-emerging as an issue in this section, after it was suggested by teacher participants in their responses on a similar question.

'Multilingual dictionaries would be a useful tool if they were standardised.'

Therefore, it may be prudent to invest in mathematics dictionaries as suggested by both the teachers and the teacher educators. Word walls and charts were also a popular suggestion from the teacher participants; therefore there may be a need to increase teachers' awareness of their usefulness as well as engage policy makers and publishers in standardising the dictionaries. Chapter 3 (section 3.3.1) of this study highlighted how word walls and charts can be created in such a way that they convey more meaning to the learners beyond just being a compilation of new words or an endless list of words that end up watering down the intended meaning of the target word. Only 50% of the teacher participants recommended the use of DBE workbooks and computer-based activities. The decline in interest in these two teaching and learning resources as compared to the above-mentioned more popular resources is explained below. Two teacher educators indicated that the DBE workbooks had many errors in them.

> *'The DBE workbooks have a lot of errors; therefore I do not recommend them'*

Determining the accuracy of this fact is beyond the scope of this study; however, as a newly introduced resource used to mitigate the shortage of textbooks in public schools DBE workbooks may need to be revised regularly, so that they meet the intended requirement of being an additional teaching and learning resource.

> '*These workbooks have been developed for the children of South Africa… as part of the Department of Basic Education's range of interventions aimed at improving the performance of South African learners in the first six grades… They provide every learner with worksheets to practise the language and numeracy skills they have been taught in class…'*

www.education.gov.za

Regarding the use of computer-based activities, two teacher educators indicated that they make these available on their website; however, the accessibility of these resources to teachers in under-resourced schools without computers and internet connectivity may be limited. Therefore, a lot of work may still need to be done to ensure that computer-based activities are easily accessible to teachers for use in IP classroom to address language-based mathematical problems. Other suggestions included the use of tangible objects such as Lego, beads, egg boxes and dice to help learners better understand abstract mathematical concepts.

To gain more insight into the use of English as LoLT from the teacher educators' perspective, the next question intended to establish the challenges experienced by the teacher educators when lecturing and observing IP mathematics teachers using English as a language of instruction. Responses from the teacher educators are compiled in Table 6.6.

Table 6.6: Challenges experienced by Teacher Educators when lecturing and observing IP mathematics teachers using English as LoLT

	Question: What major challenges do you experience when lecturing and observing IP mathematics teachers using English as LoLT?
TE1	a) Many or most of them struggle with 'engaging' the learners in terms of the many meanings attached to symbols and the required mathematical actions that need to be performed.
TE2	a) Intermediate Phase teachers tend to over-rely on explaining mathematical concepts, and procedures in the 1st language e.g. isiXhosa which is not the official language of instruction and assessment. This is a disservice to the learners as they are assessed in English. b) Often objectivity is lost when discussing the use of English as the LoLT as the issue of language is often politicised hence the debate on language tends to loose objectivity.
TE3	a) Communication is difficult if the student teachers do not have a good grasp of reading and listening to English. b) Strong regional accents also cause problems with communication. c) Mathematical concepts are very difficult to understand if you do not understand the language.
TE4	a) In the Eastern Cape (former Transkei) where communities in rural areas use one monolingual, teachers grapple to teach in English and find themselves switching to isiXhosa and ultimately using mother tongue. b) Over years, teachers' proficiency in English drops and eventually they struggle to express themselves in English. c) Lack of using appropriate learning and teaching devices. d) Lack of basic resources in schools (libraries).
TE5	a) knowledge of vocabulary b) knowing how to explain things c) knowing when to code switch
TE6	a) The biggest challenge is teachers being unable to reason and understand the mathematics they teach. They then translate these incorrectly. b) Some teachers struggle to use the correct mathematical words/vocabulary when they teach and very often code switch to isiXhosa which very often does not give a clear description of the mathematical term that is being emphasised. c) We have observed a few teachers (especially in the rural areas) who teach in mother tongue only during the whole lesson. We have stressed that teachers must teach in English and do minimum code switching.
TE7	a) Frequent disruptions to mathematical coherence in teacher talk – this is sometimes related to mathematical problem-solving, sometimes to limited explanatory repertoires, leading to repetition rather than elaboration of ideas, imprecise language, and slippage in the ways mathematical ideas are named and connected.
TE8	a) I honestly believe that most of the students who teach mathematics in the IP as well as in the other phases, do not understand the math concepts themselves. Therefore they struggle with the language of math and also with teaching the math in English, which in most cases is not their mother tongue.
TE9	a) Learners not being able to speak English fluently and thus not being able to participate in the learning conversation.
TE10	a) Teachers who: ○ are not aware how language can be used to impart mathematical understanding ○ battle with communication in the prescribed LoLT. ○ have the knowledge but have no language to explain the concepts. ○ use code switching inappropriately, thus use code switching not to help the learner but to help themselves to continue with the utterance.

One of the challenges raised by the teacher educators in the above responses is the lack of reading material in English; this challenge was also raised by the teachers. In addition, it emerges that teachers are not sure of how and when to code switch:

> *'...knowing when to code switch'*
>
> *'We have observed a few teachers (especially in the rural areas) who teach in mother tongue only during the whole lesson. We have stressed that teachers must teach in English and do minimum code switching.'*

Given the vast amounts of research in mathematics learning in multilingual classrooms and the large number of studies devoted to the effectiveness of code-switching strategies, the issue of code switching should not be causing so much concern. Could it be that this literature is not available to IP mathematics teachers? Or could it be that research findings do not filter down to primary school mathematics student and practising teachers?

The teacher educator responses above highlight teacher language proficiency in the LoLT as one of the most significant challenges observed among IP mathematics teachers. Without labelling teachers as ineffective, can the study to extrapolate that the teachers have limited access to good practice during the initial teacher education? Since all the teachers who participated in the study are qualified by different universities as able to teach, could it be the South African education system is embroiled in a chain reaction where teacher educators fail teachers who in turn fail the learners and the entire education system?

Having established the challenges experienced by the teacher educators, it was imperative to establish different ways in which the teacher educators thought could improve the teaching and learning of IP mathematics using English as LoLT. Responses obtained are compiled in Table 6.7.

Table 6.7: Ways of improving teaching and learning of IP mathematics using English as LoLT

	Question: Suggest other ways that could improve the teaching of IP mathematics using English as LoLT
TE1	a) I suggest that special emphasis be given to the multiple meanings of mathematical symbols. The challenge is then to work with learners who may believe that such multiple meanings can be 'confusing.' b) I often hear them complaining about 'confusing' and 'confusion.' It is challenging for the BEd (pre-service) teachers to see that experiencing and reflecting on confusion as part of learning something. c) The multiple meanings of mathematical symbols should be listed in a three column table, for example. The first column can have the actual symbol, the middle column the English and the last column the mother-tongue equivalent and an appropriate example. This example must be one that is *rich* in meaning and one that the teacher knows the learners struggle with. Through formative assessment the teacher knows which symbols; words are confusing and difficult for the learners.

TE2	a) Address the resistance teachers have towards teaching using English. b) Empower the teachers in teaching maths in English, some of the teachers are not proficient in English hence are not confident in teaching maths in English. c) Address the politicization of the use of English as a medium of instruction.
TE3	a) Have subtitles in the local language. b) Have fun activities using English keywords and phrases to improve level of understanding. c) Sit learners who can read and speak some English with those who have poor English.
TE4	a) Engaging in research projects in schools b) Reviving subject associations in local schools c) Collaborative programmes among schools and d) Programmes that promote learner participation such as competitions.
TE5	a) an emphasis on the issue during ITE, and finding ways for teachers in classrooms to address the issue, such as given below ○ making new vocabulary explicit ○ discussion of mathematics vocabulary to help learners remember and understand words (e.g. where does this word come from? ○ playing word games with learners. ○ using the home language as appropriate.
TE6	a) It is imperative to connect the teaching of language FAL to Mathematics and work with the language teachers in the schools to get their learners to understand what they are reading, for example. Reading is key to understanding any mathematics that is being taught. b) Especially in Grade 4 it is important to have all word problems written in both isiXhosa and English so that learners can choose which language they feel more comfortable to answer the questions as they will be able to comprehend what they are reading. As the year progresses, less mother tongue should be used so that towards the end of the year, the word problems are in English only. From Grade 5 teachers should teach in English only and do minimum code switching. c) Teaching resources in mother tongue for teachers to use as reference might be useful.
TE7	a) Learning mathematics through a focus on representing and explaining has helped us to help teachers learn maths in ways that are helpful for teaching.
TE8	a) Student teachers need to become English-literate and they need to master the math concepts they are going to teach. They actually need to master the math from at least one phase beyond the phase they are going to teach.
TE9	a) English should be developed stronger in earlier grades and there should be ELL support for Grade 4 learners to support their EL development.
TE10	a) Awareness is important, teachers need to: ○ be conscious of the pedagogy of mathematics and learn the appropriate pedagogic strategies. ○ use simple language to explain mathematical concepts. ○ speak slowly to allow the ELLs brain to capture and process the mathematical concepts.

The majority of the teacher educators' responses implied that teachers were not confident in using English as a language of instruction, and called for upskilling the teachers in this regard:

> *'-... teachers need to become English-literate...'*
> *'Empower the teachers in teaching maths in English, some of the teachers are not proficient in English hence are not confident in teaching maths in English.'*

This observation resonates with the suggestions raised by 27% of the IP teachers who indicated that the DBE needs to invest in additional CPTD course to help the teachers understand the most effective ways of using English as LoLT in IP mathematics classrooms (see Figure 6.13). By virtue of being more experienced and having access to scientific research output, the teacher educators' suggestions were more focused that those made by the teachers. Suggestions made by the teacher educators indicated that the upskilling of teachers needs to commence during initial teacher education (ITE) programmes and continue as part of teacher professional development while the teachers are in the classrooms, thus linking and providing a bridge between the two programmes instead of treating them as separate entities.

'... an emphasis on the issue during ITE, and finding ways for teachers in classrooms to address the issue'

The teacher educators' suggestions also raised the issue of awareness as an important factor. Thus, if teachers are made aware of the various ways they can tackle the problem, they become more effective and address even seemingly unimportant factors like the use of simple language for ELLS and speaking slowly when addressing ELLs.

'- use simple language to explain mathematical concepts'
'- speak slowly to allow the ELLs brain to capture and process the mathematical concepts'

To enable a smooth transition from FP to IP level teacher educators suggested the provision of English language support to Grade 4 learners, the entry level of IP. Making use of interactive, engaging and fun language-based activities was also suggested. In as much as all these suggestion are pivotal in supporting the transition, they focus on the learners rather than the teachers. Therefore, by extrapolation, the IP teachers need to be supported during and after initial teacher education to enable them to handle the linguistic needs of their learners.

One of the most important factors suggested by the teacher educators which is not directly linked to the teaching and learning environment, but directly linked to policy makers, is the separation of education and politics:

'Address the politicisation of the use of English as a medium of instruction.'

This study deems this to be an important factor as the consequences of politicising the use of English as LoLT affects the learners, and especially those in under-resourced schools with very limited choices regarding which schools they can possibly attend. As such, this study is intended to inform curriculum changes regarding the production of linguistically equipped IP mathematics teachers who would be able to better serve whichever school they are deployed in and the learners there.

The sections above provided information gathered through the teacher and the teacher educator questionnaires. After the administration of the questionnaires, two teacher assessments were administered on the teachers. The section below presents, analyses and discusses data gathered through the teacher assessments.

6.3.2 Teacher Assessments

Two forms of needs analyses were conducted in form of teacher assessments in this study: an English Language Proficiency Assessment and a Mathematics Word Problem Assessment. Two independent analyses of the teacher assessments were conducted: a statistical analysis conducted by Stellenbosch University's CSC as well as a descriptive analysis conducted by JET's Data Unit. The statistical analyses are presented first followed by the descriptive analyses. The section below commences by analysing and discussing the statistical results from the teacher English Language Proficiency Assessment followed by those from the mathematics word problem assessment, before comparing the relationship between the two assessments.

6.3.2.1 Statistical Analyses: Language Proficiency Assessment

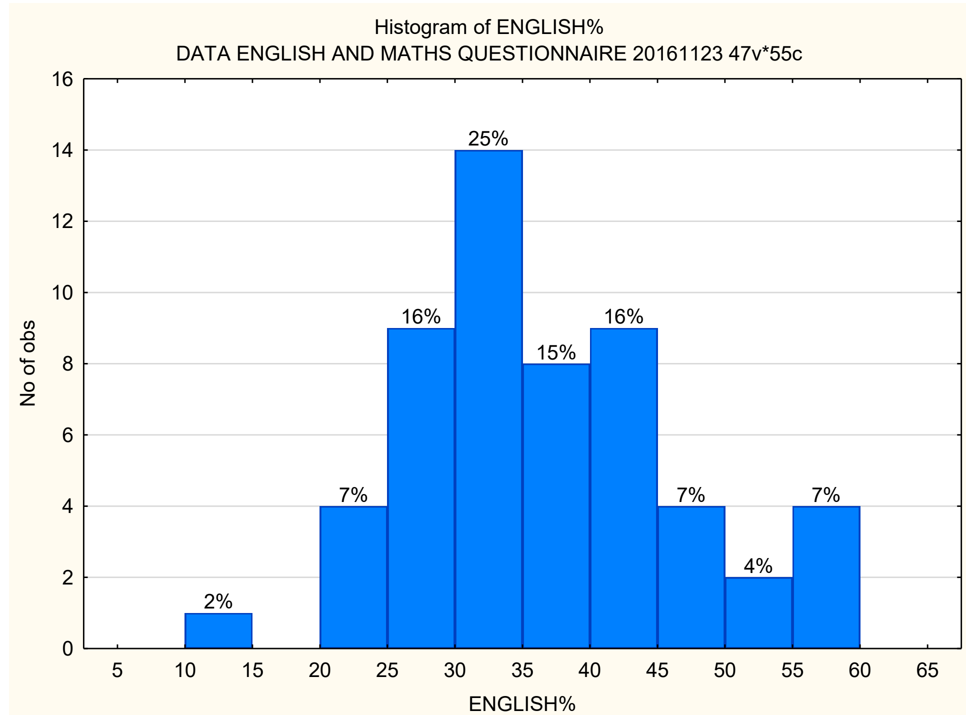
The teacher English-language proficiency assessment was the key component of the data collected. The teacher assessment, a standardised test compiled by JET and piloted in 5 other South African universities, is set more or less at the proficiency level of a Grade 7 learner. The assessments were marked out of 80 and they were comprised of questions of varying difficulty levels as indicated in the language proficiency assessment framework attached as Appendix C1. The assessment was administered to the 55 teacher participants and the purpose was to ascertain the language competency levels of the IP mathematics teachers sampled in the study.

The teacher English-language proficiency scores are presented graphically in the form of a frequency table and a histogram in order to indicate the nature of the distribution of the scores as well as to identify possible outliers. The frequency table and histogram present the same information; however, it is easier to identify outliers on the histogram. Results from the English language proficiency assessment are presented in Figure 6.15.

Figure 6.15: Histogram of English language assessment %

Frequency Table: English %	Histogram: English %

Category	Frequency table: Overall Total Mark (English Test in D/ Count	Cumulative Count	Percent	Cumulative Percent
9	1	1	1.81818	1.8182
17	3	4	5.45455	7.2727
20	1	5	1.81818	9.0909
21	2	7	3.63636	12.7273
22	1	8	1.81818	14.5455
23	3	11	5.45455	20.0000
24	3	14	5.45455	25.4545
25	1	15	1.81818	27.2727
26	2	17	3.63636	30.9091
27	3	20	5.45455	36.3636
28	8	28	14.54545	50.9091
29	4	32	7.27273	58.1818
30	1	33	1.81818	60.0000
31	3	36	5.45455	65.4545
33	3	39	5.45455	70.9091
34	2	41	3.63636	74.5455
35	1	42	1.81818	76.3636
36	3	45	5.45455	81.8182
37	1	46	1.81818	83.6364
38	2	48	3.63636	87.2727
40	1	49	1.81818	89.0909
41	1	50	1.81818	90.9091
44	1	51	1.81818	92.7273
45	2	53	3.63636	96.3636
48	2	55	3.63636	100.0000



Out of the 55 teachers who wrote the test, the lowest mark obtained was $\frac{9}{80}$ = 11 %, while the highest mark was $\frac{48}{80}$ = 60%. The modal mark was $\frac{28}{80}$ = 35%. It is troublesome to note that on average teachers exhibited a lower proficiency than what is expected of a Grade 7 learner.

As stated in Chapter 1 of the study, research analysing initial teacher education across five South African universities reveals that "the situation with respect to the language of learning and teaching, predominantly English, is of particular concern" (Taylor, 2015: 23). The participants' English-language proficiency as shown in Figure 6.15 confirms Taylor's findings. However, merely establishing and/or confirming this low proficiency level is only the beginning. The next steps should be a review of the teacher education curriculum during and after ITE in order to provide modules that will upskill teachers linguistically for the purposes of changing the status quo and ultimately contributing to the improvement of teacher classroom practice.

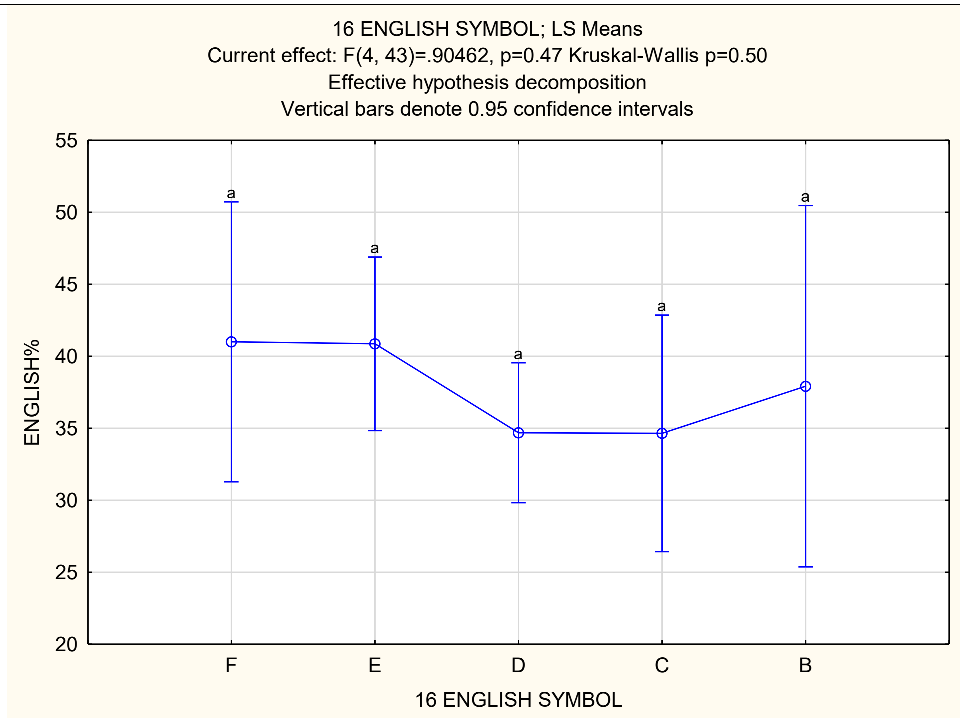
Demographic data (Section 5.4.3) statistically analysed the teacher participants' English-language symbols obtained at matriculation. The data on teacher English-language matriculation symbols were correlated to the teacher English-language proficiency scores. Figure 6.16 illustrates the correlation between the teachers' English-language proficiency level compared to the English symbols obtained at matriculation.

Figure 6.16: English symbol at matriculation Versus English Language proficiency assessment means

Descriptive Statistics: English % / English Symbol

	Descriptive Statistics (DATA ENGLISH AND MATHS QUESTIONNAIRE 20161123.sta)							
Effect	Level of Factor	N	ENGLISH% Mean	ENGLISH% Std.Dev.	ENGLISH% Std.Err	ENGLISH% -95.00%	ENGLISH% +95.00%
Total		48	37.21354	10.73508	1.54948	34.0964	40.33068
16 ENGLISH SYMBOL	F	5	41.00000	11.50408	5.14478	26.7158	55.28420
16 ENGLISH SYMBOL	E	13	40.86538	10.69687	2.96678	34.4013	47.32944
16 ENGLISH SYMBOL	D	20	34.68750	10.40207	2.32597	29.8192	39.55582
16 ENGLISH SYMBOL	C	7	34.64286	6.36209	2.40464	28.7589	40.52681
16 ENGLISH SYMBOL	B	3	37.91667	19.93479	11.50936	-11.6041	87.43743

Non Parametric ANOVA: English % / English Symbol



In the previous sections it was established that the majority of the teachers obtained symbol **D** and below; the group that obtained the D symbol has the lowest LS mean. It is evident that there is a correlation between the matric English symbol and the English-language proficiency level.

Closely related to the matric English symbol obtained is the teacher qualification as established in participant demographic data as detailed in Chapter 5 of this study. According to the demographic information, all the participant teachers are qualified; however, the learner performance as detailed in Chapter 4 is significantly low, indicating there is a gap. The fact that all participants are qualified teachers is a good starting point; however, if these qualified teachers are exhibiting language deficiencies as indicated in the teacher language proficiency assessment, it means there is still more that needs to be done. The qualifications provide a good starting point to further develop the teachers to become better classroom practitioners in order to bridge the gap between the qualified teachers and the significantly low learner performance at GET level.

As detailed in the participant teacher demographic information, there were two outlying participants – an ABET[20] trained teacher (lower level qualification) and a teacher who was completing a Master's Degree in Education (upper level qualification). The ABET-trained

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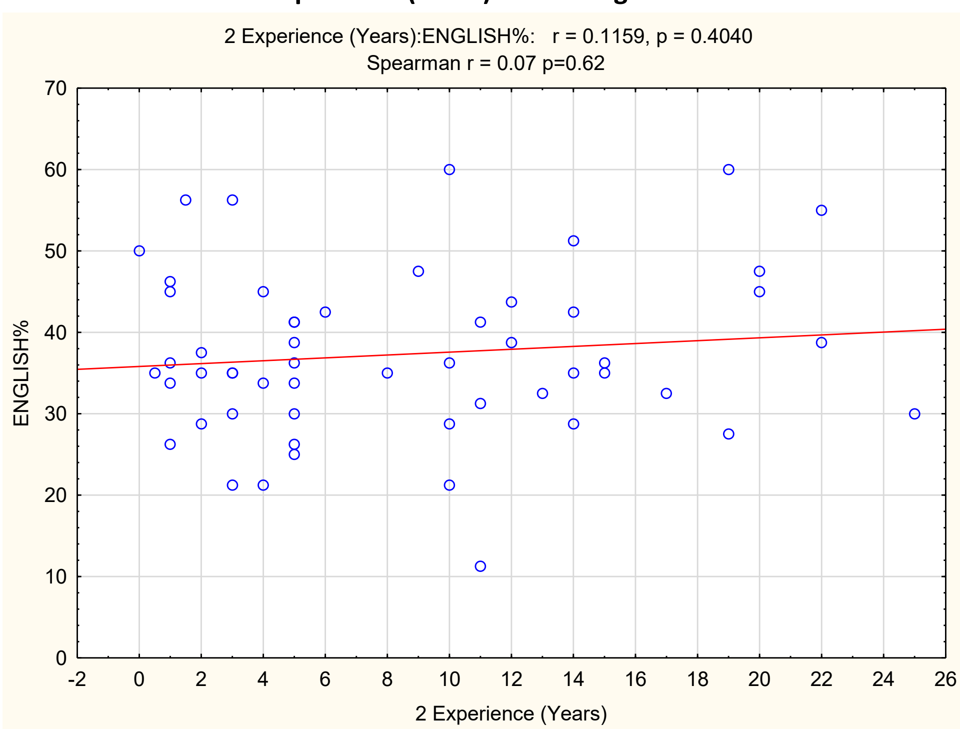
[20] ABET: Adult Basic Education and Training

teacher ended up teaching in a mainstream IP classroom after upgrading their qualification as exemplified in Section 5.4.3 of Chapter 5. On one hand, although the ABET trained participant is recommended for furthering their studies, this study envisages that teachers in this category need special attention so that their effectiveness in the classroom is improved. The requirements of an ABET course are not the same as those of a formal curriculum and therefore the teacher's upgrade into a mainstream curriculum teaching post needs to be supported. On the other hand, the participant who was in the process of completing a Master's degree in Education is relatively highly qualified for an IP teaching post. By virtue of being in the process of completing such a high-level qualification, it would have been expected of this participant to obtain relatively higher marks in the English language and/or mathematics assessments components of this study; however, this was not the case.

Demographic data (Section 5.4.3) statistically analysed the teacher participants' experience in in teaching IP mathematics. The data on experience in teaching IP mathematics were correlated to the teacher English-language proficiency assessment scores. Figure 6.17 illustrates the correlation between English-language proficiency levels and experience in teaching IP mathematics.

Figure 6.17: Correlation between experience (Years) versus English %



As established in the demographic data (section 5.4.3), about 60% of the participants are experienced teachers who have been teaching IP mathematics for between 5 and 12 years. As illustrated in Figure 6.17, with a correlation coefficient of r = 0.1159, there is a positive correlation between English-language proficiency and experience in teaching IP mathematics. This correlation implies that as teachers gain more experience in teaching mathematics, their proficiency in English language improves, and this could be attributed to the exposure the teachers gain as they engage with the teaching and learning content.

However, this result is not in line with a suggestion from one of the teacher educators who implied that soon after completing ITE, teachers tend to use the English language often, but this use decreases as they spend more time in the classrooms, surrounded by a challenging teaching and learning environment.

> '*In the Eastern Cape (former Transkei) where communities in rural areas use one monolingual, teachers grapple to teach in English and find themselves switching to isiXhosa and ultimately using mother tongue. Over years, teachers' proficiency in English drops and eventually they struggle to express themselves in English.'*

An analysis of the two notions implies that teachers in under-resourced communities need extra linguistic support in order to raise the standard of teaching and learning mathematics within their communities and the prevailing school environment. As established in earlier sections of this chapter, it is worth reiterating that teachers need language guidance in the use English as a language of instruction during ITE. Furthermore, they need to be supported through comprehensive in-service CPTD programmes focusing on upskilling them linguistically so that they are able to rise above the prevailing conditions in under-resourced schools.

Being humane, like all people, some teacher respondents were uncomfortable of their poor performance in the language competency assessments; one respondent was overtaken by emotions and broke down in tears because of a low mark in the language proficiency assessment; however, their thirst for knowledge and professional development transcended their emotions and self-consciousness, and they continued to participate in the rest of the data-collection phase. The identification of such ineffective practices within the teacher education system (established in this section through teacher self-reporting and confirmed by the teacher educators) requires the attention of society at large, specifically those involved in education. As such, those concerned can make improvements or adjustments: policy makers may, for instance, adapt the teacher education curriculum to raise the linguistic competencies of primary school teachers.

The sections above provided information gathered through the teacher English Language Proficiency assessments by initially analysing the raw scores and then relating the scores to data collected from other quantitative instruments, namely the teacher and teacher educator questionnaires, including the demographic data. After the administration of the language proficiency assessment, the mathematics word problem assessment was administered. The section below presents analyses and discusses data gathered through the teacher mathematics word problem assessments.

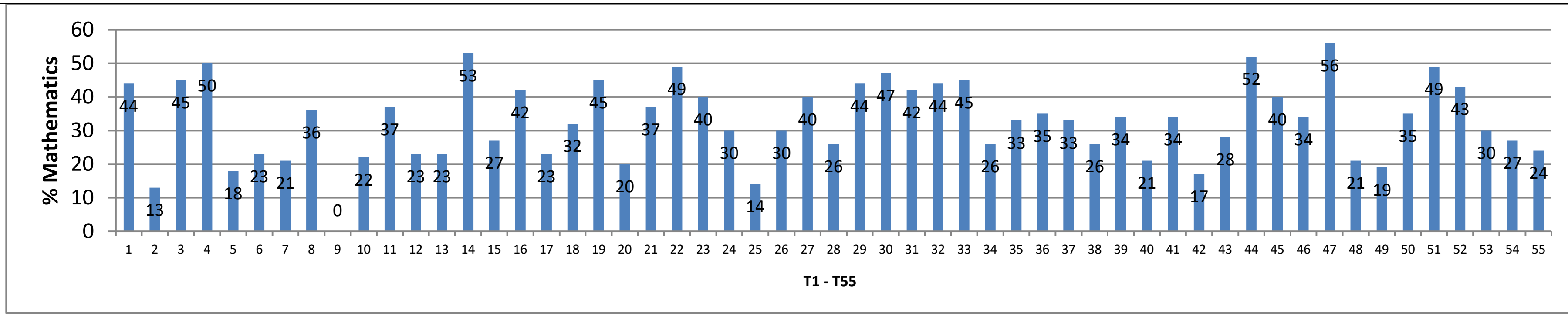
6.3.2.2 Statistical Analyses: Mathematics Word Problem Assessment

The mathematics word problem assessment, also sourced from JET, is a standardised IP teacher assessment more or less set at the proficiency level of a Grade 7 learner. The purpose of administering the assessments was to ascertain how IP teachers fared in solving language-based IP mathematical problems. The assessments were marked out of 80 and they consisted of questions of varying difficulty levels as indicated in the mathematics word problem assessment framework attached as Appendix D1. The assessment was administered to 55 IP mathematics teachers.

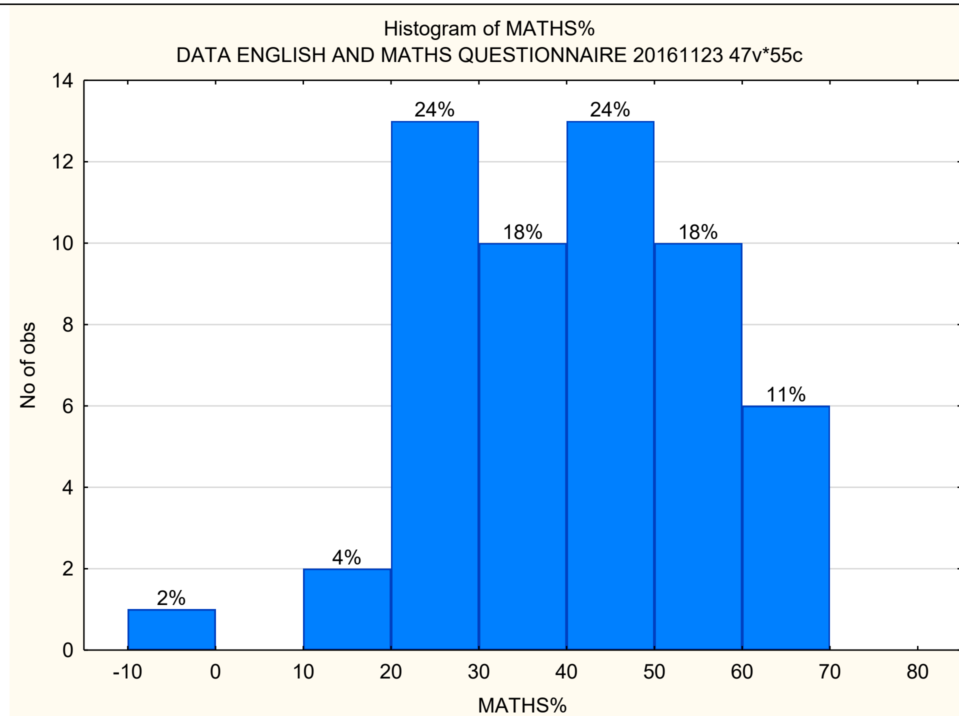
The teacher mathematics word problem scores are presented graphically in the form of a bar graph and a histogram in order to see the nature of the distribution of the scores as well as to identify possible outliers. The bar graph and histogram present the same information; however, it is easier to identify outliers on the histogram. Results from the mathematics word problem assessment are presented in Figure 6.18.

Figure 6.18: Mathematics Overall %

Bar Graph: Mathematics %



Histogram: Mathematics %



Out of the 55 scripts, one was spoilt; the lowest mark obtained was $\frac{13}{80}$ = 16 %, while the highest mark was $\frac{56}{80}$ = 70%. The modal mark was $\frac{34}{80}$ = 42%. Similarly, as noted in the English-language proficiency assessment, it is worrying to note that on average, teachers revealed a lower performance than what is expected of a Grade 7 learner.

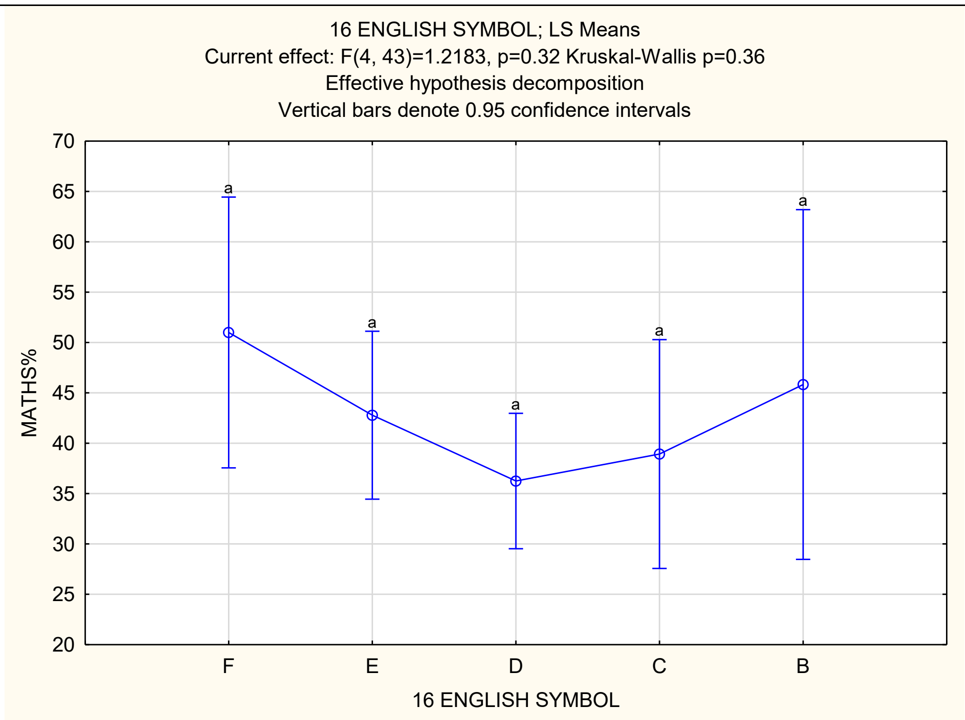
Demographic data (Section 5.4.3) statistically analysed the teacher participants' English-language symbols obtained at matriculation. The data on matriculation English-language symbols were correlated to the teacher scores on mathematics word problem assessments. The two variables were compared using descriptive statistics as well as with an ANOVA test. Figure 6.19 illustrates the correlation between teacher scores in teacher Mathematics word problem scores compared to the English symbol attained at matriculation.

Figure 6.19: English symbol at matriculation Vs Mathematics Word Problem Assessment Means

Descriptive Statistics: Maths % / English Symbol

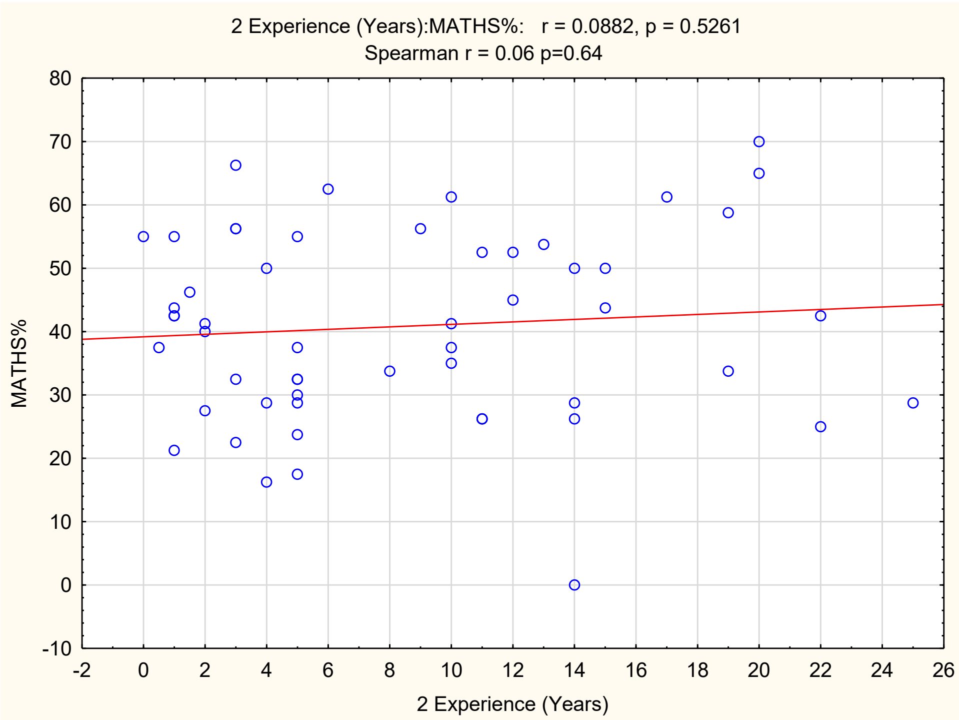
	Descriptive Statistics (DATA ENGLISH AND MATHS QUESTIONNAIRE 20161123.sta)						
Effect	Level of Factor	N	MATHS% Mean	MATHS% Std.Dev.	MATHS% Std.Err	MATHS% -95.00%	MATHS% +95.00%
Total		48	40.54688	15.04626	2.17174	36.17790	44.91585
16 ENGLISH SYMBOL	F	5	51.00000	15.08828	6.74768	32.26542	69.73458
16 ENGLISH SYMBOL	E	13	42.78846	12.92158	3.58380	34.98003	50.59689
16 ENGLISH SYMBOL	D	20	36.25000	16.36850	3.66011	28.58931	43.91069
16 ENGLISH SYMBOL	C	7	38.92857	10.85963	4.10455	28.88509	48.97205
16 ENGLISH SYMBOL	B	3	45.83333	20.55227	11.86586	-5.22134	96.88800

Non Parametric ANOVA: Maths % / English Symbol



Demographic data (Section 5.4.3) statistically analysed the teacher participants' experience in teaching IP mathematics. The data on experience in teaching IP mathematics were correlated to the teacher scores on mathematics word problem assessments. Figure 6.20 illustrates the correlation between teacher scores in Mathematics word problem assessment compared to experience in teaching IP mathematics.

Figure 6.20: Correlation between Experience (Years) in teaching Mathematics vs Mathematics %



As established in the demographic data (section 5.4.3), about 60% of the participants are experienced teachers who have been teaching IP mathematics for between 5 and 12 years. As illustrated in Figure 6.20, with a correlation coefficient of r=0.0882, there is a positive correlation between mathematics word problem assessment scores and experience in teaching IP mathematics. This correlation implies that as teachers gain more experience in teaching mathematics, aptitude in solving mathematics word problems improves, and this could be attributed to the exposure the teachers gain as they engage with the teaching and learning content.

Be this as it may, 27% of the participants were newly graduated teachers who had been teaching IP mathematics for between 0 and 4 years and they will still need to be upskilled in solving mathematics word problems. In addition, if the policy still stipulates that IP teachers continue to be generalists, it means more teachers who could have specialized to teach other subjects may find themselves teaching IP mathematics and they will be adding on to the number of teachers that need upskilling in solving mathematics word problems. Therefore additional CPTD courses in using English as LoLT will always be in demand as suggested by the majority (99%) of the teachers (Figure 6.13) and also by some of the teacher educators:

> *'Empower the teachers in teaching maths in English...'*

The sections above provided information gathered through the teacher mathematics word problem assessments by initially analysing the raw scores and then relating the scores to data collected from other quantitative instruments, the teacher and teacher educator questionnaires, including the demographic data. The section below presents analyses of and discusses the relationship between the scores obtained from the teacher assessments.

6.3.2.3 Statistical Analyses: English Language Proficiency versus Mathematics Word Problem Assessment

Since the current study is a relational analysis, it was imperative to present and compare the different characteristics of the teacher English-language proficiency scores against the mathematics word problem scores based on Stellenbosch University's CSC analyses.

The characteristics of the teacher English-language proficiency scores were presented in descriptive terms as well as graphically in the form of a box and whisker plot in order to illustrate the nature of the assessment characteristics as well as to identify possible outliers. The descriptive statistics and the box and whisker plots present the same information; however, it is easier to identify outliers on the box and whisker plot, which is a non-parametric comparison of the two variables.

A comparison of the characteristics of the teacher English-language proficiency scores against mathematics word problem scores according to mean values, medians, mode quartiles, maximum/minimum values and standard deviation are presented in Figure 6.21.

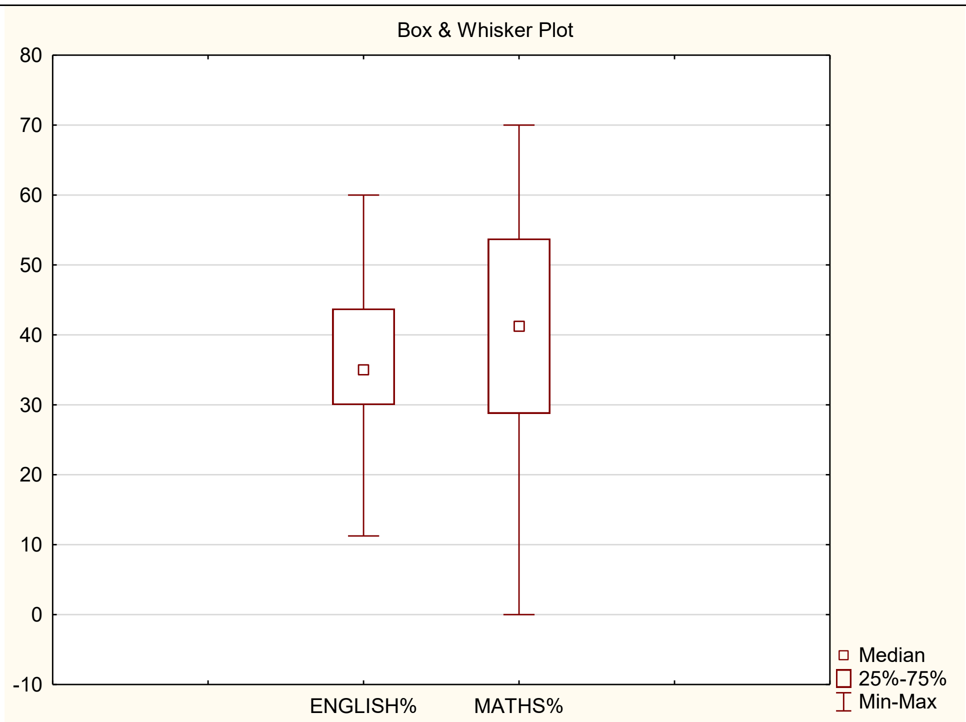
Figure 6.21: Statistical Analyses: English Language Proficiency vs Mathematics Word Problem Scores

Descriptive statistics: English vs Maths %

Descriptive Statistics (DATA ENGLISH AND MATHS 20161017.sta)

Variable	Valid N	Mean	Confidence -95.000%	Confidence 95.000%	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Std.Dev.
ENGLISH%	55	37.27273	34.53894	40.00651	35.00000	11.25000	60.00000	30.00000	43.75000	10.11248
MATHS%	55	40.95455	36.96098	44.94811	41.25000	0.00000	70.00000	28.75000	53.75000	14.77251

Box & Whisker Plot: English vs Maths %



When the spoilt mathematics score is excluded, the descriptive data show that both the minimum (11%) and maximum (60%) values of the teacher English-language proficiency scores are lower than those of the mathematics word problem assessment minimum (16%) and maximum (70%).

To illustrate the level of nominal variance between the English-language proficiency scores and the mathematics word problem scores, an ANOVA F-Test was conducted. The results are presented as a table of means of the two sets of scores, giving the standard errors, and the lower and upper limits of the two assessment scores as illustrated in the preceding graph. The results of the analysis are presented in Figure 6.22.

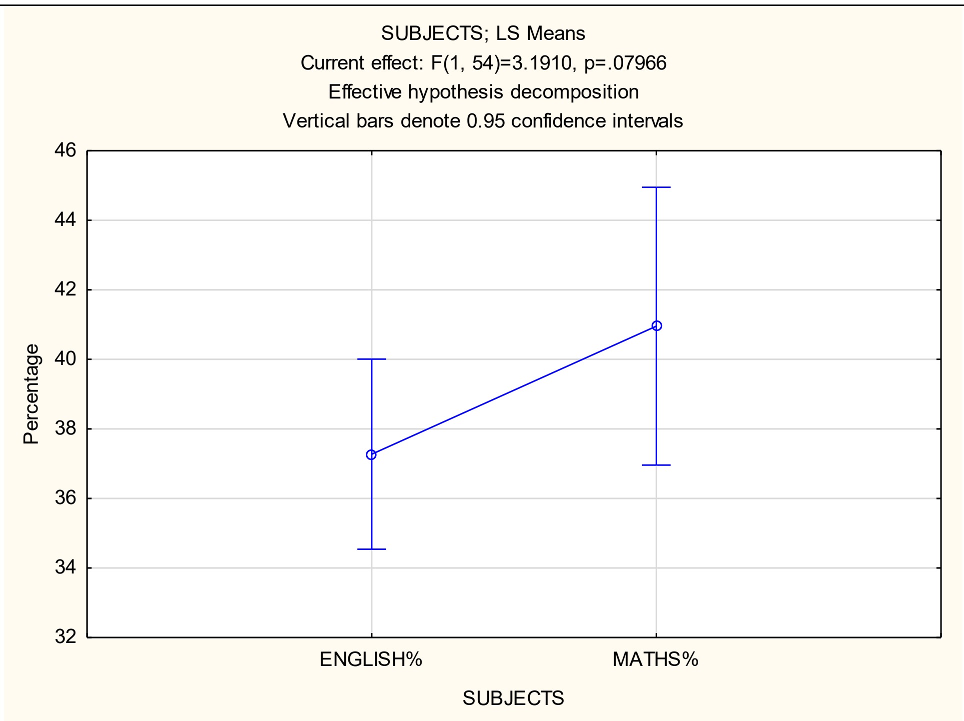
Figure 6.22: English and Mathematics %; LS Means

Descriptive Statistics: English & Maths % Means

SUBJECTS; LS Means (DATA ENGLISH AND MATHS 20161017.sta)
Current effect: F(1, 54)=3.1910, p=.07966
Effective hypothesis decomposition

Cell No.	SUBJECTS	DV_1 Mean	DV_1 Std.Err.	DV_1 -95.00%	DV_1 +95.00%	N
1	ENGLISH%	37.27273	1.363566	34.53894	40.00651	55
2	MATHS%	40.95455	1.991925	36.96098	44.94811	55

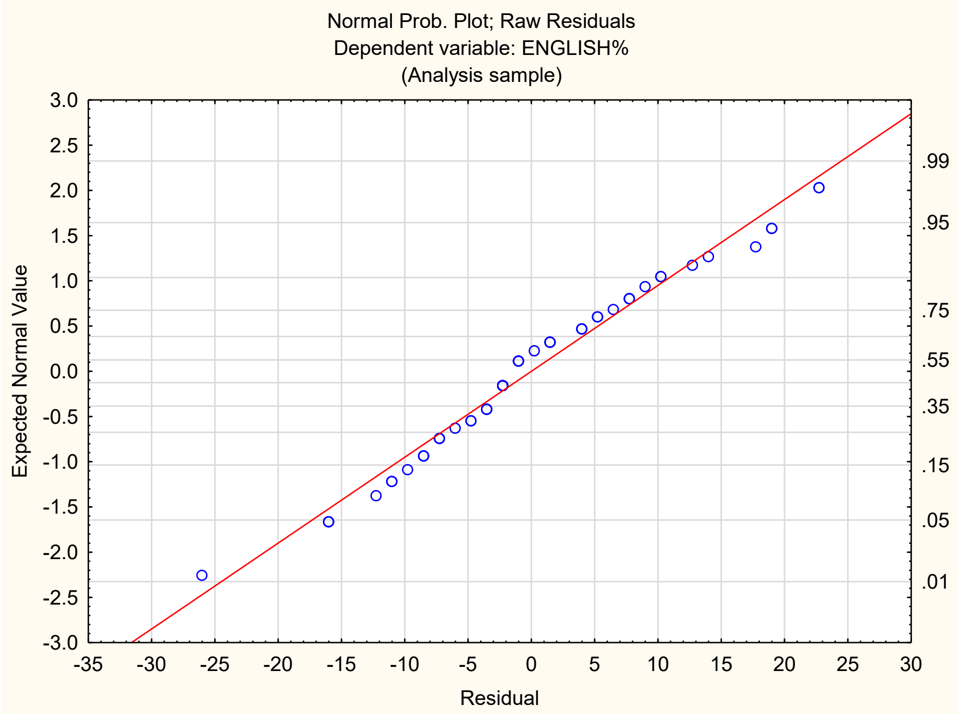
ANOVA: English & Maths % Means



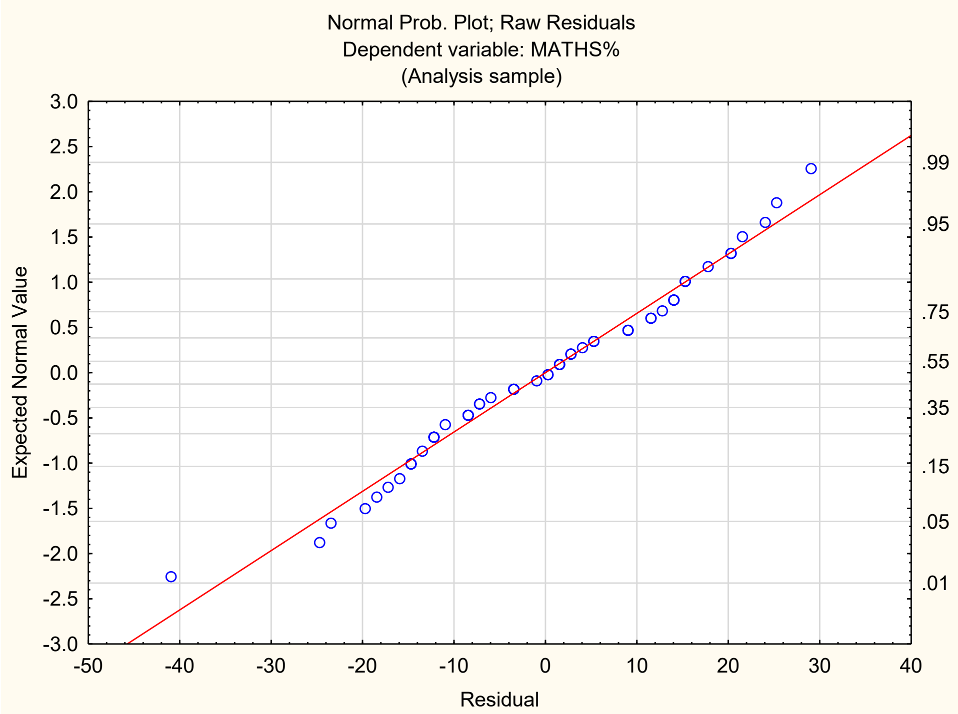
The ANOVA F-Test gives a p-value of 0.79, indicating that the mean scores of the two assessments do not differ significantly. The ANOVA test was also used to establish whether the data from the two teacher assessments is normally distributed. Figure 6.23 indicates the analysis results.

Figure 6.23: Normal distribution of English and Mathematics Scores

Normal Prob. Plot; Raw Residuals: English %

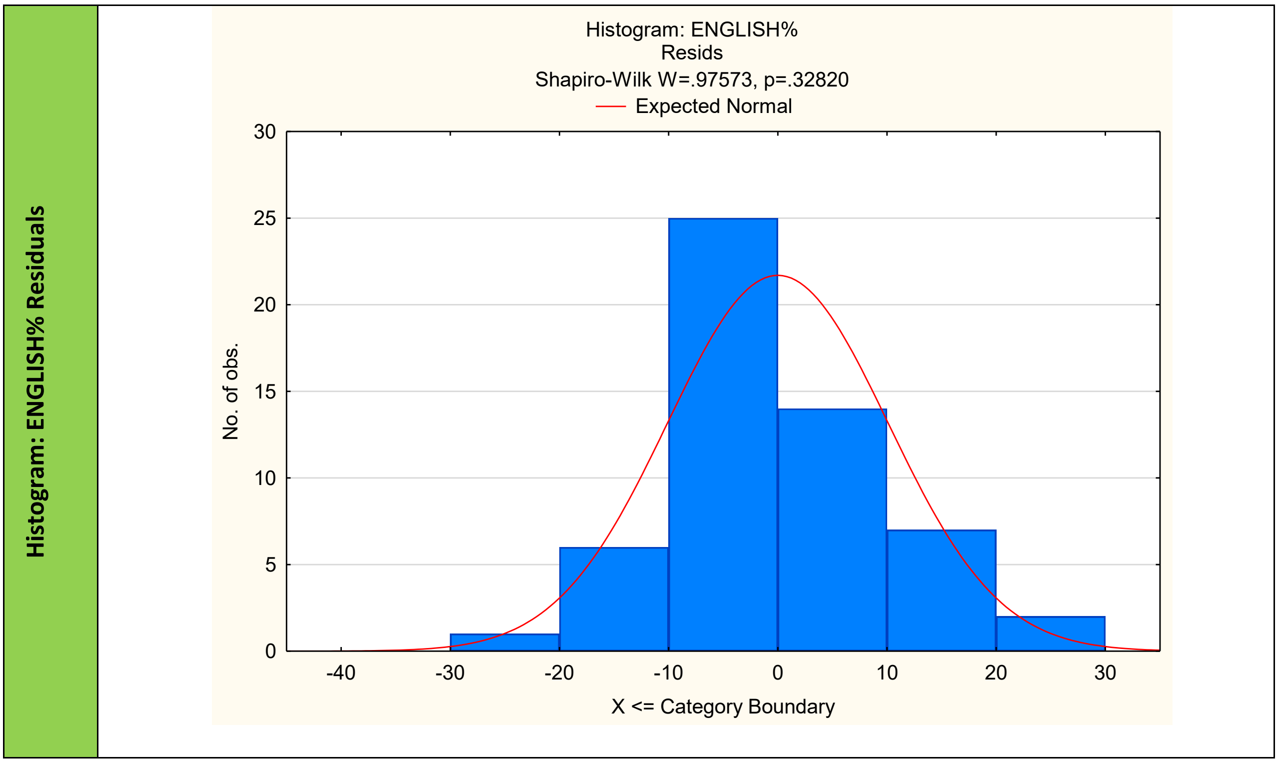


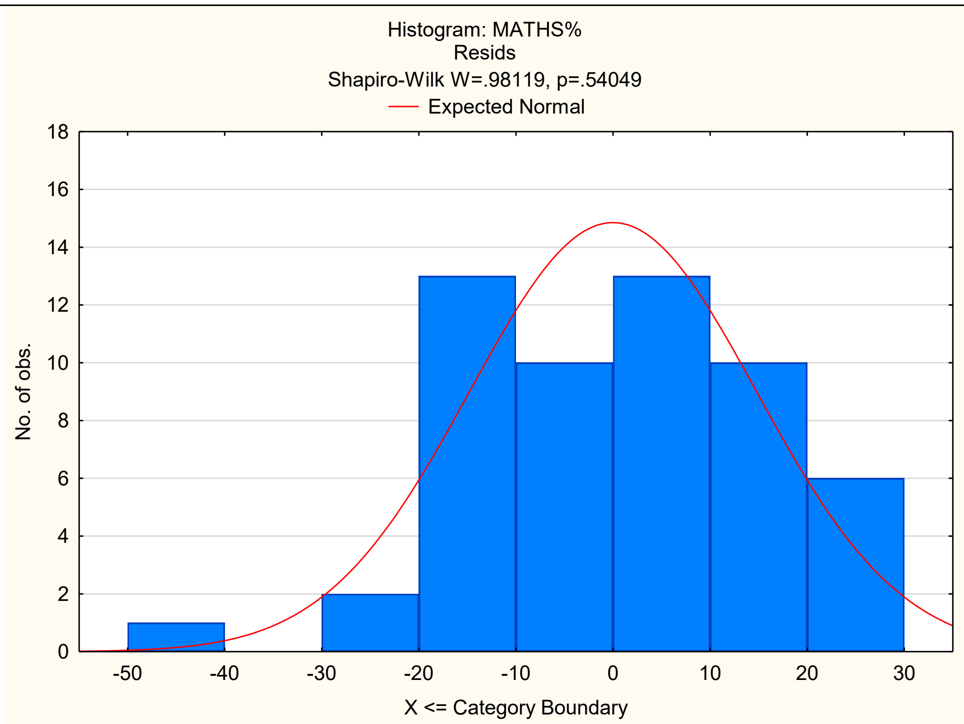
Normal Prob. Plot; Raw Residuals: Maths %



To further check if these measurements are indeed normally distributed, the normality was tested with a Shapiro-Wilk test. The null hypothesis is that the measures are normally distributed. Since the p-values are both > 0.05 the null hypothesis could not be rejected for both English and Maths percentages and thus the analysis is completely valid. The analysis was, however, also done with a non-parametric test, i.e. the Wilcoxon paired test, to confirm that these mean/median percentages do not differ significantly. Figure 6.24 illustrates the English and Mathematics Score Residuals.

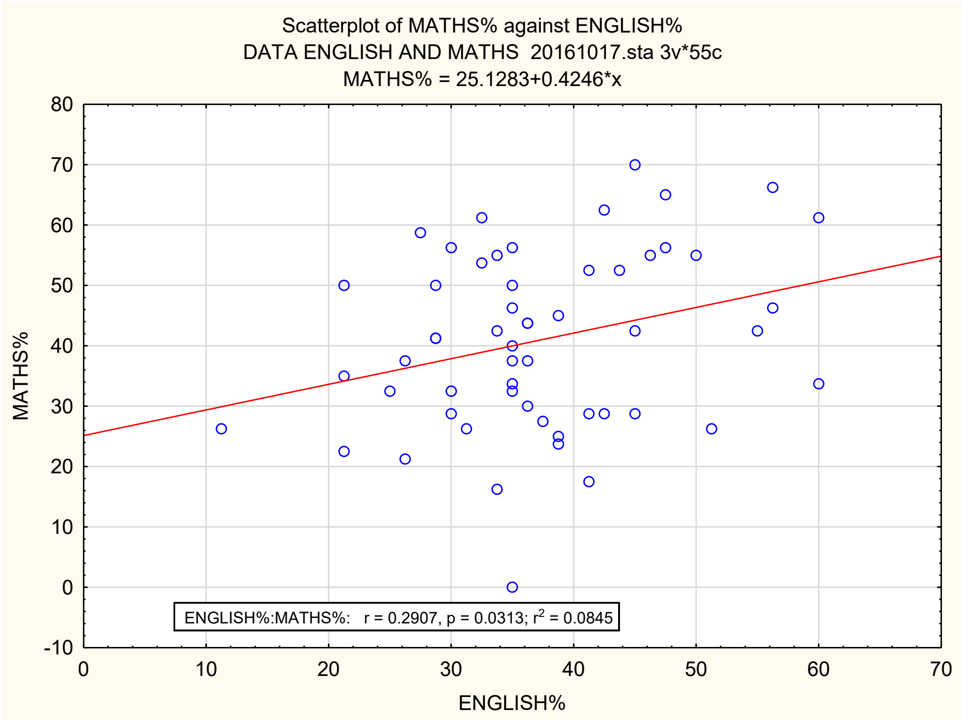
Figure 6.24: English and Mathematics score residuals



Histogram: MATHS % Residuals	

Lastly, the correlation between teacher English language proficiency score (%) as a predictor of Mathematics word problem score (%) was investigated. There is a positive correlation of r=0.2907, which is significant with p-value p=0.0313 < 0.05. The regression of Math% on English% explains only 8.45 % of the variation in Maths% (i.e. the r^2x100 = 0.0845x100). Figure 6.25 is a scatterplot of the teacher English-language proficiency score against the mathematics word problem scores.

Figure 6.25: Scatterplot of Mathematics % versus English %



Since the analysis indicates that there is a correlation between English-language proficiency as a predictor of performance in mathematics word problems, it thus follows that if the English-language proficiency increases, the performance in mathematics word problems will also increase.

As stated in Chapter 1 of this study, Howie (2001) and Taylor (2008) believe that "teachers cannot teach what they do not know". Thus, in extrapolation, teachers cannot improve the learners' language proficiency and mathematics word problem solving skills if their own proficiency is low.

This indicates that if the IP mathematics teachers received support to improve their linguistic skills, they would be able to perform better in mathematics word problems. The advantages of increasing the teachers English-language proficiency would supposedly improve their confidence and the frequency with which they use English as LoLT in IP mathematics classrooms. As such, this improved performance would contribute to improving the learners' performance in mathematics as well.

As established in Chapter 5 (Section 5.5.2.3), the levels of the test are "quite low, as they are trying to establish absolute minimum standards for teachers, the pass rate was thus set at 70% for the two assessments" (JET, 2015). Based on JET's performance scales, a consolidation of these performance scales is illustrated in Table 6.27.

Table 6.8: English and Mathematics assessments performance scales

	English Language Proficiency Scores	Mathematics Word Problem Scores
70% and above	(0) 0%	(1) 2%
50% - 69%	(6) 11%	(18) 33%
Below 50%	(49) 89%	(36) 65%

Key

- **70% and above:** satisfied requirements
- **50% - 69%:** cause for some concern
- **Below 50%:** cause for serious concern

None of the teachers met the requirements in the English language proficiency assessment satisfactorily, because the maximum score recorded is 60%, while 6 (11%) of the teachers scored between 50% - 69%, which is thus *cause for some concern*; 49 (89%) of the teachers scored below 50% and this is *cause for serious concern*. Regarding the Mathematics word problem assessment, only one teacher met the requirement in the mathematics word problem assessment satisfactorily by scoring 70%; 18 (33%) of the teachers scored between 50% - 69%, which is thus cause for some concern, while 36 (65%) of the teachers scored below 50% and this is *cause for serious* concern. Thus, the performance of the majority of the teachers is a cause for *serious concern* in both language proficiency and mathematics word problem assessment; there is greater cause for serious concern in the English-language proficiency assessment than in the mathematics word problem assessment. These consolidated scores emphasise that much still needs to be done to improve the linguistic competencies of IP mathematics teachers.

The sections above provided statistical analyses of the two teacher assessments, while the section below provides a descriptive analysis of the assessments. Considering that the sample size of 55 IP mathematics teachers may be relatively small to be analysed statistically, the descriptive analysis was conducted to complement the statistical analysis as well as to provide an in-depth insight into the teacher assessment scores compared to the statistical analyses.

6.3.3 Descriptive Analysis of Teacher Assessments

The descriptive analyses were conducted on the teacher assessments. The itemised descriptive analyses were conducted by JET and for each assessment item the analyses show the number of teachers who scored different marks against the sum achievable marks. JET analyses excluded on spoilt script; hence the sum of teachers is 54 instead of the sampled 55. In comparison to the Stellenbosch University CSC analyses, which focused on the overall marks obtained in each assessment, JET focused on the itemised analyses of the assessments. Thus the JET descriptive analyses complement the CSC statistical analyses and provide finer details about the teachers' performance in each question of the assessment.

Separate analyses for each teacher assessment were conducted. Since the assessments were used to establish the teacher needs, the identification of these low-score items through the itemised analyses enabled the researcher to identify the sections of the assessment in which the majority of the teachers struggled most. The section below provides the descriptive presentation, analyses and discussion of the English-language proficiency assessment.

6.3.3.1 Descriptive Analyses: Language Proficiency Assessment

The teacher scores on each of the English Language proficiency Assessment items are illustrated in Table 6.9, with the items showing poor performance[21] highlighted.

Table 6.9: Itemised Analyses: English Language Proficiency Assessment

Q1 0 1 Sum 27 27 54	**Q11** 0 1 Sum 40 14 54	**Q21** 0 1 Sum 50 4 54	**Q31** 0 1 2 Sum 29 24 1 54
Q2 0 1 Sum 42 12 54	**Q12** 0 1 2 Sum 16 20 18 54	**Q22** 0 1 2 Sum 20 12 22 54	**Q321** 0 1 Sum 10 44 54 **Q322** 0 1 Sum 12 42 54
Q3 0 1 Sum 52 2 54	**Q13** 0 1 Sum 20 34 54	**Q231** 0 1 Sum 43 11 54 **Q232** 0 1 Sum 42 12 54	**Q33** 0 1 2 Sum 41 6 7 54
Q4 0 1 Sum 36 18 54	**Q14** 0 1 Sum 25 29 54	**Q24** 0 1 2 Sum 30 13 11 54	**Q34** 0 1 2 Sum 26 20 8 54
Q5 0 1 Sum	**Q15** 0 1 Sum	**Q25** 0 1 Sum	**Q35** 0 1 2 Sum

[21] The assessment items highlighted are those where more than half of the respondents obtained zero.

9 45 54	32 22 54	48 6 54	7 28 19 54
Q6a 0 1 Sum 44 10 54 **Q6b** 0 1 Sum 40 14 54	**Q16a** 0 1 Sum 30 24 54 **Q16b** 0 1 Sum 28 26 54	**Q26** 0 1 2 Sum 48 4 2 54	**Q36** 0 1 2 Sum 32 15 7 54
Q7 0 1 2 Sum 35 10 9 54	**Q17** 0 1 2 3 Sum 15 30 7 2 54	**Q27** 0 1 Sum 27 27 54	**Q37a** 0 1 2 Sum 10 26 18 54 **Q37b** 0 1 2 Sum 12 31 11 54
Q8 0 1 Sum 15 39 54	**Q18** 0 1 Sum 52 2 54	**Q28** 0 1 2 Sum 17 30 7 54	**Q38** 0 1 2 Sum 24 22 8 54
Q9 0 1 Sum 50 4 54	**Q19** 0 1 2 3 Sum 14 11 8 21 54	**Q29** 0 1 Sum 12 42 54	**Q39** 0 1 11 Sum 43 10 1 54
Q101paragraphformat 0 1 Sum 4 50 54 **Q102Content** 0 1 2 3 4 Sum 2 12 19 20 1 54 **Q103Descriptivelanguage** 0 1 2 Sum 3 47 4 54 **Q104Grammar** 0 1 2 Sum 11 40 3 54	**Q20** 0 1 Sum 47 7 54	**Q30** 0 1 Sum 28 26 54	**Q40** 0 1 2 Sum 43 10 1 54 **Q41** 0 1 2 Sum 36 11 7 54 **Q42** 0 1 2 Sum 20 32 2 54 **Q43** 0 1 Sum 41 13 54
		Total Number of Assessment Items	**51 (100%)**

Total Number of Assessment Items in which ≥50% of the teachers scored 0	**29 (57%)**

An overview of the itemised analyses of the English Language Proficiency Assessment indicated that at least 50% of the teachers scored 0 in 57% of the assessment items. These results concur with the data from earlier sections of this chapter, which reveal that the teacher language proficiency in English is significantly low.

The English-language competency assessment consisted of six different sections (A, B, C, D E, and F), focusing on a variety of language skills such as basic paragraph format, comprehension of content, use of descriptive language, grammar and pedagogy, as detailed in the assessment framework in Section 5.4.3 of this study. The first three sections made up Part One of the assessment, while the last three sections made up Part Two. Each part had a variety of multiple-choice, restricted-response and open-ended questions. The level of difficulty of questions increased from Part One to Part Two of the assessment. A more detailed descriptive analysis of the English Language Assessment is illustrated in Table 6.10.

Table 6.10: Itemised Analyses: English Language Proficiency Assessment

	N	Mean	StError	Median	StDev	Min	Max	Range
Total Mark A %	54	40.92	1.769	40.48	13	4.762	71.43	66.67
Total Mark B %	54	39.35	2.573	41.67	18.91	0	75	75
Total Mark C %	54	28.52	2.132	26.67	15.67	0	60	60
Total Mark Part One %	54	36.65	1.444	34.38	10.61	14.58	60.42	45.83
Total Mark D %	54	46.53	2.133	43.75	15.67	12.5	75	62.5
Total Mark E %	54	53.24	3.968	50	29.16	0	100	100
Total Mark F %	54	22.38	2.391	20.83	17.57	0	100	100
Total Mark Part Two %	54	38.31	1.864	40.62	13.7	6.25	71.88	65.62
Raw Total Mark %	54	37.31	1.388	35.62	10.2	11.25	60	48.75

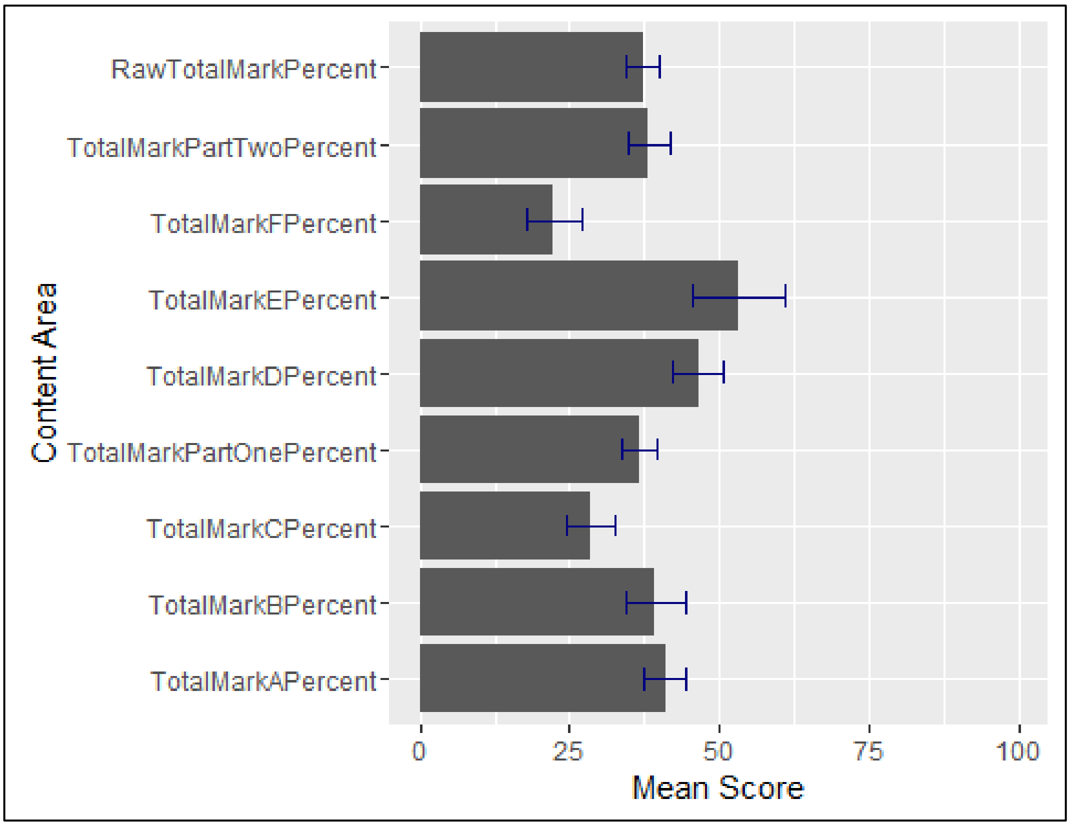
As illustrated in Table 6.10 above, the teachers fared better in Part One (Minimum 14.58%, Maximum 60.42%) compared to Part Two (Minimum 6.25%, Maximum 71.88%). Thus, performance in the more demanding sections which required detailed descriptions and explanations of linguistic concepts instead of mere recall of facts was significantly low. A summarised analysis of English Language Competency Assessment scores is illustrated in Table 6.11.

Table 6.11: Summary of Descriptive Analyses: English Language Proficiency Assessment

	N	Mean	StError	Median	StDev	Min	Max	Range
English	54	37.31	1.388	35.62	10.2	11.25	60	48.75

As illustrated in Table 6.11, the mean score was 37.31%, the median was 35.62%, while the minimum and maximum scores were 11.25% and 60% respectively. The range between the minimum and maximum was thus 48.75%. The descriptive analyses tally with Stellenbosch University CSC's analyses illustrated in earlier sections of this chapter (Section 6.2). Figure 6.26 illustrates the mean scores on each section of the English Language Proficiency Assessment.

Figure 6.26: Bar Graph of Sub-section: English Language Proficiency Assessment



As illustrated in Figure 6.26, Section E had the highest mean score (above 50%), while section F had the lowest mean score (below 25%). Based on Section E, which had the highest mean score, followed by section D, the mean score for Part Two which encompasses these two sections is thus much higher than the mean score for Part One.

What is noteworthy about Section E is that the total achievable marks were only [4] and, although forming part of the English Language Competency Assessment, the question was based on a typical lower-cognitive demand *mathematical word problem*, which requires simple recall of facts and interpretation of tabulated information as illustrated in Table 6. 12.

Table 6.12: Sample Teacher Responses to a typical English Language Proficiency Assessment Question

Question

Section E.

Read the table of results from a survey which asked children about their favourite foods. Note that they could choose more than one food item and many did so.

Table 1: Children's favourite foods

Food item	***Percentage of children who chose the item***
Chips	***36%***
Fresh vegetables	***15%***
Toasted cheese	***25%***
Chicken	***65%***
Hamburgers	***27%***

37) Write two questions that you could ask Grade 4 to 6 learners about the information in the table.

a) ____

____ *(2)*

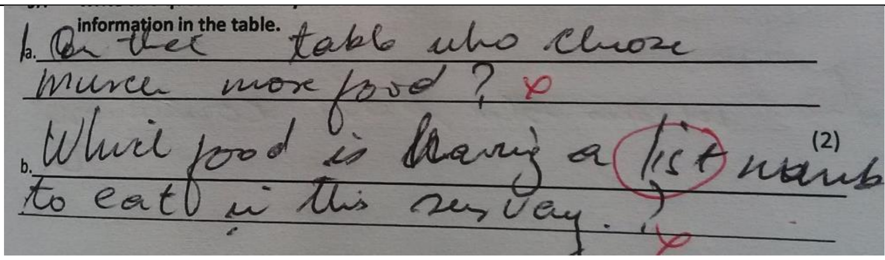
b) ____

____ *(2)*

Total marks for Section E = 4 marks

Sample Responses

T5

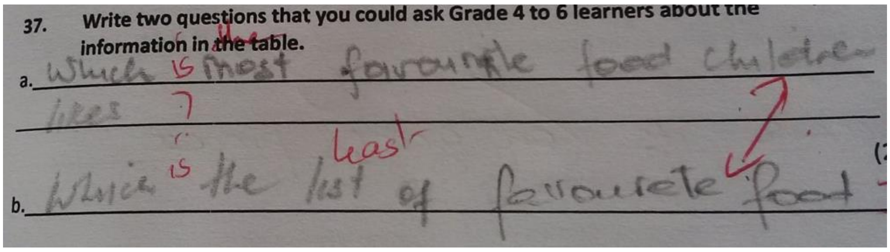


information in the table.

a. On the table who chose muce more food? ✗

b. Which food is having a list want to eat in this survey.? ✗ (2)

T10

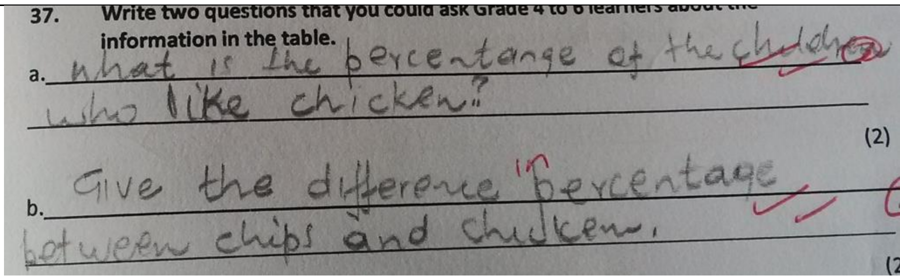


37. Write two questions that you could ask Grade 4 to 6 learners about the information in the table.

a. Which is most favourite food children likes ?

b. Which is the least list of favourete food

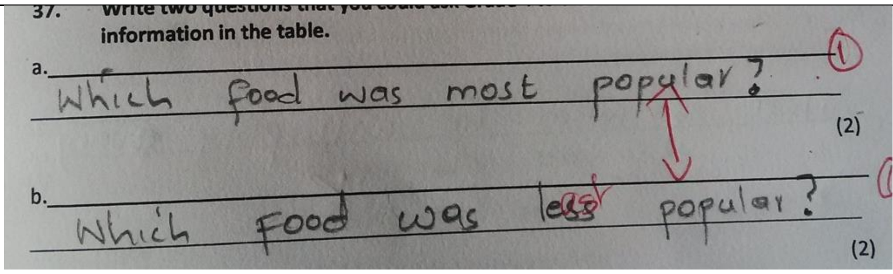
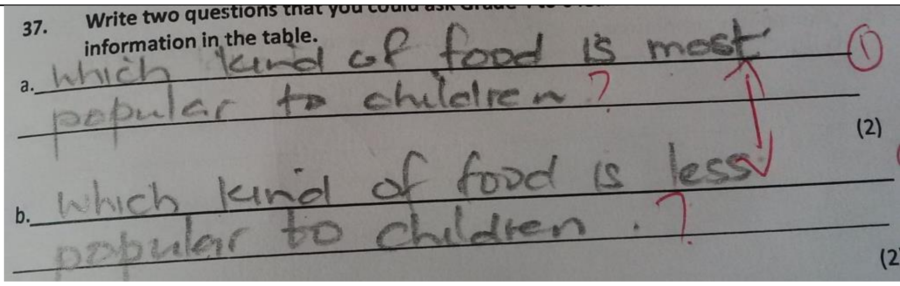
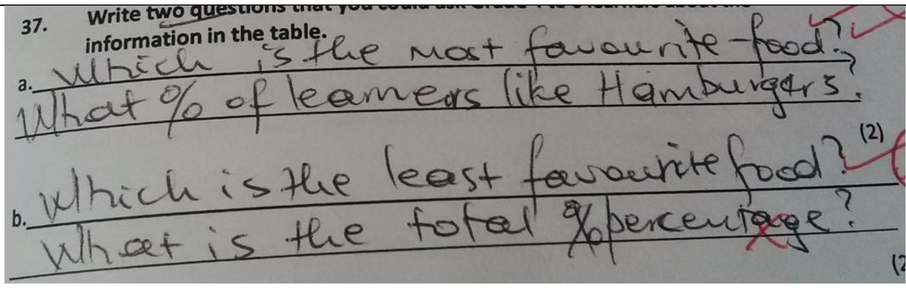
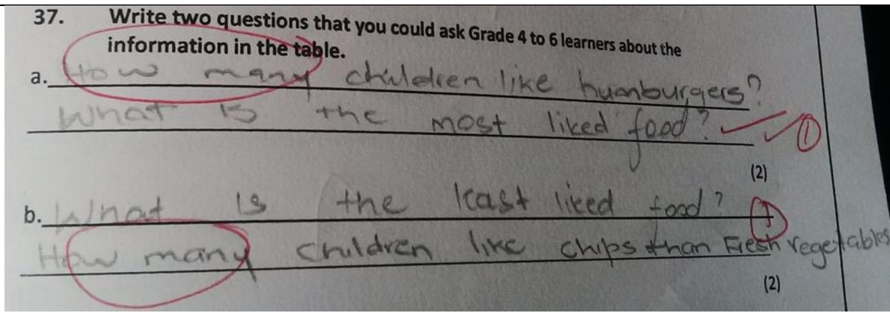
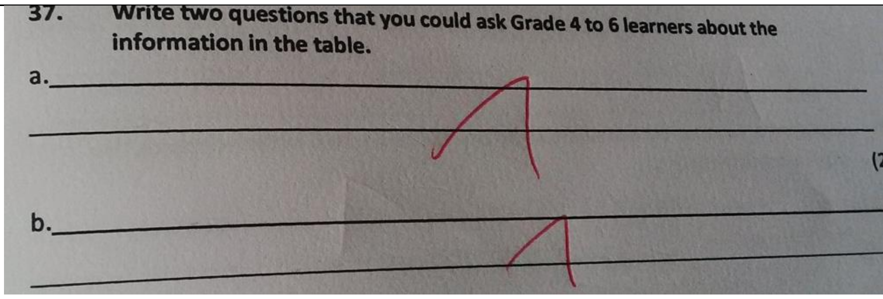
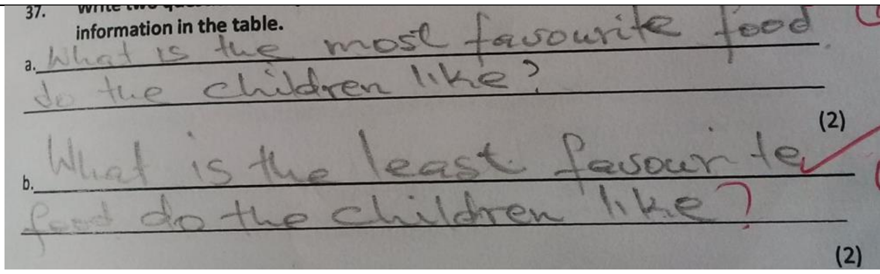
T15

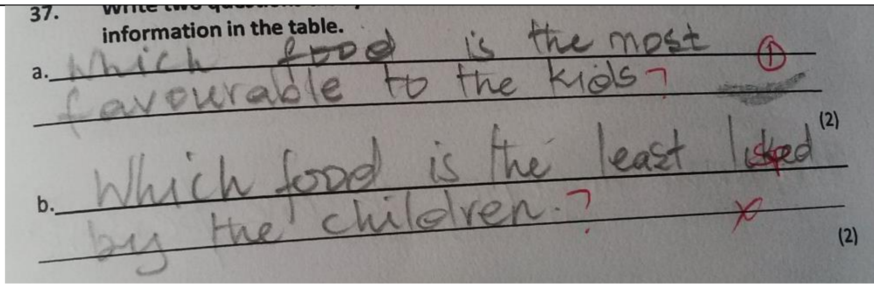
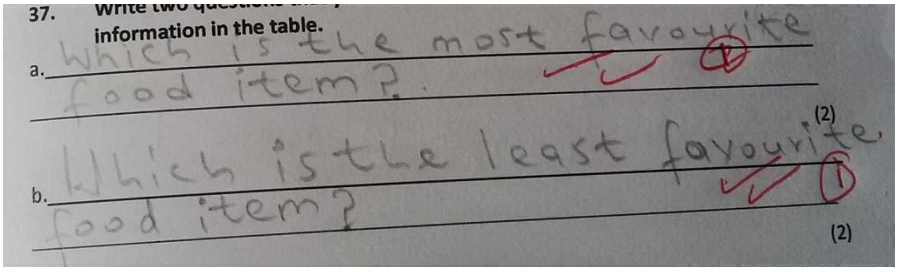


37. Write two questions that you could ask Grade 4 to 6 learners about the information in the table.

a. what is the percentange of the children who like chicken? (2)

b. Give the difference in percentage between chips and chicken.

	T20	 37. Write two questions that you could ask Grade ... information in the table. a. Which food was most popular? (2) b. Which food was less popular? (2)
	T25	 37. Write two questions that you could ask Grade 4 to 6 ... information in the table. a. which kind of food is most popular to children? (2) b. which kind of food is less popular to children.? (2
	T30	 37. Write two questions that you could ask Grade 4 to 6 learners about the information in the table. a. Which is the most favourite food? What % of learners like Hamburgers? (2) b. Which is the least favourite food? What is the total % percentage? (2
	T35	 37. Write two questions that you could ask Grade 4 to 6 learners about the information in the table. a. How many children like humburgers? What is the most liked food? (2) b. What is the least liked food? How many children like chips than Fresh Vegetables (2)
	T40	 37. Write two questions that you could ask Grade 4 to 6 learners about the information in the table. a. (2 b.
	T45	 37. Write two ... information in the table. a. What is the most favourite food do the children like? (2) b. What is the least favourite food do the children like? (2)

<table>
<tr>
<td rowspan="2"></td>
<td>T50</td>
<td>
37. information in the table.
a. Which food is the most favourable to the kids? (2)
b. Which food is the least liked by the children.? (2)</td>
</tr>
<tr>
<td>T55</td>
<td>
37. information in the table.
a. Which is the most favourite food item?. (2)
b. Which is the least favourite food item? (2)</td>
</tr>
<tr>
<td colspan="2">Itemised Analysis</td>
<td>
Q37a
<table>
<tr><td>0</td><td>1</td><td>2</td><td>Sum</td></tr>
<tr><td>10</td><td>26</td><td>18</td><td>54</td></tr>
</table>
Q37b
<table>
<tr><td>0</td><td>1</td><td>2</td><td>Sum</td></tr>
<tr><td>12</td><td>31</td><td>11</td><td>54</td></tr>
</table>
</td>
</tr>
</table>

Adapted from JET, (2015a)

The sample responses illustrated in Table 6.12 exhibit a variety of linguistic challenges ranging from spelling mistakes, omission of the question mark (punctuation), grammatical mistakes, repetition and duplication of information as well as provision of information that does not answer the question, and incomplete answers. In earlier sections of this chapter the respondents (through teacher questionnaires) commented on the learners' poor language competency without commenting on their own language competency, which borders on inadequate, as shown in the language competency assessment. However, the descriptive analyses in Figure 6.26 indicate that sub-section E had the highest scores; thus, teachers are relatively comfortable with answering questions with lower-order linguistic demands, but such questions address only a minority of the teaching and learning content. In as much as the relatively high performance in low-order questions is highly commendable, IP teachers need to broaden their command of the English language to include even higher-order questions for the purposes of improving the quality of instruction using English as LoLT.

The section below provides the descriptive presentation, analyses and discussion of the Mathematics Word Problem Assessment.

6.3.3.2 Descriptive Analyses: Mathematics Word Problem Assessment

The teacher scores on each of the Mathematics Word Problem Assessment items are indicated in Table 6.13, with the items exhibiting poor performance[22] highlighted:

Table 6.13: Itemised Analyses: Mathematics Word Problem Assessment

Q1 0 1 Sum 34 20 54	**Q11** 0 1 Sum 26 28 54	**Q21** 0 Sum 54 54	**Q31** 0 1 Sum 39 15 54
Q2 0 1 Sum 34 20 54	**Q12** 0 1 Sum 49 5 54	**Q22** 0 1 2 Sum 25 8 21 54	**Q32** 0 1 Sum 40 14 54
Q3a 0 1 Sum 23 31 54 **Q3b** 0 1 Sum 31 23 54 **Q3c** 0 1 Sum 16 38 54 **Q3d** 0 1 Sum 8 46 54	**Q13ai** 0 1 Sum 8 46 54 **Q13aii** 0 1 Sum 41 13 54 **Q13bi** 0 1 11 Sum 3 50 1 54 **Q13bii** 0 1 Sum 33 21 54 **Q13ci** 0 1 Sum 20 34 54 **Q13cii** 0 1 Sum 35 19 54	**Q23** 0 1 Sum 30 24 54	**Q33a** 0 1 Sum 47 7 54 **Q33b** 0 1 2 Sum 49 2 3 54
Q4ai 0 1 Sum 3 51 54 **Q4aii**	**Q14a** 0 1 2 Sum 5 33 16 54 **Q14bi**	**Q24a** 0 1 Sum 17 37 54 **Q24b**	**Q34a** 0 1 Sum 42 12 54 **Q34b**

[22] The assessment items highlighted are those where more than half of the respondents obtained zero.

0	1	Sum
3	51	54

Q4aiii

0	1	Sum
10	44	54

Q4bi

0	1	Sum
20	34	54

Q4bii

0	1	Sum
26	28	54

Q4biii

0	1	Sum
27	27	54

0	1	Sum
11	43	54

Q14bii

0	1	2	Sum
23	13	18	54

0	1	2	Sum
34	13	7	54

0	1	2	3	Sum
35	1	9	9	54

Q5a

0	1	Sum
24	30	54

Q5b

0	1	11	Sum
7	46	1	54

Q5c

0	1	Sum
22	32	54

Q5d

0	1	Sum
48	6	54

Q15

0	1	2	Sum
40	13	1	54

Q25

0	1	Sum
33	21	54

Q35

0	1	Sum
53	1	54

Q6

0	1	Sum
31	23	54

Q16

0	1	2	3	Sum
27	7	7	13	54

Q26

0	1	Sum
51	3	54

Q7a

0	1	Sum
9	45	54

Q7b

Q17

0	1	Sum
32	22	54

Q27a

0	1	Sum
33	21	54

Q27b

0 1 Sum 23 31 54 **Q7c** 0 1 Sum 21 33 54 **Q7d** 0 1 Sum 16 38 54		0 1 Sum 35 19 54 **Q27c** 0 1 Sum 53 1 54 **Q27d** 0 1 Sum 26 28 54 **Q27e** 0 1 Sum 43 11 54 **Q27f** 0 1 Sum 53 1 54	
Q8a 0 1 Sum 21 33 54 **Q8b** 0 1 Sum 22 32 54 **Q8c** 0 1 Sum 33 21 54	**Q18a** 0 1 Sum 18 36 54 **Q18b** 0 1 Sum 10 44 54	**Q28** 0 1 Sum 36 18 54	
Q9 0 1 Sum 53 1 54	**Q19a** 0 1 Sum 45 9 54 **Q19b** 0 1 Sum 50 4 54	**Q29** 0 1 Sum 34 20 54	
Q10 0 1 Sum 46 8 54	**Q20** 0 1 Sum 48 6 54	**Q30** 0 1 Sum 19 35 54	

Total Number of Assessment Items	**68 (100%)**
Total Number of Assessment Items in which ≥50% of the teachers scored 0	**38 (56%)**

An overview of the itemised analyses of the Mathematics Word Problem Assessment indicated that at least 50% of the teachers scored 0 in 56% of the assessment items.

The mathematics word problem assessment consisted of different sub-sections covering the four mathematical strands, namely number operations; patterns, functions and algebra; geometry and measurement; data handling and the associated pedagogy, as detailed in the assessment framework in Section 5.4.3 of this study. The descriptive analysis illustrated how teachers fared on the lower and higher cognitive questions categorised into easy, moderate and difficulty levels. Since IP teachers are expected to teach up to Grade 7 level and the assessment was set at Grade 7 level, the assessment included questions from both IP and SP levels, though there were fewer SP questions than IP questions. A more detailed descriptive analysis of the Mathematics Word Problem Assessment is provided in Table 6.14.

Table 6.14: Itemised Analyses: Mathematics Word Problem Assessment

	N	Mean	StError	Median	StDev	Min	Max	Range
Sub11 Number Operations %	54	54.35	2.349	53.49	17.26	18.6	88.37	69.77
Sub12 Patterns Functions Algebra %	54	36.89	2.477	38.46	18.2	0	69.23	69.23
Sub13 Geometry Measurement %	54	25.69	3.063	18.75	22.51	0	93.75	93.75
Sub14 Data Handling %	54	21.85	4.304	0	31.63	0	80	80
Sub21 Lower %	54	53.47	2.266	54.69	16.65	25	87.5	62.5
Sub22 Higher %	54	37.17	1.845	37.04	13.56	7.407	62.96	55.56
Sub23 Pedagogy %	54	33.23	2.666	27.78	19.59	5.556	83.33	77.78
Sub31 Easy %	54	61.95	2.578	63.64	18.94	27.27	95.45	68.18
Sub32 Moderate %	54	39.41	2.157	37.21	15.85	11.63	74.42	62.79
Sub33 Difficult %	54	23.3	1.74	25	12.79	0	50	50
Sub41 IP %	54	52.08	2.307	51.04	16.95	20.83	85.42	64.58
Sub42 SP %	54	28.86	1.78	27.59	13.08	6.897	58.62	51.72
Sub51 Restricted Response %	54	43.96	2.043	43	15.01	16	74	58
Sub52 Open Ended %	54	32.26	2.535	26.32	18.63	5.263	78.95	73.68
Sub53 MCQ %	54	65.74	2.521	62.5	18.52	25	100	75

Key: IP = ***Intermediate Phase*** **SP =** ***Senior Phase*** **MCQ =** ***Multiple Choice Question***

As illustrated in Table 6.13, the teachers fared better in the multiple-choice questions, (Minimum 25%, Maximum 100%); compared to the restricted-response questions (Minimum 16%, Maximum 74%), and the open-ended questions (Minimum 5.26%, Maximum 78,95%). Thus, performance in the open-ended questions, which required detailed descriptions and explanations of procedures instead of mere recall and computation of digits, was significantly low. A summarised analysis of Mathematics Word Problem Assessment scores is provided in Table 6.15.

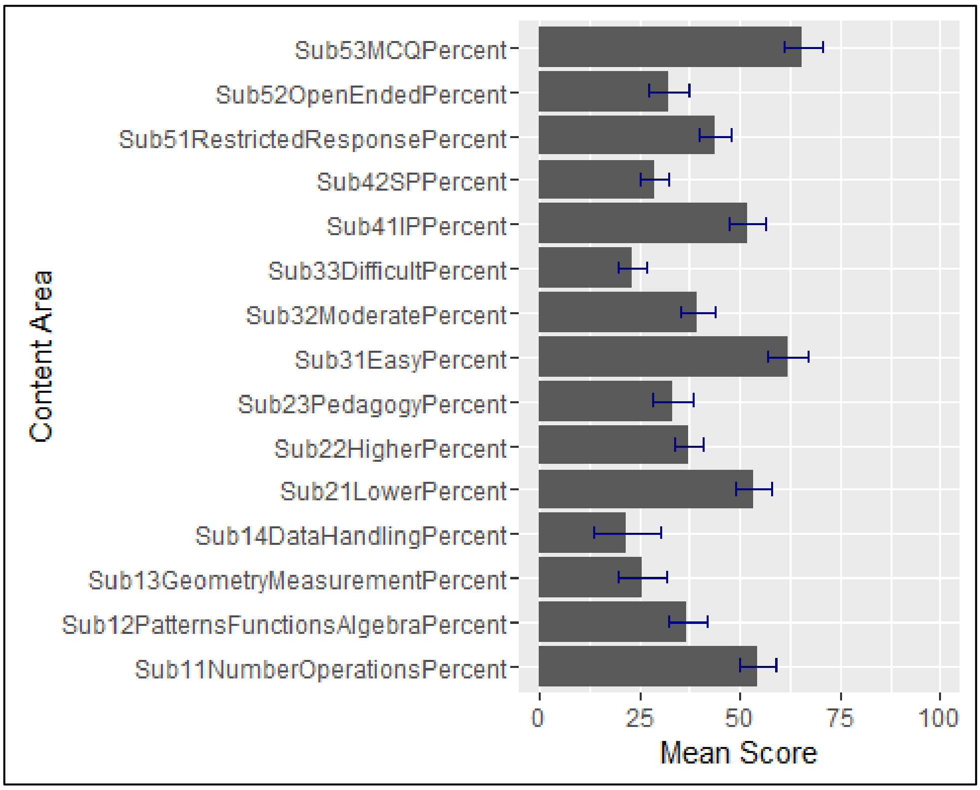
Table 6.15: Summary of Descriptive Analyses: Mathematics Word Problem Assessment

	N	Mean	StError	Median	StDev	Min	Max	Range
Maths	54	43.34	1.949	43.51	14.33	16.88	72.73	55.84

As illustrated in Table 6.15, the mean score was 43.34%, the median was 43.51%, while the minimum and maximum scores were 16.88% and 72.73% respectively. The range between the minimum and maximum scores was thus 55.84%. The descriptive analyses tally with Stellenbosch University CSC's analyses illustrated earlier in this chapter (Section 6.2).

Figure 6.27 indicates the mean scores on each sub-section and content area of the Mathematics Word Problem Assessment.

Figure 6.27: Bar Graph of Sub-sections: Mathematics Word Problem Assessment

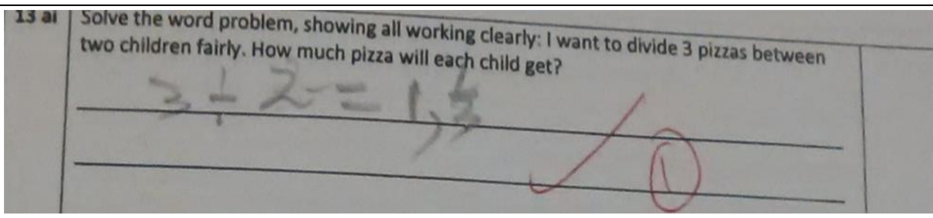


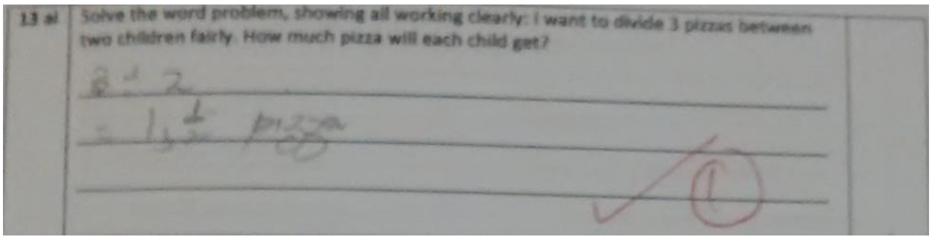
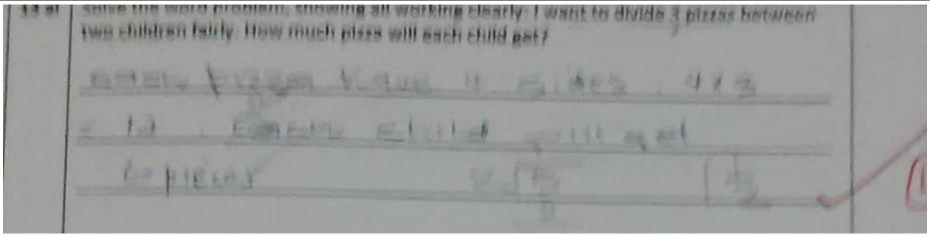
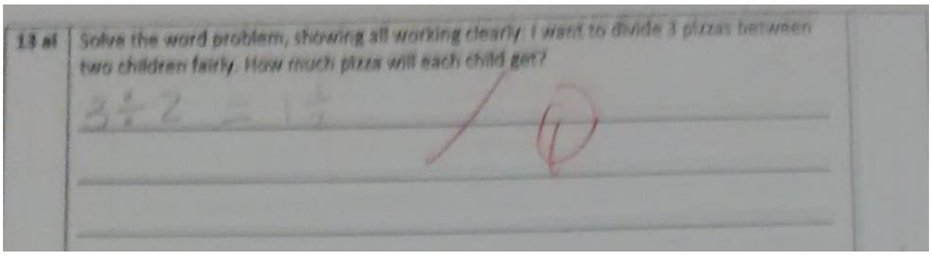
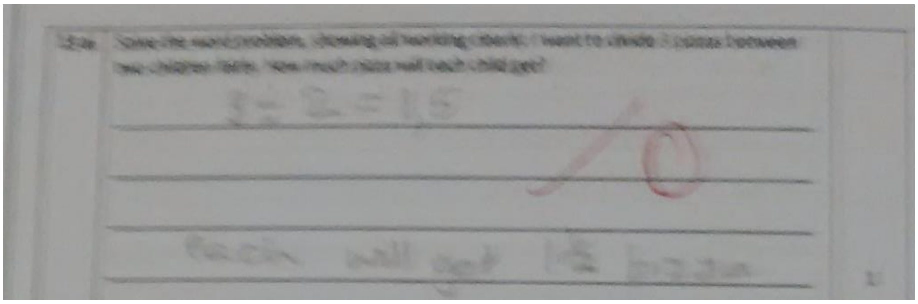
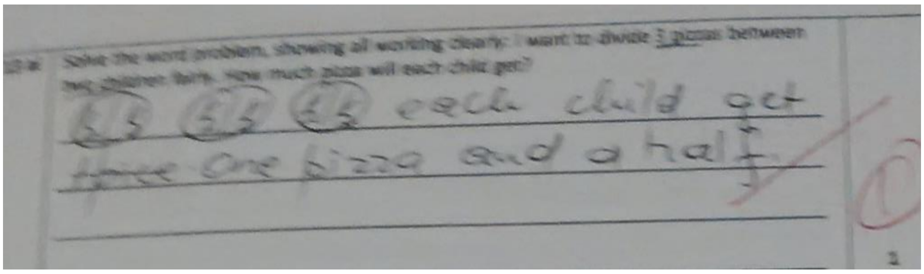
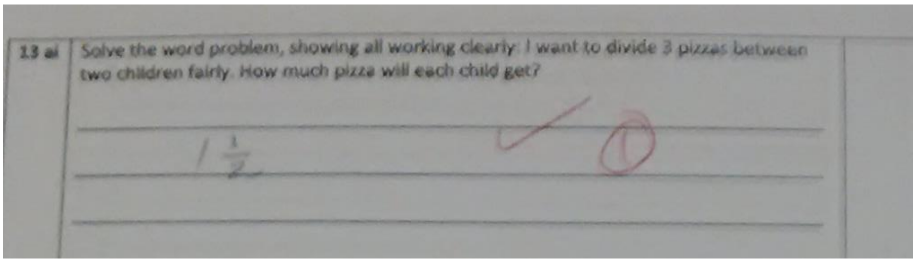
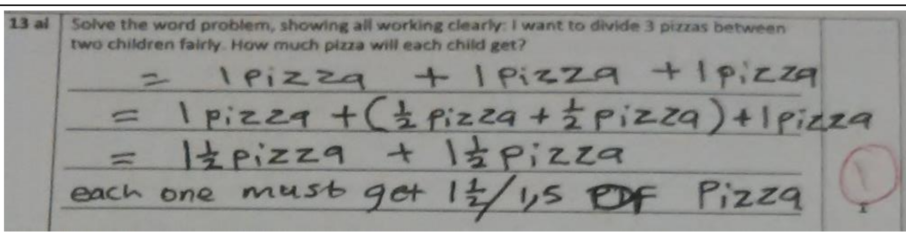
As illustrated in Figure 6.27 regarding question type, multiple-choice questions had the highest mean score (above 62.5%) followed by restricted-response questions (above 37.5%), while open-ended questions had the lowest mean score (slightly above 25%). Regarding school phase levels, IP questions had a higher mean score of above 50% compared to SP questions with a mean score slightly above 25%. Regarding difficulty levels, easy questions had the highest mean score (62.5%) followed by moderate questions (slightly above 37.5%), while the difficult questions had the lowest mean score (slightly below 25%). Regarding knowledge domains, lower cognitive questions had the highest mean score (above 50%) followed by higher cognitive questions (37.5%), while the application and pedagogical questions had the lowest mean score (slightly below 37.5%). Regarding the broad mathematical content area, Number Operation questions had the highest mean score (slightly above 50%), followed by Patterns, Functions and Algebra questions (37.5%), followed by Geometry and Measurement (25%), while Data Handling questions had the lowest mean score (slightly below 25%).

Noteworthy about the different sections analysed in Figure 6.27 is the fact that multiple-choice questions, IP questions, easy questions, and low-order questions had significantly higher mean scores compared to their respective counterparts. Similarly, Number Operations questions that rely heavily on computation of digits also had significantly higher scores compared to the mathematical strands involving more language-based questions. This further confirms that teachers grapple with language-based mathematical problems.

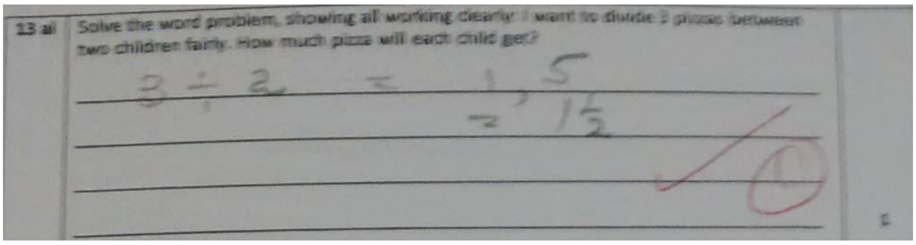
Some of the data presented above includes aspects falling beyond the scope of this study. The section below presents, analyses and discusses a comparison between the teachers' competency levels in English to their performance, particularly in word based mathematical problems, namely Questions 13, 14 and 15 of the mathematics assessment. Samples of the teacher responses in the word-based mathematical problems (Question 13 are provided in Table 6.16 with the items exhibiting significantly poor performance highlighted.

Table 6.16: Sample Teacher Responses: Mathematics Word Problem Assessment

Question		***13ai)*** *Solve the word problem, showing all working clearly: I want to divide 3 pizzas between two children fairly. How much pizza will each child get?* ***(1)*** ________ ________ ________
Responses	**T5**	 13 ai Solve the word problem, showing all working clearly: I want to divide 3 pizzas between two children fairly. How much pizza will each child get? 3 ÷ 2 = 1,5 (1)

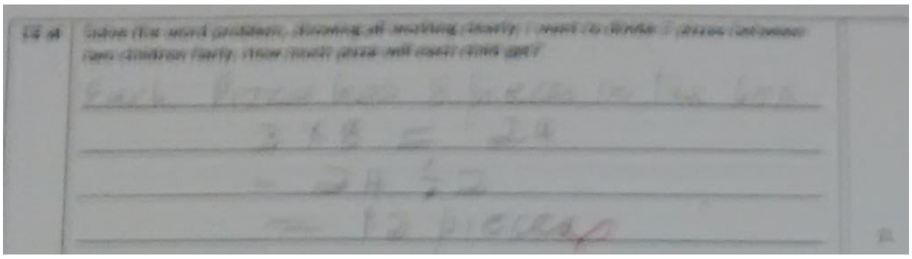
	T10	
	T15	
	T20	
	T25	
	T30	
	T35	
	T40	

T45

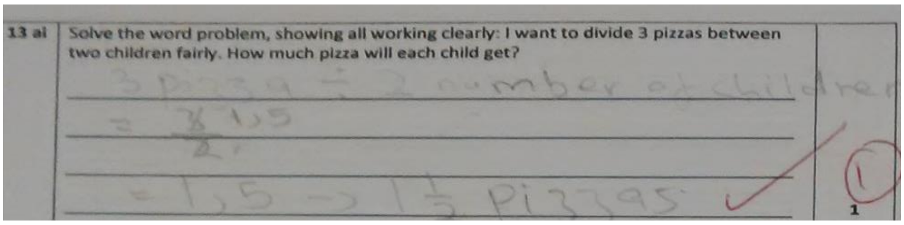

13 ai Solve the word problem, showing all working clearly: I want to divide 3 pizzas between two children fairly. How much pizza will each child get?

3 ÷ 2 = 1,5 = 1½

T50



T55


13 ai Solve the word problem, showing all working clearly: I want to divide 3 pizzas between two children fairly. How much pizza will each child get?

3 pizza ÷ 2 number of children

= 3/2 1,5

= 1,5 → 1½ pizzas

Itemised Analysis

0	1	Sum
8	46	54

Question

13aii) *Would the word problem "I want to divide 3 pizzas between two children fairly. How much pizza will each child get?" be a good word problem to illustrate 3 divided by ½? Explain why you say so.*

(1)

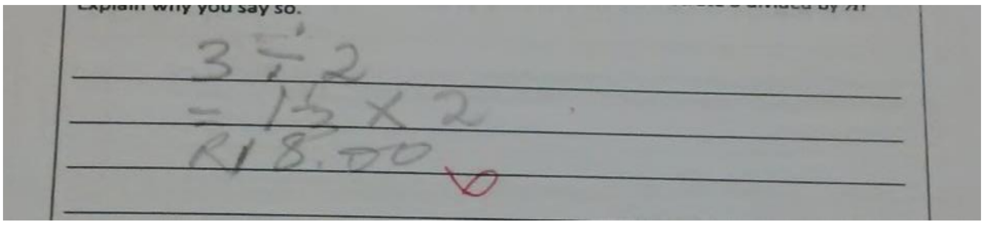
____

____

____

Sample Responses

T5

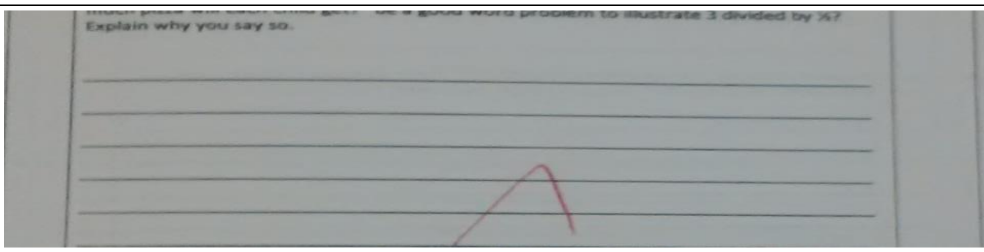

Explain why you say so.

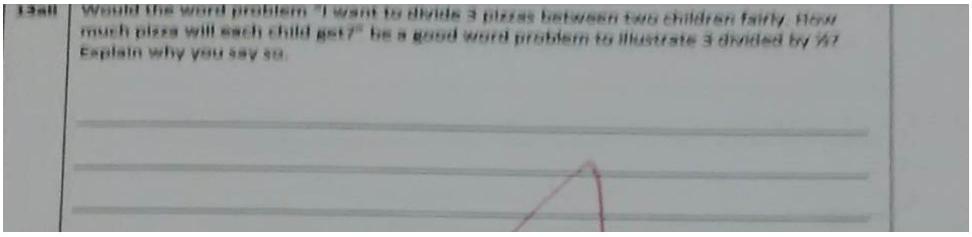
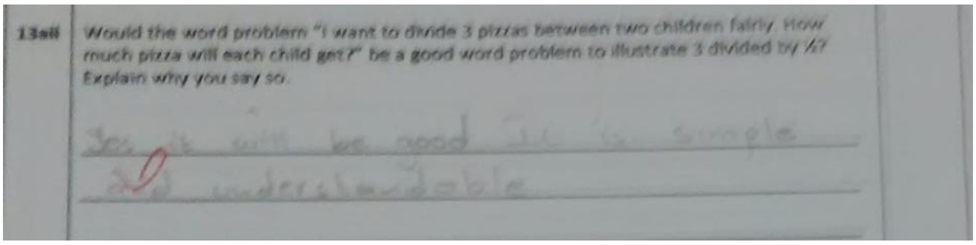
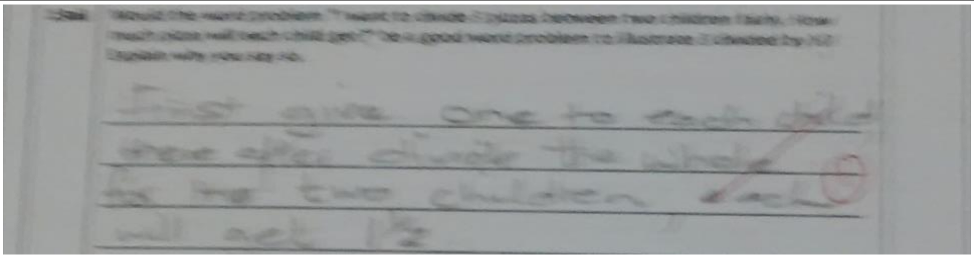
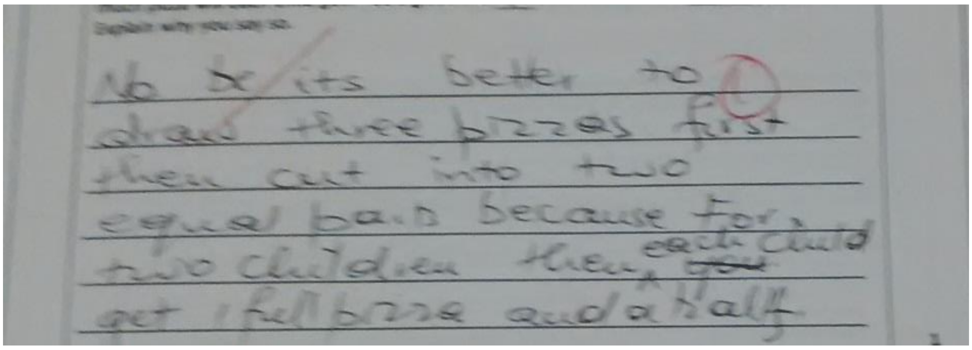
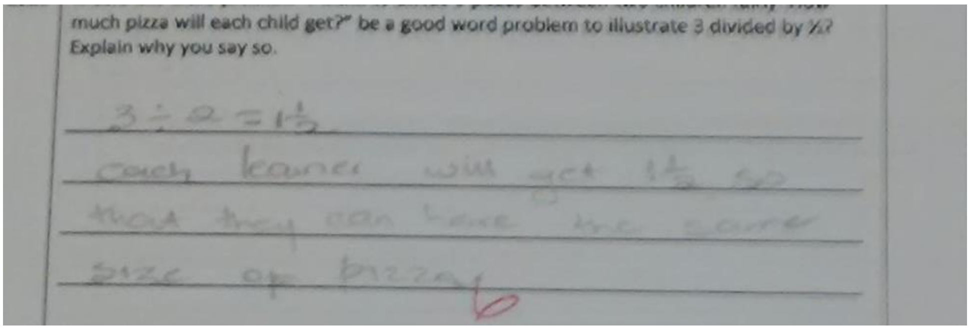
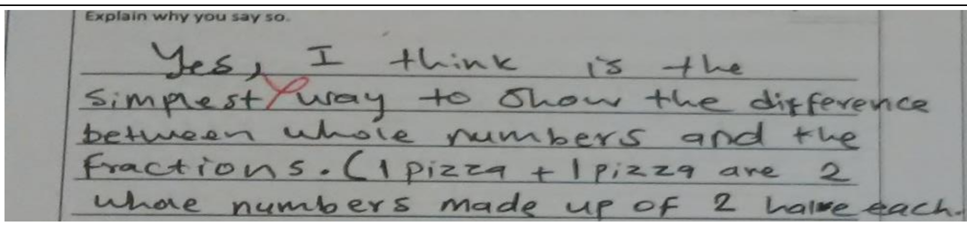
3 ÷ 2

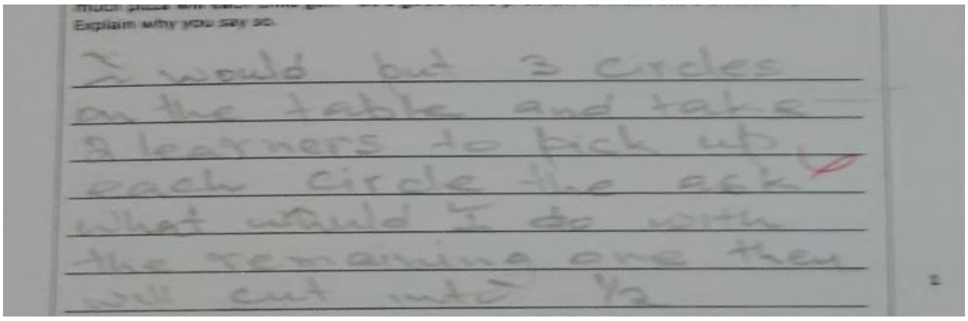
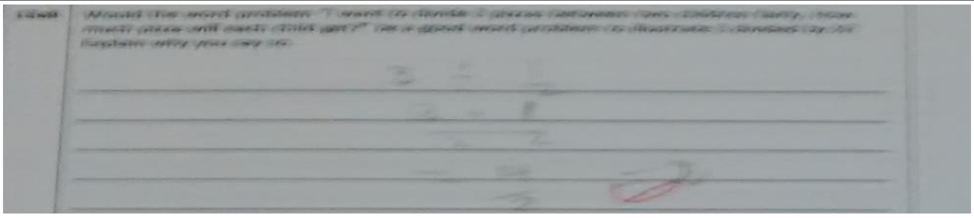
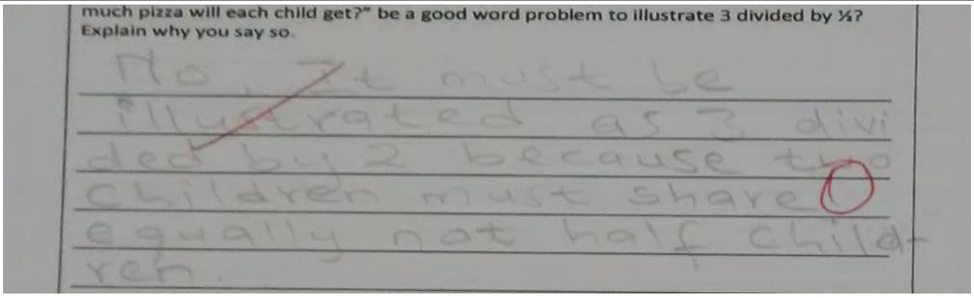
= 1½ x 2

R18.00

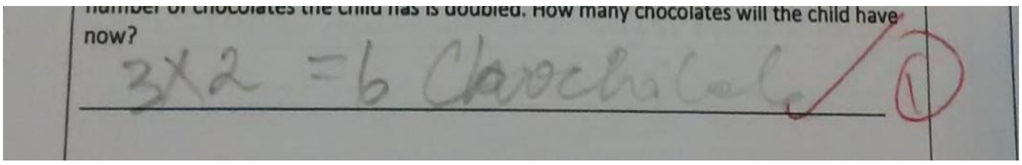
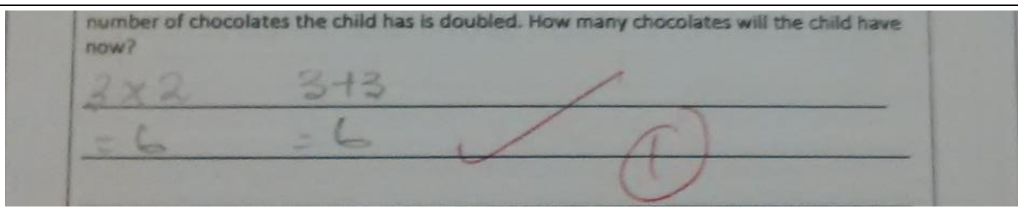
T10

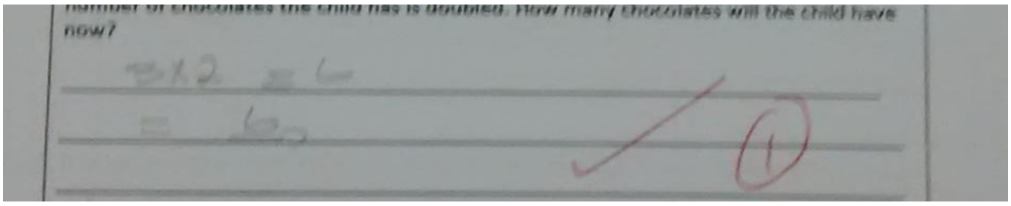
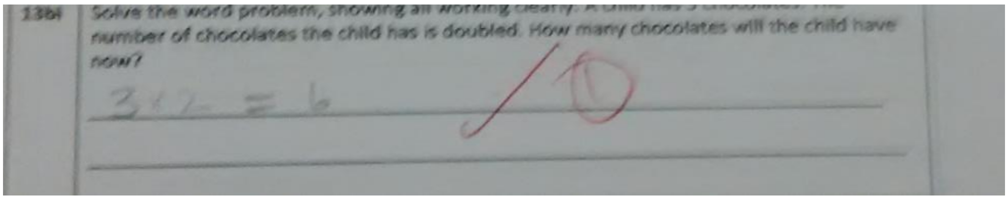
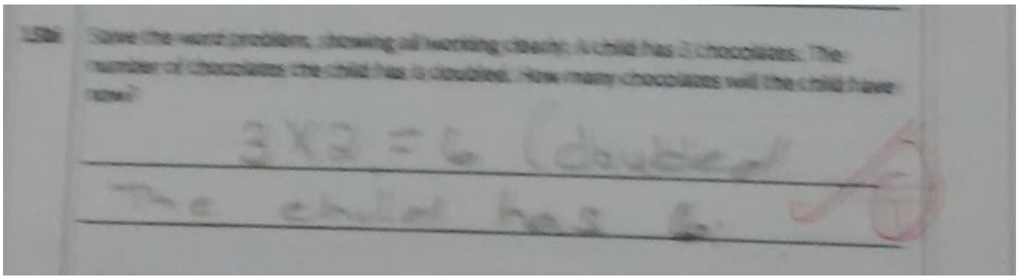
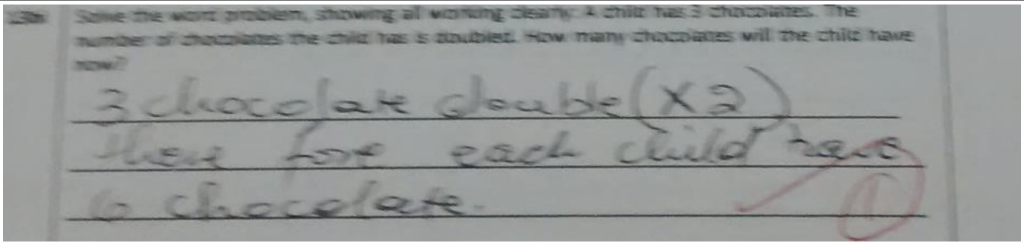
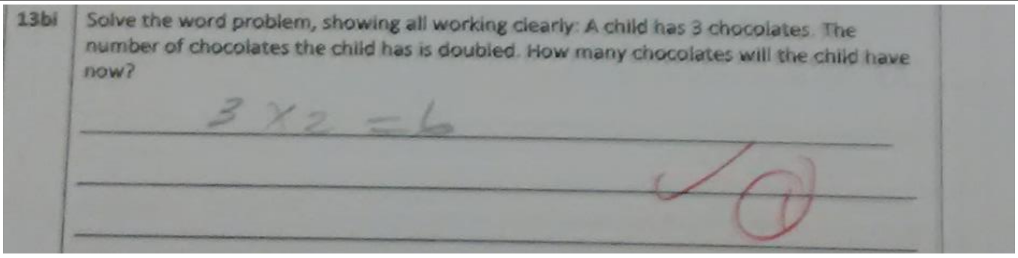
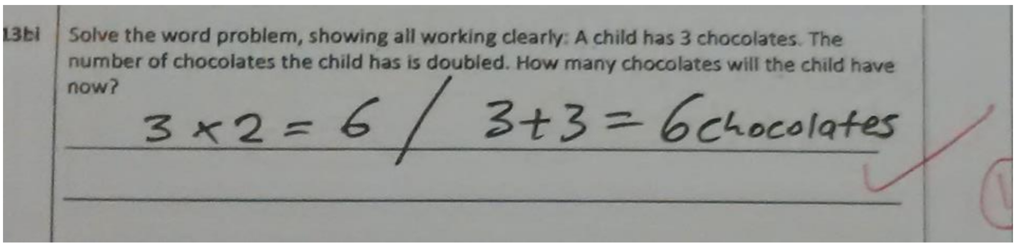
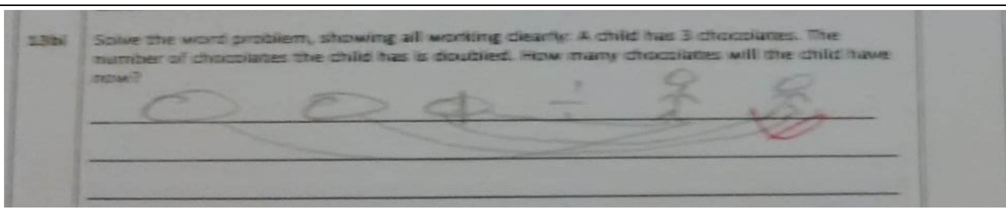

Explain why you say so.

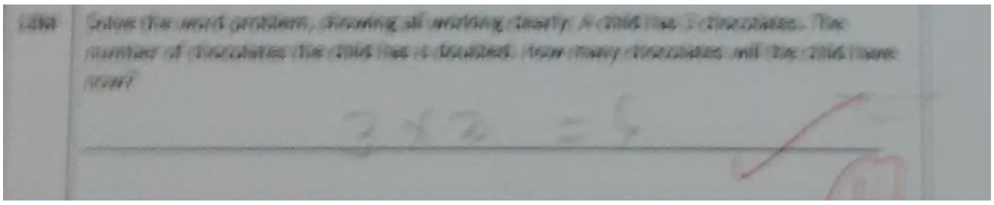
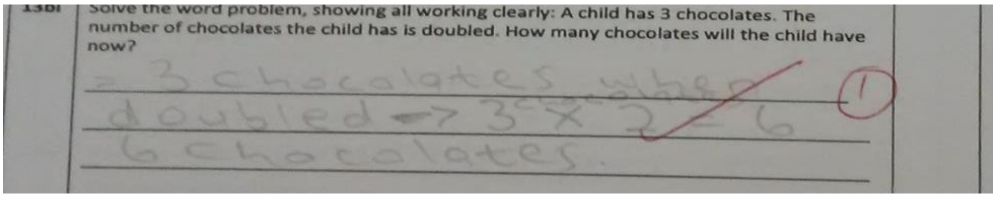
	T15	 13aii Would the word problem "I want to divide 3 pizzas between two children fairly. How much pizza will each child get?" be a good word problem to illustrate 3 divided by ½? Explain why you say so.
	T20	 13aii Would the word problem "I want to divide 3 pizzas between two children fairly. How much pizza will each child get?" be a good word problem to illustrate 3 divided by ½? Explain why you say so. Yes, it will be good it is simple and understandable
	T25	 13aii Would the word problem "I want to divide 3 pizzas between two children fairly. How much pizza will each child get?" be a good word problem to illustrate 3 divided by ½? Explain why you say so. First give one to each child there after divide the whole for the two children each will get 1½
	T30	 Explain why you say so. No it's better to draw three pizzas first then cut into two equal part because for two children then each child get 1 full pizza and a half
	T35	 much pizza will each child get?" be a good word problem to illustrate 3 divided by ½? Explain why you say so. 3 ÷ 2 = 1½ each learner will get 1½ so that they can have the same size of pizza
	T40	 Explain why you say so. Yes, I think is the simplest way to show the difference between whole numbers and the fractions. (1 pizza + 1 pizza are 2 whole numbers made up of 2 halve each.

	T45	 much pizza will each child get ... Explain why you say so. I would put 3 circles on the table and take 3 learners to pick up each circle the ask what would I do with the remaining one then will cut into ½
	T50	 Would the word problem "I want to divide 3 pizzas between two children fairly, how much pizza will each child get?" be a good word problem to illustrate 3 divided by ½? Explain why you say so.
	T55	 much pizza will each child get?" be a good word problem to illustrate 3 divided by ½? Explain why you say so. No, It must be illustrated as 3 divided by 2 because two children must share equally not half children. 0
Itemised Analysis		0 1 Sum 41 13 54

Question	***13bi)*** *Solve the word problem, showing all working clearly: A child has 3 chocolates. The number of chocolates the child has is doubled. How many chocolates will the child have now?* ***(1)*** ____ ____ ____

Sample Responses	T5	 number of chocolates the child has is doubled. How many chocolates will the child have now? 3x2 = 6 Chocolate 1
	T10	 number of chocolates the child has is doubled. How many chocolates will the child have now? 2x2 3+3 =6 =6 1

	T15	 number of chocolates the child has is doubled. How many chocolates will the child have now? 3×2 = 6 = 6 1
	T20	 13bi Solve the word problem, showing all working clearly: A child has 3 chocolates. The number of chocolates the child has is doubled. How many chocolates will the child have now? 3×2 = 6 1
	T25	 13bi Solve the word problem, showing all working clearly: A child has 3 chocolates. The number of chocolates the child has is doubled. How many chocolates will the child have now? 3×2 = 6 (doubled) The child has 6. 1
	T30	 13bi Solve the word problem, showing all working clearly: A child has 3 chocolates. The number of chocolates the child has is doubled. How many chocolates will the child have now? 3 chocolate double (×2) there fore each child have 6 chocolate. 1
	T35	 13bi Solve the word problem, showing all working clearly: A child has 3 chocolates. The number of chocolates the child has is doubled. How many chocolates will the child have now? 3×2 = 6 1
	T40	 13bi Solve the word problem, showing all working clearly: A child has 3 chocolates. The number of chocolates the child has is doubled. How many chocolates will the child have now? 3×2 = 6 / 3+3 = 6 chocolates 1
	T45	 13bi Solve the word problem, showing all working clearly: A child has 3 chocolates. The number of chocolates the child has is doubled. How many chocolates will the child have now?

	T50	
	T55	
Itemised Analysis		

Itemised Analysis

0	1	11	Sum
3	50	1	54

Question

13bii) *Would the word problem "A child has 3 chocolates. The number of chocolates the child has is doubled. How many chocolates will the child have now?" be a good word problem to illustrate 3 divided by ½? Explain why you say so.*

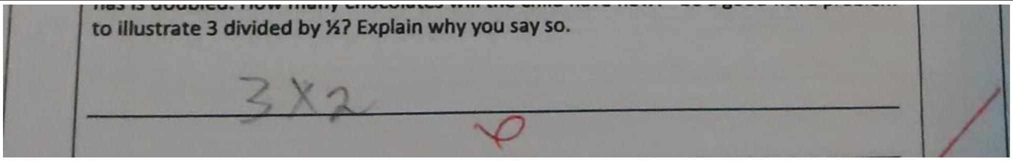
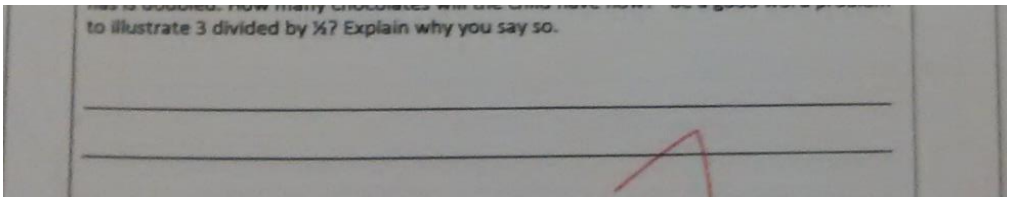
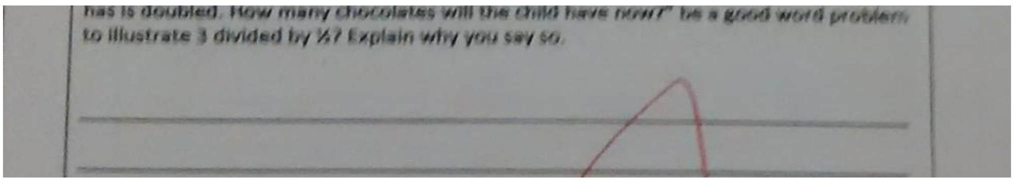
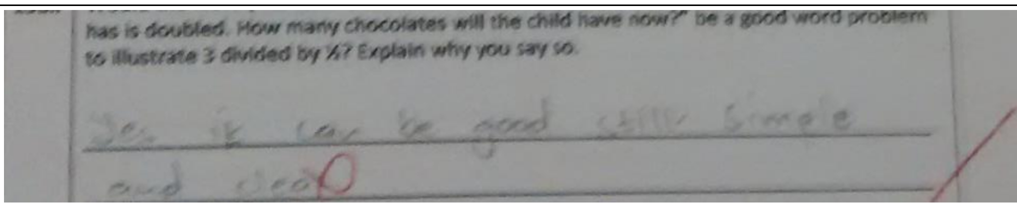
(1)

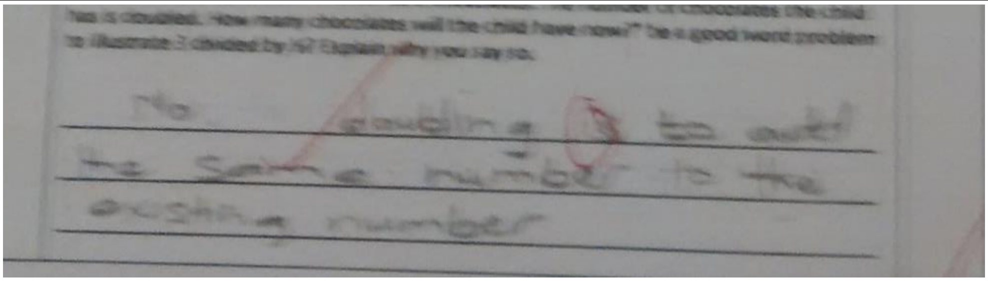
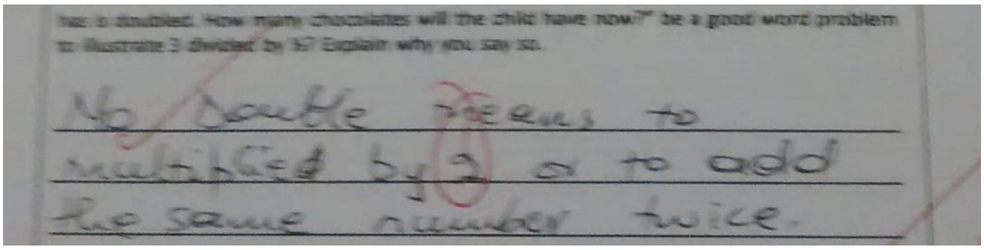
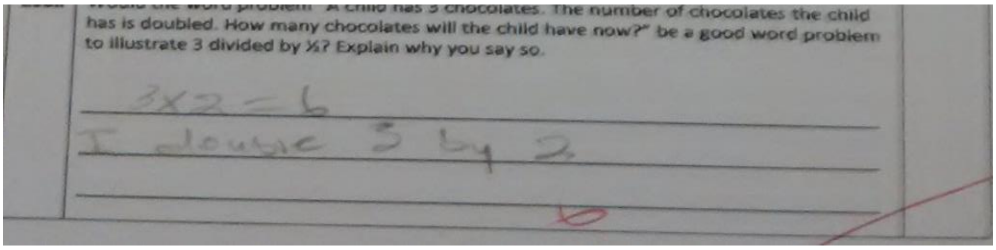
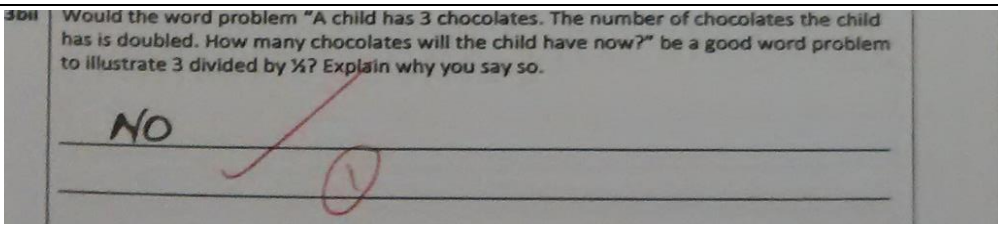
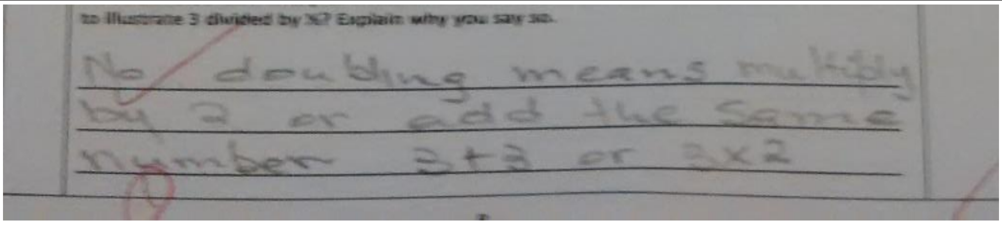
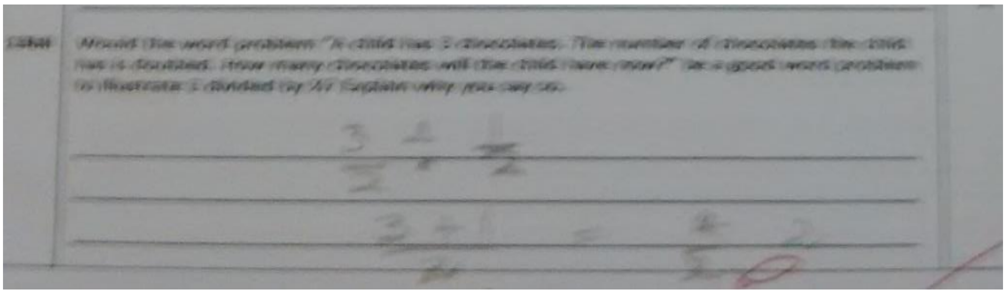
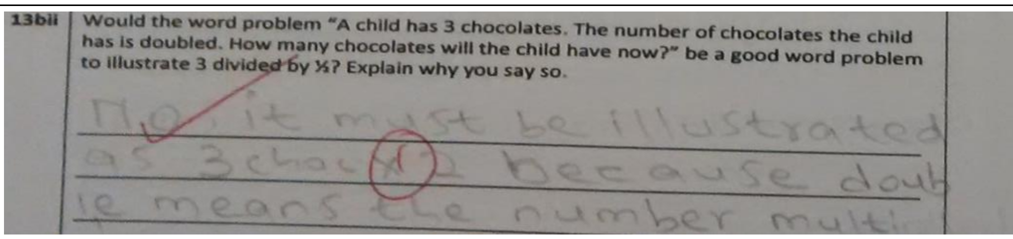
____

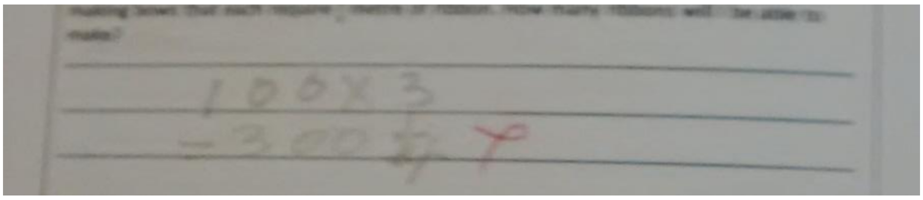
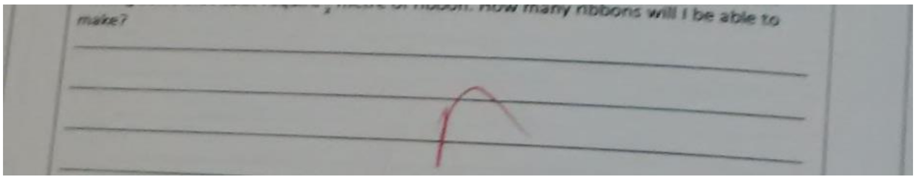
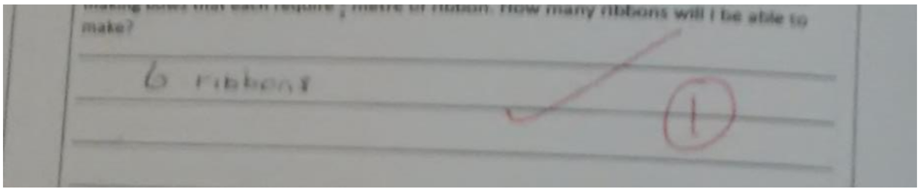
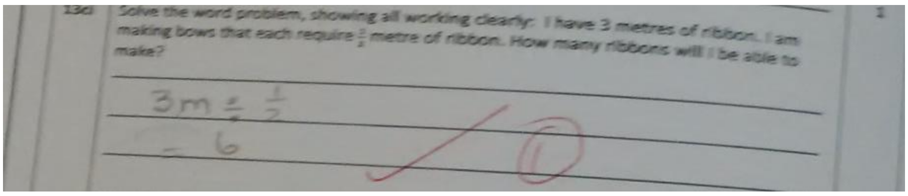
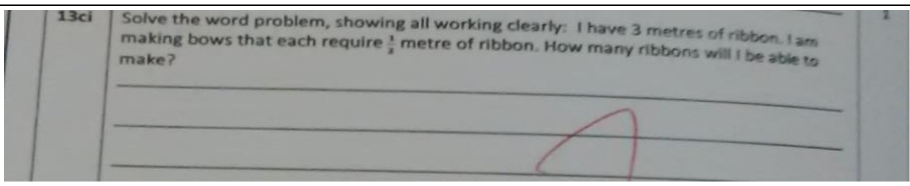
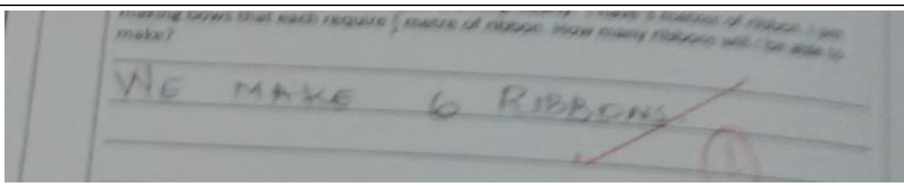
____

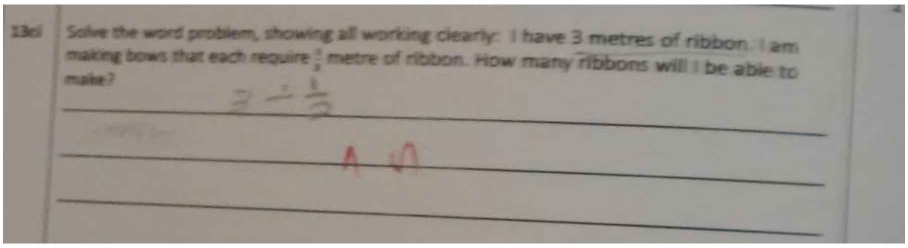
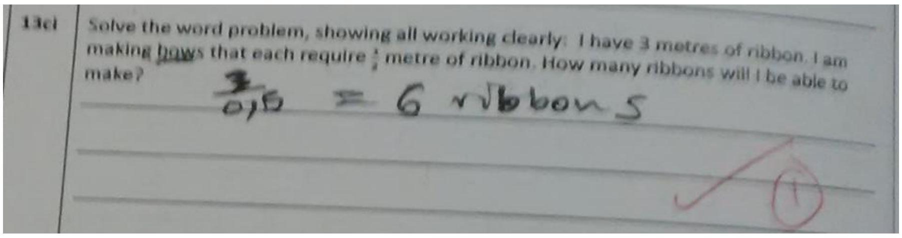
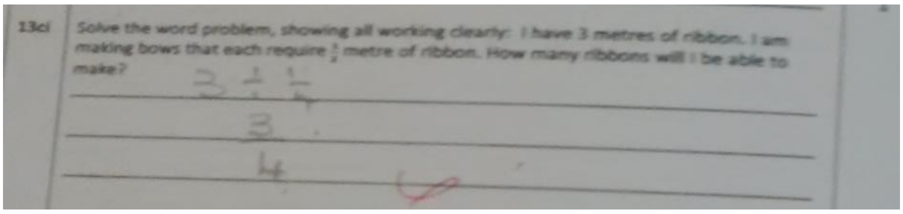
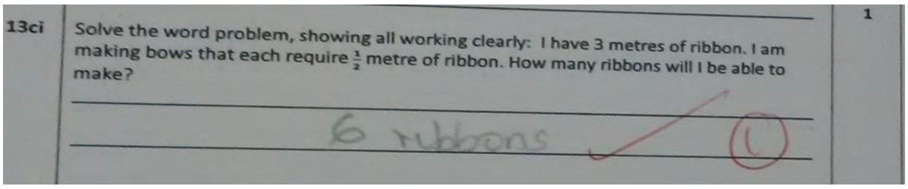
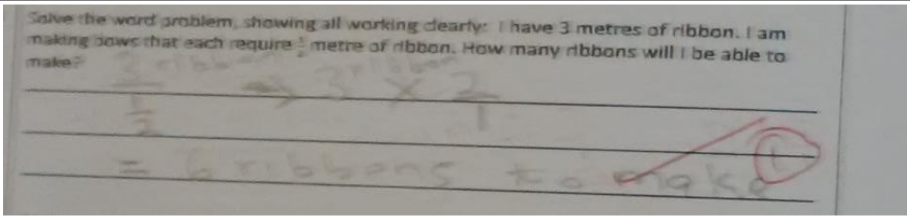
____

Sample Responses

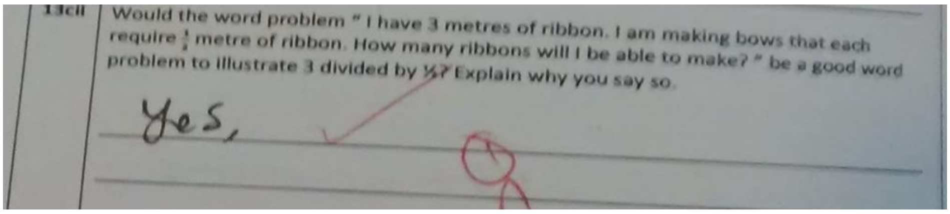
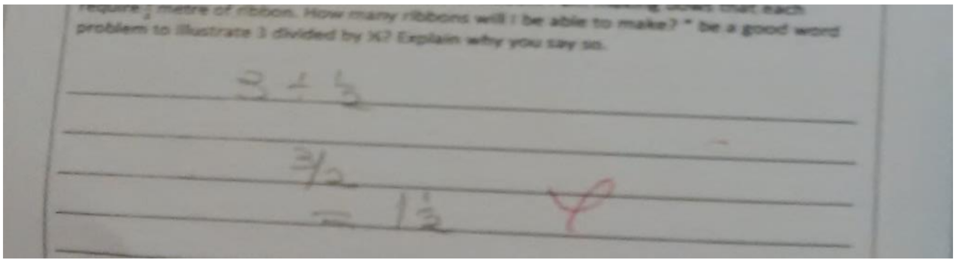
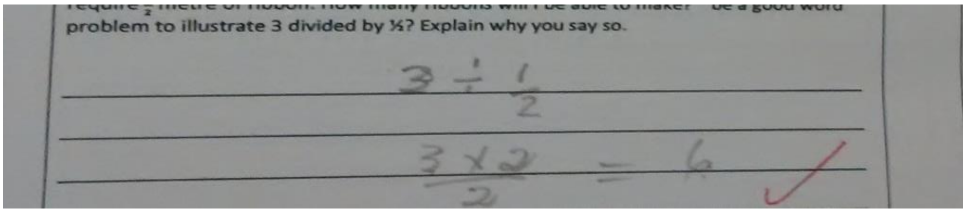
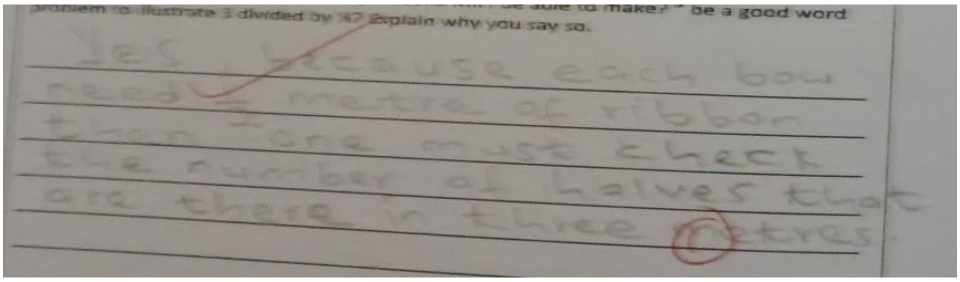
T5	
T10	
T15	
T20	

	T25	 has is doubled. How many chocolates will the child have now?" be a good word problem to illustrate 3 divided by ½? Explain why you say so. No doubling to add the same number to the existing number
	T30	 has is doubled. How many chocolates will the child have now?" be a good word problem to illustrate 3 divided by ½? Explain why you say so. No double means to multiplied by 2 or to add the same number twice.
	T35	 Would the word problem "A child has 3 chocolates. The number of chocolates the child has is doubled. How many chocolates will the child have now?" be a good word problem to illustrate 3 divided by ½? Explain why you say so. 3x2 = 6 I double 3 by 2
	T40	 3bii Would the word problem "A child has 3 chocolates. The number of chocolates the child has is doubled. How many chocolates will the child have now?" be a good word problem to illustrate 3 divided by ½? Explain why you say so. NO
	T45	 to illustrate 3 divided by ½? Explain why you say so. No doubling means multiply by 2 or add the same number 3+3 or 3x2
	T50	 Would the word problem "A child has 3 chocolates. The number of chocolates the child has is doubled. How many chocolates will the child have now?" be a good word problem to illustrate 3 divided by ½? Explain why you say so.
	T55	 13bii Would the word problem "A child has 3 chocolates. The number of chocolates the child has is doubled. How many chocolates will the child have now?" be a good word problem to illustrate 3 divided by ½? Explain why you say so. No it must be illustrated as 3 choc because double means the number multi

Itemised Analysis		0 1 Sum 33 21 54
Question		***13ci)*** *Solve the word problem, showing all working clearly: I have 3 metres of ribbon. I am making bows that each require ½ metre of ribbon. How many ribbons will I be able to make?* ***(1)*** ____ ____ ____
Sample Responses	**T5**	 100X3 = 300
	T10	 make?
	T15	 make? 6 ribbons 1
	T20	 13ci Solve the word problem, showing all working clearly: I have 3 metres of ribbon. I am making bows that each require ½ metre of ribbon. How many ribbons will I be able to make? 1 3m ÷ ½ = 6 1
	T25	 13ci Solve the word problem, showing all working clearly: I have 3 metres of ribbon. I am making bows that each require ½ metre of ribbon. How many ribbons will I be able to make? 1
	T30	 WE MAKE 6 RIBBONS

	T35	 13ci Solve the word problem, showing all working clearly: I have 3 metres of ribbon. I am making bows that each require ½ metre of ribbon. How many ribbons will I be able to make?
	T40	 13ci Solve the word problem, showing all working clearly: I have 3 metres of ribbon. I am making bows that each require ½ metre of ribbon. How many ribbons will I be able to make? 3/0,5 = 6 ribbons (1)
	T45	 13ci Solve the word problem, showing all working clearly: I have 3 metres of ribbon. I am making bows that each require ½ metre of ribbon. How many ribbons will I be able to make?
	T50	 13ci Solve the word problem, showing all working clearly: I have 3 metres of ribbon. I am making bows that each require ½ metre of ribbon. How many ribbons will I be able to make? 1 6 ribbons (1)
	T55	 Solve the word problem, showing all working clearly: I have 3 metres of ribbon. I am making bows that each require ½ metre of ribbon. How many ribbons will I be able to make? = 6 ribbons to make (1)
Itemised Analysis		0 1 Sum 20 34 54
Question		***13cii)*** *Would the word problem "I have 3 metres of ribbon. I am making bows that each require ½ metre of ribbon. How many ribbons will I be able to make? " be a good word problem to illustrate 3 divided by ½? Explain why you say so.* ***(1)*** ____ ____ ____

Responses	T5	A
	T10	13cii Would the word problem "I have 3 metres of ribbon. I am making bows that each require ½ metre of ribbon. How many ribbons will I be able to make?" be a good word problem to illustrate 3 divided by ½? Explain why you say so. 1 $3 \div \frac{1}{2}$ $= 1\frac{1}{2}$ ribbons ✓
	T15	require ½ metre of ribbon. How many ribbons will I be able to make?" be a good word problem to illustrate 3 divided by ½? Explain why you say so. A
	T20	How many ribbons will I be able to make?" be a good word problem to illustrate 3 divided by ½? Explain why you say so. 0 Yes. The questions and straight forward
	T25	problem to illustrate 3 divided by ½? Explain why you say so. A
	T30	problem to illustrate 3 divided by ½? Explain why you say so. We ARE ABLE TO MAKE 6 Ribbon so we won't do division instead $(\frac{1}{2})(\frac{1}{2}) + (\frac{1}{2}) + (\frac{1}{2}) + (\frac{1}{2}) + (\frac{1}{2}) = 3m$ 3m
	T35	ribbons will I be able to make?" be a good word problem to illustrate 3 divided by ½? Explain why you say so. A

	T40	
	T45	
	T50	
	T55	
Itemised Analysis		0 1 Sum 35 19 54

Adapted from JET, (2015b)

As shown in Table 6.16, sample responses exhibit a variety of linguistic challenges ranging from complete omissions – leaving the question unanswered, partial omissions – concentrating on the calculations (computation of digits), and not explaining the procedures as requested by the question. This could be attributed to the fact the teachers "are ensnared by the language rather than by the mathematics hidden therein" as suggested by Kambule (1984). Sample responses also included the use of one-word *'yes'* / *'no'* answers without supporting these answers, as well as the use of diagrammatic representations to compensate for the *missing written* explanations as an attempt to fulfil the requirements of the question. As a result, out of the six questions sampled in Table 6.16, three questions had more than 50% of the teachers scoring zero as indicated in the itemised analysis at the end of each question. Some responses were composed of detailed answers, though some of the detail included irrelevant information not answering the question.

The itemised and mean score descriptive analyses of the two teacher assessments provided a general insight into the teachers' linguistic competences in English, the prescribed LoLT in the majority of the schools, as well as their mathematics content knowledge at IP level; separately, the section below compares and contrasts patterns emanating from the two descriptive analyses.

6.3.3.3: Descriptive Analyses: Language Competency versus Mathematics Word Problem Assessment

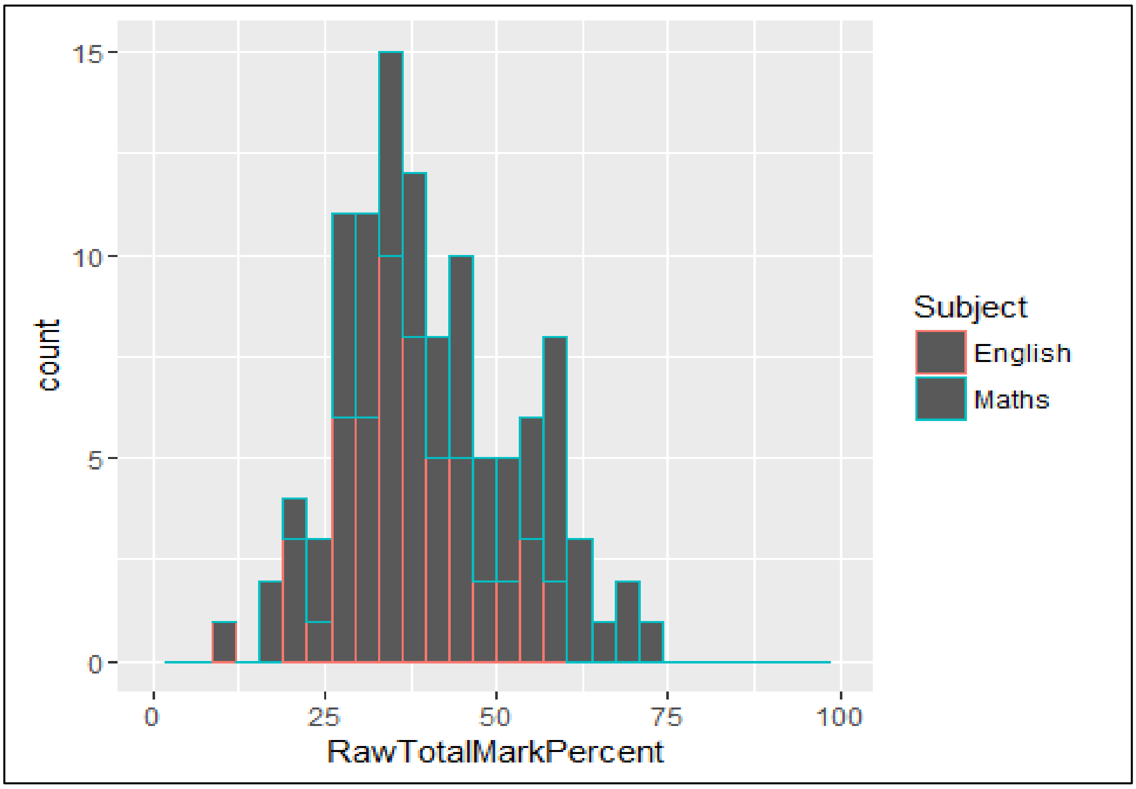
Since the current study is a relational analysis, it was imperative to present and compare the different characteristics of the teacher English-language proficiency scores against the mathematics word problem scores based on JET's descriptive analyses as shown in Table 6.17.

Table 6.17: Descriptive Analysis English Language Competency versus Mathematics Word Problem Scores

	N	Mean	StError	Median	StDev	Min	Max	Range
English	54	37.31	1.388	35.62	10.2	11.25	60	48.75
Maths	54	43.34	1.949	43.51	14.33	16.88	72.73	55.84

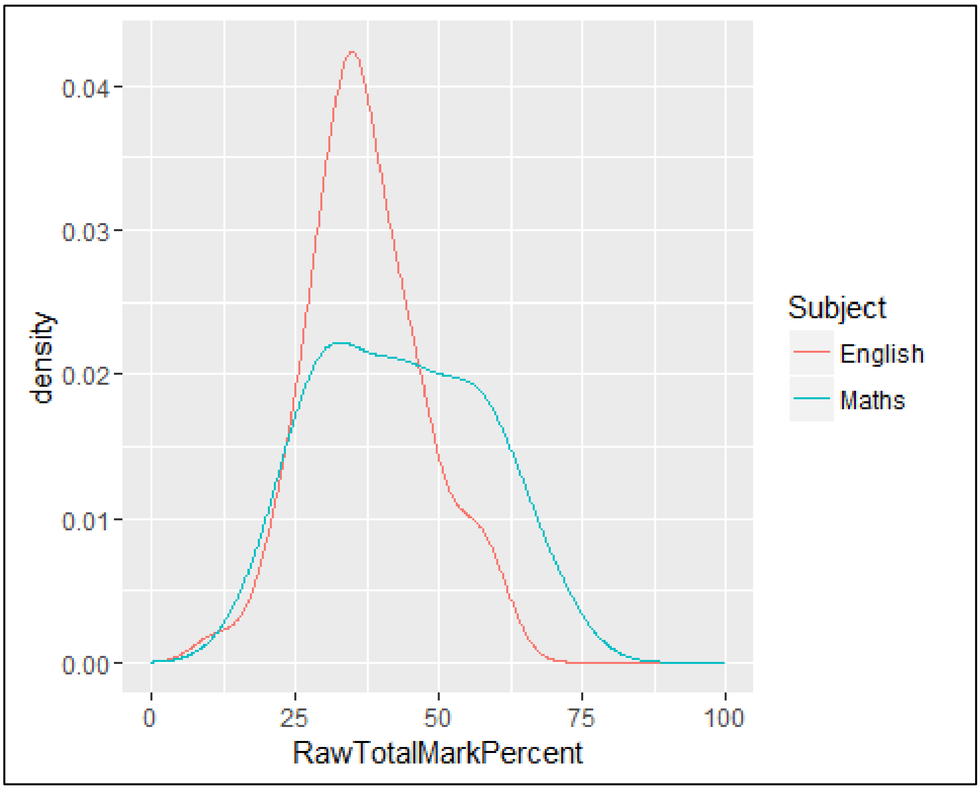
Although the descriptive comparison of the two teacher assessments shown in Table 6.17 excludes the participant's spoilt scripts, it still concurs with the statistical comparison detailed in section 6.3.2.3. The mean, the median, the minimum and the maximum scores obtained in English-language proficiency assessments are lower than those obtained in the mathematics word problem assessment. The fact the majority of the teachers are non-native speakers of English, as established in the demographic details in Chapter 5, may contribute to these significantly lower scores; however, since these demographic details of the teachers deployed to the under-resourced schools are not going to change any time soon, these statistics re-emphasize the need to upskill the teachers in English proficiency, among other skills, in order to improve the quality of education in the school they are deployed in. Figure 6.28 illustrates the distribution of the two teacher assessment scores by subject.

Figure 6.28: Histogram by Subject: English Language Competency versus Mathematics Word Problem Scores



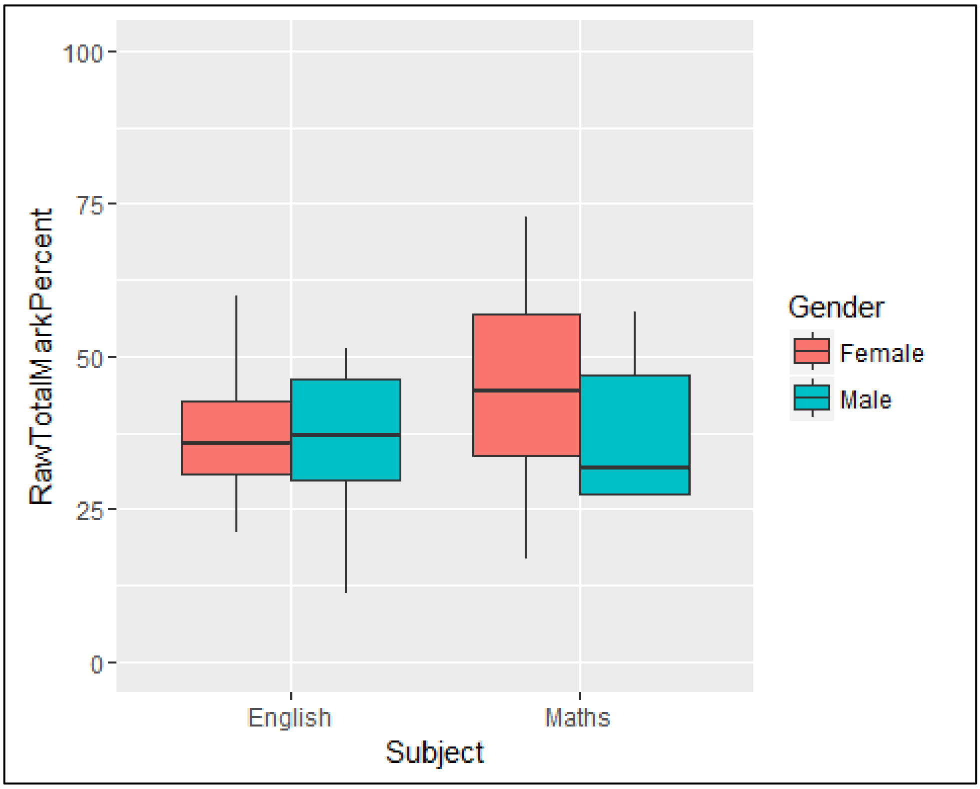
As illustrated in Figure 6.28, the majority of the teachers scored between 25 – 37.5% in the English Language Proficiency Assessment, while in the Mathematics Word Problem Assessment the majority of the teachers scored between 37.5 – 50%. This descriptive distribution also confirms the statistical distribution detailed in Section 6.3.2.3 earlier in this chapter. Noteworthy in this section is that the majority of the teachers are performing below 50% in both assessments and are therefore categorised as representing *cause for serious concern*, according to JET performance scale. Figure 6.29 illustrates the density of the two teacher assessment scores by subject.

Figure 6.29: Density by Subject: English Language Proficiency versus Mathematics Word Problem Scores



The analysis illustrated in Figure 6.27 further confirms the distribution of the teacher scores in the two assessments. The two curves are both skewed to the left-hand side, with the marks below 50%. In addition, both curves are relatively bell shaped; however, the English Language Proficiency curve is relatively more symmetrical than the Mathematics Word Problem Assessment curve. Generally, both the density curves confirm the statistical analyses of the distribution of scores as established in Section 6.3.2.3 of this chapter. Figure 6.30 indicates the density of the teacher assessment scores by gender.

Figure 6.30: Density by Gender



As illustrated in Figure 6.30, the female participants' English Language Proficiency mean score was lower than of the males, while the females' Mathematics Word Problem mean score was higher than that of the males. This distribution by gender is interpreted in the light of the demographic data detailed in Chapter 5, which established that the study participants comprised more females (89%) than males (11%); thus, there is no significant difference in the distribution.

6.4 Conclusion

This chapter presented, analysed and discussed the quantitative data collected in this study, namely the teacher questionnaires, the teacher educator questionnaires, and the teacher assessments in English language competency and mathematics word problems. The teacher assessments were analysed by two independent entities: Stellenbosch University's CSC conducted the statistical analyses, while JET provided the descriptive analyses. Based on the relatively small sample size of 55 teachers, the descriptive analysis provided finer details compared to the statistical analyses. The statistical analyses were presented first, followed by the descriptive analyses and the comparison of the two.

Data from the semi-structured teacher questionnaires showed the different strategies used by teachers when teaching IP mathematics using English as well as the challenges faced in providing instruction. The data also provided an overview of the depth of the guidance in using English as LoLT received by the teachers during their initial teacher education. Data from the teacher educator questionnaires corroborated the teachers' self-reported data on strategies used in the classroom, the challenges faced during instruction as well as the guidance provided in using English as a LoLT in IP mathematics instruction. Both teachers and teacher educators provided information alluding to the existence of teachers with significantly low proficiency levels in English, and concurred that teachers need to be upskilled during and after initial teacher education on how to use English in IP mathematics instruction. Of interest is the fact that teacher respondents were more comfortable with pin pointing other teachers' low proficiency levels in English, than they were in identifying this low proficiency in themselves.

Data from the teacher assessments confirmed the teachers' low proficiency levels in English as well as in solving language-based mathematical problems. Language competency levels and solving language-based mathematical problems are not the only concerns in IP mathematics instruction, and an exploration of both the teachers' and teacher educators' perspectives indicated ways of changing the current status quo for the purposes of improving the teaching and learning of IP mathematics.

The next chapter will provide a description of the qualitative data analysis employed in this study and the presentation, analyses and discussion of these data.

CHAPTER 7

QUALITATIVE DATA PRESENTATION, ANALYSIS AND DISCUSSION

7.1 Introduction

The congruent parallel mixed method research design was used to achieve the aims and objectives of this study; thus, both quantitative and qualitative date were collected and analysed independently, and then merged for interpretation. As mentioned in Chapter 5, Chapter focused 6 exclusively on quantitative data presentation, analysis and discussion, while this chapter focuses exclusively on qualitative data presentation, analysis and discussion. The first part of this chapter provides the presentation, analysis and discussion of data gathered through semi-structured interviews, while the second part provides presentation, analyses and discussion of the data gathered through the structured non-participant classroom observations. The chapter concludes by recapitulating and synthesising strands of data emanating from the different qualitative sources. Data analysis was thematic.

7.2 Qualitative Data Analysis

Qualitative data collected in this study were analysed using open and axial coding. Coding is the process of examining the raw qualitative data which will be in the form of words, phrases, sentences or paragraphs, and assigning codes or labels. The main reason why qualitative data are coded is for the purposes of moving beyond *description* to *analysis* (Askew, 2017). This is done through breaking up data and reassembling the components into themes. The ongoing process involves four main elements, namely open coding, axial coding, organizing and classification, and memo writing (Strauss & Corbin, 1990). Thus, the process can be described as combing through data. In this study, all the coding was done by the researcher; no software was used in order to allow a holistic view as well as to avoid over-coding.

According to Strauss and Corbin (1990) as well as Saldana (2009), open coding involves assigning codes or labels to words and phrases found in the transcript or text, while axial coding involves creating themes or categories by grouping codes or labels given to words and phrases. In open coding the researcher *sweeps* through the data highlighting sections of the text as selected codes or labels. The researcher may have in mind some predetermined and expected codes (inductive approach), or may be looking for codes emanating from the data (deductive approach). Since the current study is focused by a mixed method approach, the researcher expected some codes to align with the quantitative data results and also looked out for other ideas to arise out of the qualitative data. Open coding can be further subdivided into *in vivo* and constructed codes. *In Viv*o coding uses the exact words used by the participants in the data-collection process, while constructed coding uses academic terms that are created by the researcher. In constructed coding the researcher needs to guard against the use of interpretive and so should use descriptive terms. In addition, the researcher should not undertake memo writing only at the end, but throughout the coding process.

Axial coding involves making connections amongst the categories and the subcategories. This involves coding for: conditions giving rise to a phenomena; the context in which it is embedded; actions/interactional strategies of those involved; and consequences of those strategies. As additional data are collected, the researcher moves back and forth amongst the data collected, continuously open coding, axial coding and refining the categories and their interconnections.

Charmaz (2003) states that during the coding process the researcher must continuously be asking the following questions:

- What is going on?
- What are people doing?
- What is the person saying?
- What do these actions and statements take for granted?
- How do structure and context serve to support, maintain, impede or change these actions and statements?

After open and axial coding, the researcher then organizes and classifies information. Organising and classification, according to Lincoln and Guba, (1985), take place when a large number of codes have been assigned to data and it becomes necessary to categorise them into some sort of order or into groups; this is a process which involves constant comparisons.

7.3 Qualitative Data Presentation

The following sections present the qualitative data collected in this study. Since the collection of qualitative data through interviews preceded the classroom observations, the presentation of the data also follows the same sequence.

7.3.1 Interviews

The first qualitative data-collection technique to be administered was the interview. The interviews were the first-line cross-checking technique of the quantitative data collected from the participants of the study. Two different types of semi-structured interviews were administered in this study, one for the teachers and the other for the teacher educators. The section below presents analyses and discusses data gathered from the teacher interviews.

7.3.1.1 Interviews: Teachers

The double-pronged teacher interview schedule incorporated baseline questions cross-checking information provided in the questionnaire as well as the Newman hierarchy of error causes for written mathematical tasks (Newman, 1983). The error analysis questions were incorporated into the interview schedule, because these questions solicited for responses better suited to answer the research questions because of their likelihood to establish IP mathematics teachers' English-language competency. The interview was administered to 5 (10%) of the sampled IP mathematics teachers after the administration of the mathematics word problem assessment. Table 7.1 presents the profiles of the 5 teacher interviewees.

Table 7.1: Interviewee Profiles: Teachers

S	P	G	Race Group	AGE	ETM	Q
S1	T1	Female	Black	4		- Primary Teacher's Diploma - Advanced Certificate in Education (Mathematics)
S2	T2	Female	Black	4		- Primary Teachers' Diploma - Advanced Certificate in Education (Technology)
S3	T3	Female	Black	4		- Primary Teachers' Diploma
S4	T4	Female	Black	4		- Primary Teachers' Diploma
S5	T5	Male	Black	4		- Primary Teachers' Diploma - Advanced Certificate in Education (Management)

Key:
S – School
P – Participant
G – Gender
AGE – Age Group {1: 25 years and below**; 2:** 26 – 29 years**; 3:** 30 – 34 years**; 4:** 35 years and above**}**
ETM – Experience Teaching Mathematics
Q – Qualifications

As illustrated in Table 7.1, all the interviewees were middle-aged black teachers and four of the five were female, further confirming demographic data collected earlier in this study as well as the general patterns in the teaching profession in South Africa.

The Teacher Interview Schedule (**APPENDIX E**) was used to gather specific data on the following aspects: comparisons between the the teacher's and respective learners' home languages; the language(s) spoken by the learners on arrival at school; teacher perceptions of whether English is a barrier in learners' understanding of IP mathematics; the teachers' frequency of using code switching; an error analysis task based on a mathematics word problem and suggestions on CPTD deemed necessary to improve efficiency in teaching IP mathematics using English as a language of instruction.

Responses to the teacher interviews are presented sequentially question by question in the section below. Table 7.2 presents the responses to the first question on the teacher interview schedule.

Table 7.2: Comparison between teacher and learner home languages

	Question 1: ***(a) Is your mother tongue and that of your learners the same?*** ***(b) Is this an advantage or a disadvantage in your teaching IP mathematics English as LoLT?*** ***(c) Give a reason to your answer in (b) above.***		
	Yes / No	**Advantage / Disadvantage**	**Reason**
T1	Yes	Disadvantage	- In FP learners use isiXhosa and in IP they switch to English, so most of the time I have to explain, for slow learners I have to teach them English first.
T2	Yes	Disadvantage	- Because they cannot switch to English when they reach IP.
T3	Yes	Disadvantage	- Because learners read numbers in their home language.
T4	Yes	Disadvantage	– Learners are unable to understand English and mathematics terminology.
T5	Yes	Disadvantage	- Sometimes English is difficult to understand for learners.

As illustrated in Table 7.2, in response to part (a) of the question, all the interviewees indicated that their mother tongue is the same as that of their learners. In response to part (b) of the question, all the interviewees also indicated sharing the same mother tongue with their learners is a disadvantage. On reflection of these answers which state that it is a disadvantage to share the same language with the learners, the researcher acknowledges interplay of the Hawthorne Effect (Mouton, 2001) on the participants, based on the following facts. Firstly, the interviewees could have imagined this as the kind of response the researcher was anticipating; secondly, the interviewees were oblivious of the fact that the home language that they shared with their learners could be a resource that could be used effectively in IP mathematics instruction; and thirdly the interviewees did not receive comprehensive instruction on using English to teach IP mathematics. In response to part (c) of the question; the interviewees provided reasons that confirmed the above comments and that they were encountering numerous challenges in handling ELLS while teaching mathematics. Also, as noted in earlier sections on the quantitative data collection, the interviewees found problems with the learners' English-language competency and none whatsoever with their own.

Having established whether the teachers' and learners' home languages were the same or not, it was important to document the different home languages spoken by the learners on arrival at school. Table 7.3 presents the responses to the second question on the teacher interview schedule.

Table 7.3: Learner linguistic profiles on arrival at school

	Question 2: On arrival at school, what home language(s) do the learners already speak? (You may mention more than one).			
	English	**Afrikaans**	**isiXhosa**	**Other (specify)**
T1	X	X	✓	–
T2	X	X	✓	-
T3	X	X	✓	-
T4	X	X	✓	-
T5	X	X	✓	-

As indicated in Table 7.3, all five respondents indicated that when the learners arrived at school, the only language they could speak proficiently is isiXhosa. The information presented was expected, as the teachers are based in the Eastern Cape Province's under-resourced schools where learners do not have much exposure to languages other than their home language, isiXhosa. The information presented also confirmed the data gathered through the quantitative data collection.

Having established a general overview of the learner linguistic profiles, interviewees were requested to state their opinions on whether English is a barrier to their learners' understanding of the mathematical concepts taught in class. Table 7.4 presents the responses to the third question on the teacher interview schedule.

Table 7.4: Teacher perceptions on English as a barrier in learners' understanding of IP mathematics

	Question 3: Would you say English is a barrier to IP learners' understanding of mathematics?	
	Yes / No	**Reason**
T1	No	- Not to all the learners, to some learners it is a barrier because they are not familiar with the language. At the back of the learners exercise books I always ask learners to provide space for new vocabulary and dictionary words.
T2	Yes	- Because they start school in Grade R – 3 using their home language when learning.
T3	Yes	- Because leaners cannot read and write numbers in English; e.g. '*zimbini*' in isiXhosa instead of 'two'.

T4	Yes	- It is a barrier since they fail to understand the symbol and notation of mathematics.
T5	Yes	- They are not good in English.

As indicated in Table 7.4, the majority of the interviewees indicated that they perceive English to be a barrier to IP learners' understanding of mathematics. Only one interviewee indicated that English is not a barrier to some of the learners. This particular interviewee, who possibly because of extensive experience in teaching IP mathematics, alluded to a strategy used to ensure that English is not a barrier during mathematics instruction.

> *'At the back of the learners exercise books I always ask learners to provide space for new vocabulary and dictionary words'.*

Although the listing of new vocabulary and dictionary words only contributes to the compilation of passive vocabulary, as noted by Henkel (2007), the teacher respondent is commended for at least trying to help learners better understand mathematics by ensuring that English is not a barrier in the teaching and learning process, compared to other respondents who merely acknowledge that English is a barrier and do nothing much to assist the learners.

For the interviewees who indicated that English is a barrier to IP mathematics instruction, challenges related to the switch from mother-tongue instruction at FP to English instruction at IP were cited. As stated in earlier sections and further confirmed though various data-collection procedures in this study, although the home language for learners based in rural schools is isiXhosa, the language of instruction is English. Many of these learners are not frequently exposed to English, which becomes a challenge for them because their language proficiency and level of reading comprehension play an important role when solving mathematics word problems. Reynders, (2014) discovered that language barriers for learners who are not taught in their mother tongue lead to misunderstanding regarding mathematical word problems.

Having established teacher perceptions on whether English is a barrier in learners' understanding of IP mathematical concepts and procedures, interviewees were requested to rate their frequency in using code switching during instruction. Table 7.5 presents the responses to the fourth question on the teacher interview schedule.

Table 7.5: Teacher frequency on using code switching in IP mathematics lessons

	Question 4: ***(a) Would you rate your frequency in using code switching when teaching mathematics lessons as never, sometimes, always?*** ***(b) Give a reason to your answer in (a) above.***			
	Never	**Sometimes**	**Always**	**Reason**
T1		✓		- Even though I explain in English, learners would not understand. I give a new word, I give its meaning in isiXhosa without explaining further because I want the learners to familiarise themselves with the maths concepts in English.
T2		✓		- Because they do not understand English.
T3		✓		- Because learners will be unable to follow instructions during the lesson.
T4			✓	- To make them understand mathematical language.
T5		✓		- To help the learners.

When posing the question, the researcher briefly explained what the process of code switching entails to provide interviewees with clarity on the question. The explanation was given in such a way that it would not influence the interviewees' responses. As indicated in Table 7.5, the majority of the respondents indicated that they 'sometimes' use code switching during IP mathematics instruction, while one interviewee indicated that he 'always' uses code switching. The reasons cited in support of the responses presented indicate that the teachers code switch in order to help learners better understand the mathematics concepts, since the learners are not proficient in English. Noteworthy is **T1**'s response highlighted below:

> *'I give a new word, I give its meaning in isiXhosa without explaining further because I want the learners to familiarise themselves with the maths concepts in English'.*

In this response the interviewee indicated that, although they use code switching to help the learners understand the mathematical concepts and procedures, the code switching is done bearing in mind that the LiEP requires instruction to be done in English. As such, the teacher only provides the meaning of the new word in isiXhosa, but does not go further to explain the meaning on isiXhosa as way of encouraging the learners to master the English version of the new word. Although the interviewee does not categorically state that this is a systematic way of using code switching, the way the whole process is done indicates a systematic use of the practice. Again, considering the fact that the interviewee is an experienced IP mathematics teacher, it can be inferred that the practice emerged out of a number of trial and error methods, hence the need to introduce systematic strategies of code switching and translanguaging during and after initial teacher education curricula.

Having answered general questions that sought to cross-check information obtained from previous sections of the data-collection process, interviewees had to answer the error analysis question. The interviewees were informed that the error analysis question was based on three of the mathematics word problem assessment questions which they had answered previously. In addition, interviewees had access to their unmarked scripts on the three sampled questions and the researcher briefly explained that this particular question sought to identify error causes in written mathematical tasks. Table 7.6 presents the responses to the fifth (error analysis) question on the teacher interview schedule.

Table 7.6: Error Analysis on selected Mathematics Word Problems

Question 5: *The following questions are based on the* ***JET mathematics word problems*** *you solved earlier:* ***(Question 13 or 14 or 15).***

Sample Mathematics Word Problem	***13ai)*** *Solve the word problem, showing all working clearly: I want to divide 3 pizzas between two children fairly. How much pizza will each child get?* ***(1)*** ____ ____ ____ ***13aii)*** *Would the word problem "I want to divide 3 pizzas between two children fairly. How much pizza will each child get?" be a good word problem to illustrate 3 divided by ½? Explain why you say so.* ***(1)*** ____ ____ ____ ***13bi)*** *Solve the word problem, showing all working clearly: A child has 3 chocolates. The number of chocolates the child has is doubled. How many chocolates will the child have now?* ***(1)*** ____ ____ ____ ***13bii)*** *Would the word problem "A child has 3 chocolates. The number of chocolates the child has is doubled. How many chocolates will the child have now?" be a good word problem to illustrate 3 divided by ½? Explain why you say so.* ***(1)*** ____ ____ ____ ***13ci)*** *Solve the word problem, showing all working clearly: I have 3 metres of ribbon. I am making bows that each require ½ metre of ribbon. How many ribbons will I be able to make?* ***(1)*** ____ ____ ____ ***13cii)*** *Would the word problem "I have 3 metres of ribbon. I am making bows that each require ½ metre of ribbon. How many ribbons will I be able to make? " be a good word problem to illustrate 3 divided by ½? Explain why you say so.* ***(1)*** ____ ____ ____ **Extracted from JET, (2015)**

	Question	Rating

		Selected	5	4	3	2	1
T1	a) Read the question. (Reading / Decoding)	13	✓				
	b) What is the question asking you to do? (Comprehension)			✓			
	c) Suggest a method that can be used to find an answer to the question. (Transformation / Mathematising)				✓		
	d) Explain how you worked out the answer (Processing)			✓			
	e) Write down the answer to the question. (Encoding)			✓			
	Comments	Question 13 was selected. The interviewee managed to read the question with ease, the comprehension was rated as above average as the interviewee provided contextual clues that could be used to interpret the question when asked what the question required them to do. The method suggested for solving the question was rated as average as the interviewee did not provide detailed answers for all the questions. The explanations of how the interviewee worked out the answer were rated as above average as the interviewee provided sufficient vocabulary to explain the computations they had undertaken. In the final question, the answer given was exactly the same as the one that had been written in the initial word problem assessment. The interviewee gave a practical example of how the problem could be simulated in class so that learners understand how to get to the final answer; however, the simulation did not indicate some steps that would make the problem better understood by the learners.					
T2	a) Read the question. (Reading / Decoding)	13	✓				
	b) What is the question asking you to do? (Comprehension)			✓			
	c) Suggest a method that can be used to find an answer to the question. (Transformation / Mathematising)					✓	
	d) Explain how you worked out the answer (Processing)					✓	
	e) Write down the answer to the question. (Encoding)						✓
	Comments	Question 13 was selected. The interviewee managed to read the question with ease, the comprehension was rated as good as the interviewee managed to rephrase the question in their own words when asked what the question required them to do. The method suggested for solving the question was rated as below					

		average as the interviewee did not answer all the questions in full. The explanations of how the interviewee worked out the answer were also rated as below average as the interviewee lacked sufficient vocabulary to explain the computations they had undertaken. In the final question, the answer given was a mere repetition of what had been written in the initial word problem assessment. The interviewee literally read through the process undertaken in the initial word problem assessment without reflecting on each step undertaken, or why it was undertaken.					
T3	a) Read the question. (Reading / Decoding)	**13**	✓				
	b) What is the question asking you to do? (Comprehension)			✓			
	c) Suggest a method that can be used to find an answer to the question. (Transformation / Mathematising)					✓	
	d) Explain how you worked out the answer (Processing)					✓	
	e) Write down the answer to the question. (Encoding)						✓
	Comments	Question 13 was selected. The interviewee managed to read the question with ease, the comprehension was rated as above average. The method suggested for solving the question was rated as below moderate as the interviewee did not answer all the questions in full and did not provide appropriate methods for solving the question. The explanations of how the interviewee worked out the answer were also rated as below average as the interviewee lacked sufficient vocabulary to explain the computations they had undertaken, or to provide reasons why they had undertaken the specific computations. In the final question, the answer given was a mere repetition of what had been written in the initial word problem assessment. The interviewee simply read through the process undertaken in the initial word problem assessment without reflecting on each step undertaken, or why it was undertaken.					
T4	a) Read the question. (Reading / Decoding)	**13**	✓				
	b) What is the question asking you to do? (Comprehension)				✓		
	c) Suggest a method that can be used to find an answer to the question. (Transformation / Mathematising)					✓	
	d) Explain how you worked out the answer (Processing)					✓	
	e) Write down the answer to the question. (Encoding)						✓

	Comments	Question 13 was selected. The interviewee managed to read the question with ease, the comprehension was average as the interviewee merely reread the question when asked what the question required them to do. The method suggested for solving the question was rated as below average as the interviewee did not answer all the questions in full. The explanations of how the interviewee worked out the answer were also rated as below average as the interviewee lacked sufficient vocabulary to explain the computations undertaken. In the final question, the answer given was a mere repetition of what had been written in the initial word problem assessment. The interviewee merely read through the process undertaken in the initial word problem assessment without reflecting on each step undertaken, or why it was undertaken.					
T5	a) Read the question. (Reading / Decoding)	-					
	b) What is the question asking you to do? (Comprehension)						
	c) Suggest a method that can be used to find an answer to the question. (Transformation / Mathematising)						
	d) Explain how you worked out the answer (Processing)						
	e) Write down the answer to the question. (Encoding)						
	Comments	The interviewee requested not to respond to this section of the interview schedule; hence it is remains unestablished how he would have fared in the ratings.					
	Key: 5 – Excellent **4 – Good / above average** **3 – Average** **2 – Below average** **1 – Poor**						

As indicated in Table 7.6, one interviewee wished to answer all the other interview questions except question 5; as such the corresponding section is cancelled out in Table 7.6. Just before the interview session, another interviewee was overheard by the researcher muttering the following comment to a fellow interviewee:

> *'... kuzothiwa abantwana bazobakwazi njani ukuthetha isilungu, nabo otitshala bengakwazi ukuthetha isilungu leso'*

translated as:

> *'... they will say how can learners be fluent in English when their teachers cannot speak English fluently'.*

Although this comment is directly responding to the current study's quest to interrogate teacher language competency in the language they are supposed to teach in, the statement will not be discussed further as it was uttered only in passing and not in response to any of the questions on the interview schedule. Nevertheless, the comment provides a snapshot of the linguistic reality in some of the under-resourced primary schools in the ECDoE.

Peters (2011: 7) defines a word problem as a "verbal description of a problem situation wherein one or more questions are posed of which the answers can be obtained through the application of mathematical operations to information available in the text". Questions 13, 14 or 15 which the error analysis questions focused on are typical word problems. They are descriptions of problems which required the interviewees to systematically explain the mathematical operations required to obtain the solution to the problem. The error analysis schedule intended to assess the interviewees' ability to (a) read / decode, (b) comprehend, (c) transform / mathematise, (d) explain / process, and (e) write / encode the solution. By systematically going through the above-mentioned steps, it would have been easy to identify the particular stage in problem solving that the interviewee faced challenges, thus identifying the exact stage where the error originated from.

For the purposes of processing and presenting the interviewee responses, a Likert scale (Likert, 1932; Boone & Boone, 2012) ranging from 1 – 5 (with 5 representing excellent and 1 representing poor) was used to rate the responses. As illustrated in table 7.6, all the interviewees who participated in the error analysis schedule selected to base their responses on question 13 of the JET Mathematics Word Assessment Problems. This could have been because the interviewees deemed the first as the easier choice out of the three suggested questions; however the interviewees fared differently in their answering of the error analysis schedule.

All the interviewees were able to satisfactorily answer section (a) of the question, which only required them to read the question. Section (b) assessed how well the interviewees understood (comprehended) the selected questions. The responses provided in answering section (b), were bordering on inadequate. The researcher was specifically looking out for the interviewees' ability to demonstrate that they had understood the question by identifying key words in the word problem and relating these key words to the problem to be solved. None of the interviewees identified any key words in their response to this section of the interview schedule. In the responses given in answering section (c), the transformation and mathematisation section, the researcher was looking out for the specific mathematical register used by the interviewees. Overall, this was done with average success. To score better marks, the researcher was expecting the interviewees to suggest at least one other different method of transforming the problem to indicate that the interviewees really understood what the question requested of them. In section (d), the processing and explanation stage, the researcher was looking out for systematic explanations which covered what needs to be done first before moving onto the next step. Overall, this section was also rated as below average. In section (e), the decoding of the problem, the researcher was looking out for solutions that indicated that further engaging with the word problem by talking and explaining through the different processes undertaken earlier would have helped the interviewees to identify their initial error in working out the word problem. However, none of the interviewees came up with a different solution to what they had initially obtained. Most importantly, none of the interviewees seemed to be able to identify the error they had made initially; however, they simply repeated what they had done in the first attempt at answering the question.

The analysis of the 2014 ANA reveals that solving word problems was challenging to learners (DBE, 2014). Problem solving is a complex process in which learners need to be coached (Klingler, 2012). It is process by which an unfamiliar situation is resolved (Killen, 2007). Word problems in mathematics involve real-life questions where information is provided to perform computations to solve them (Verschaffel, Greer & De Corte, 2010).

Phonapichat, Wongwanich and Suliva (2014) identify some key difficulties that learners experience in mathematical problem solving, namely: understanding keywords appearing in problems; interpreting keywords in mathematical sentences; and figuring out what information to assume and what information from the word problem are necessary to solve the problems. Schmacher and Fuchs (2012) found that word problem solving becomes difficult for learners as the problem is presented linguistically. Word problems challenge learners to read and interpret the problem, represent the semantic structure of the problem and then choose a strategy to resolve it (Schmacher & Fuchs, 2012).

In as much as research indicates that learners experience numerous challenges related to understanding key words, interpreting these key words and figuring out what information is vital in solving a mathematics word problem, the responses indicated in Table 7.6 indicate that some teachers also experience the same challenges as exhibited by the error analysis interview responses. As such, some interventions need to focus on equipping IP mathematics teachers with word problem-solving strategies which they will in turn pass on to their learners. Responses obtained in the section above indicate that teachers can read the word problem fairly well; however, systematically explaining the process that needs to be done to solve the word problem seems to be a huge task for them. And this confirms the low marks that the teachers obtained in the actual word problem assessment and further confirms that teacher competency in the language they are supposed to teach in needs more attention than it is currently afforded.

Thus, it was both a good and a not-so-good idea to incorporate the error analysis section into the interview schedule. It helped the researcher to identify the stages of word problem solving stages that the interviewees were comfortable with and those that they were not comfortable with. However, the process only diagnosed a problem and a possible solution to this problem would be to familiarize teachers with the error analysis schedule for the purposes of applying the same model to assist the weaker learners in their classrooms.

Familiarizing teachers with such techniques would empower teachers to coach learners on how to tackle word problems within the IP mathematics curriculum.

The not-so-good part of incorporating the error analysis schedule into the interview schedule is that the process was focused on only three questions (pre-selected by the researcher) out of the **35** word problem questions making up the JET Mathematics Word Problem Assessment. The pre-selected questions were all of relatively the same level of difficulty and more information would have been garnered if questions with different levels of difficulty had been selected and compared. Although this would have been time consuming, more balanced results would have been obtained; thus, this aspect of the study is deemed as requiring further research.

After answering the different parts of the error analysis question, the interviewees were requested to suggest any forms of professional development they thought would assist them in become more proficient in using the prescribed language of instruction at IP level. Table 7.7 presents the responses to the sixth question on the teacher interview schedule.

Table 7.7: Additional CPTD Training in using English as LoLT

	Question 6: What forms of in – service CPTD would you like to receive to become more efficient in teaching IP mathematics using English as the LoLT?
T1	- If circuits and districts can organise training for teachers to help in using English as a language of instruction.
T2	- The department must allow educators to teach maths in English not in isiXhosa. - Educators must try to teach maths using more resources or pictures.
T3	- We need to be workshopped on how to teach them. - We need resources that will help them to add and subtract numbers.
T4	- Educators should always be developed to use English during teaching and learning.
T5	- The department should give us bursaries to attend courses.

As illustrated in Table 7.7, the majority of the interviewees indicated that they would appreciate further training to equip them with skills on how to use English as language of instruction at IP level:

> *'- If circuits and districts can organise training for teachers to help in using English as a language of instruction'*

> *'- We need to be workshopped on how to teach them'*

> *'- Educators should always be developed to use English during teaching and learning'*

This information resonates with data collected in previous sections of the study. However, the interviewees were of the opinion that if the ECDoE conducts workshops for different circuits, then IP teachers would be developed in using English as language of instruction, but they did not explicitly indicate a need to have formal in-service qualifications to bridge this gap.

Having captured the interviewees' perceptions on the need for additional teacher professional development in using English as a language of instruction, the interviewees had an opportunity to provide any additional comments they felt were necessary as a way of concluding the interview session. Table 7.8 presents the responses to the final question on the teacher interview schedule which solicited participants' general comments on teaching IP mathematics using English as a medium of instruction.

Table 7.8: Teachers' general comments on use of English as a medium of instruction

	General Comments
T1	- In our schools, it is common that maths is given to somebody who is not trained to teach maths because of shortages, and the gaps are only uncovered during moderation because the teacher is not comfortable to teach certain topics. There are a lot of gaps that need to be filled. Teachers should fill those gaps. Government also wants the learners to be promoted and this system does not allow learners to repeat more than once in a phase. - I cannot blame the government only; teachers also need to do their part. If I miss part of the curriculum, I should inform the next teacher so that the teacher covers those basics. - Teachers should cover at least 90% of the curriculum; not covering the curriculum is a problem.
T2	- The department wants us to follow the CAPS document and give us time allocation, sometimes we just touch and move whereas our learners do not understand. - The department must stop to use work schedule to educators, so educators may have more time helping those learners.
T3	- The department should introduce the curriculum that will allow us to teach mathematics from Grade R in English.
T4	- Learners must start to use English in Grade 1.
T5	- None

As illustrated in Table 7.8, interviewees seem to confirm data collected from previous sections of the study which indicated that there are challenges in managing the switch from mother-tongue instruction in FP to using English as a language of instruction in IP. Although some of the interviewees' general comments – such time on management and coverage of the curriculum – fall beyond the scope of the current study, some of them, for example, on the prevalence of underqualified teachers in IP to alleviate shortage of mathematics teachers, resonate with data collected in previous sections of the study. In addition, the statement:

'I cannot blame the government only; teachers also need to do their part...'

is extrapolated to imply that the linguistic empowerment of the IP teachers should not be left to the administrators alone, but that teachers also need to own the process. Specifically in relation to in-service teachers for whom it is not compulsory to take part in professional development courses (as compared to pre-service teachers); they should take it upon themselves to identify and attend courses that will empower them linguistically in the language they are supposed to teach in, as stipulated by the prevailing LiEP.

The sections above presented, analysed and discussed data gathered in the interviews administered to 5 (10%) of the sampled IP mathematics teachers, including error analysis of sampled mathematical tasks written by the teachers as part of the quantitative data collection process. The section below presents, analyses and discusses data collected through the teacher educator interviews.

7.3.1.2 Interviews: Teacher Educators

Unlike the teacher interview which was double-pronged, the teacher educator interview excluded the error analysis section and only included questions that sought to cross-check the data collected from previous data collection exercises. Following the design of the current study, the teacher educator interview should have been administered to 1 (10%) of the sampled teacher educators; however, for the purposes of gaining a deeper insight into the teacher educators' perspectives regarding relationships between teacher language competency and IP mathematics instruction, the interview was administered to 2 (20%) of the sampled IP mathematics teacher educators after the administration of the questionnaire. Table 7.9 provides the profile of the teacher educator interviewees.

Table 7.9: Interviewee Profile: Teacher Educators

P	G	AGE	ETM	Q
TE1	Male	4	3½	- BA - BEd Hons - MSc - PhD - 20+ Peer-reviewed journal papers - 35+ Conference presentations - <5 Book chapters
TE2	Male	4	>10	- MEd - 30 + Conference presentations - <5 Book chapters

Key:

P – Participant
G – Gender
AGE – Age Group {1: 25 years and below**; 2:** 26 – 29 years**; 3:** 30 – 34 years**; 4:** 35 years and above**}**
ETM – Experience Lecturing Mathematics Education Courses
Q – Qualifications

Demographic information collected in previous sections of this study indicated a balance in gender and experience among the teacher educator participants. As illustrated in Table 7.9, although the first teacher educator has only been lecturing IP mathematics courses for three and a half years, the interviewee has a quite extensive research record which includes journal papers, conference presentations and book chapters. The interviewee's research interests lie in language and mathematics education in multilingual settings. On the other hand, the second teacher educator respondent has vast experience of over 10 years in lecturing IP CPTD mathematics courses.

The Teacher Educator Interview Schedule (**APPENDIX F**) was used to gather specific data on the following aspects: the official language of instruction at the institution; the teacher educator's experience (in years) in presenting IP mathematics education courses; the IP mathematics teacher educator qualifications offered by their institution; whether the qualifications offered include a module on using English as a language of instruction; strategies used by the teacher educator to teach specialised mathematics vocabulary; teaching and learning resources recommended by the teacher educator for use in addressing language-based mathematical problems; and any major challenges usually experienced by the teacher educator while observing IP mathematics teachers using English as a language of instruction. Table 7.10 presents the responses to the first question on the teacher educator interview schedule.

Table 7.10: Official language of instruction at the interviewee teacher educator's institution

	Question 1: What is the official language of instruction at your institution?
TE1	- English
TE2	- English

As indicated in Table 7.10, the official language of learning and teaching at both the interviewees' teacher educator institutions is English. As indicated in Chapter 5 of the current study, all teacher education institutions use English as a language of instruction; in addition, a few of these institutions use both English and Afrikaans as languages of instruction. Table 7.11 presents the responses to the second question on the teacher educator interview schedule.

Table 7.11: Teacher educator experience

	Question 2: For how many years have you presented in – service (IP) mathematics teacher education modules in a South African teacher education institution?
TE1	- 3 ½ years
TE2	- More than 10 years

Although the first teacher educator interviewee has lectured IP mathematics for less than 5 years as indicated in Table 7.11, the participant can be objectively classified as experienced based on the information provided earlier highlighting the interviewee's profile. The interviewees' relatively vast research output in the field of language and mathematics in multilingual settings position the data presented as contemporary and valuable for the current study. The second teacher educator interviewee has been lecturing IP mathematics for more than 10 years and is currently directing the institution's in-service mathematics teacher education programme, which primarily provides professional development of mathematics teachers. Table 7.12 presents the responses to the third question on the teacher educator interview schedule.

Table 7.12: IP mathematics teacher education qualifications offered

	Question 3: What in-service (IP) mathematics teacher education qualification(s) does your institution offer?
TE1	- The institution has a special unit that focuses on in-service teacher educator qualifications varying from short courses, Diplomas, Bachelor of Education, Postgraduate Certificates and Postgraduate Diplomas in Education, Master's in Education to PhD.
TE2	- Bachelor of Education (In-service)

As illustrated in Table 7.12, the first interviewee's institution provides a variety of mathematics teacher education qualifications for both in-service and pre-service teacher education and the respondent lectures modules in both streams. The second teacher educator interviewee's institution also provides both in-service and pre-service teacher education qualification and the respondent specifically lectures on the in-service programme.

The data confirms information provided in earlier sections of the study which indicates that teacher educator institutions usually separate the provision of pre-service and in-service qualifications. Among other purposes, this separation serves to ensure the smooth administration of the different programmes as well as to cater for special needs of each unit. However, it is of paramount importance to coordinate the separate provisions so that practices in the two units inform and influence each other because as soon as a teacher graduates from pre-service training, they immediately become a possible candidate for in-service teacher education. The literature also revealed that the focus on early childhood development as well as school-leaving learners belonging to the FP and FET bands respectively has driven some teacher education institutions to cater only for these bands at the expense of the IP and SP phases. This study views the education system holistically and contends that it should be treated as such in order to combat the creation of artificial but detrimental gaps within the system. Table 7.13 presents the responses to the fourth question on the teacher educator interview schedule.

Table 7.13: Inclusion of modules focusing on using English as LoLT in teacher education qualifications

	Question 4: Do any of your IP mathematics teacher education qualifications include a module focusing on using English as a Language of Learning and Teaching?
TE1	- Yes, there are 2 modules focusing on the use of English as a medium of instruction; however, this module is offered as an elective course at Masters' level.
TE2	- No exactly. It is only a small component of LOLT that is embedded in a section of another module that focuses on Mathematics and language.

The data presented in Table 7.13 indicates that in the first respondent's teacher educator institution there are two modules focusing on the use of English as a language of instruction; in the second respondent's teacher educator institution there is no specific module focusing on English as a language of instruction. This confirms data gathered in the quantitative section of the study. The second respondent further affirms that:

> '... *it is* ***only a small component of LOLT*** (my emphasis) *that is embedded in a section of another module...'*

It is worth emphasising, however, that of the 10 sampled teacher educator institutions, the first respondent's teacher educator institution is the only one providing comprehensive modules focusing on using English as LoLT. This is despite the fact that the new Curriculum Policy of the DHE: Minimum Requirements for Teacher Education Qualifications (MRTEQ)[23] prescribes that one of the competencies of a newly qualified teacher is to "know how to communicate effectively in general, as well as in relation to their subject(s), in order to mediate learning" (MRTEQ, 2015: 20). Thus, as established in the teacher educator questionnaires, it can be inferred that the majority of teacher educator institutions where the participant teacher educators are based do not provide modules focusing on the systematic and consistent use of the prescribed language of instruction in mathematics. It is also worth noting that this practice is not peculiar to South Africa alone, as Chitera's (2016) study (focusing on the use of mother-tongue instruction in mathematics) conducted in Malawi revealed similar findings. Thus, for the purposes of improving the quality of mathematics instruction in schools, all teacher educator institutions need to initiate and place even greater emphasis on the languages that will be used to convey the mathematical concepts taught. To reap better results, the focus on languages of instruction should not be left until advanced studies at Masters level, as indicated in the above data, but should be

[23] The MRTEQ provides "a basis for the construction of core curricula for Initial Teacher Education (ITE), as well as for Continuing Professional Development (CPD) Programmes that accredited institutions must use in order to develop programmes leading to teacher education qualifications" [p 8]. The policy is based on the 2011 MRTEQ policy, with revisions in place in order to align it with the Higher Education Qualifications Sub-Framework (HEQSF).

compulsory in initial teacher education programmes for the benefit of under-resourced schools and communities which cannot attract better qualified teachers. Table 7.14 presents the responses to the fifth question on the teacher educator interview schedule.

Table 7.14: Strategies for teaching specialized mathematical vocabulary used by teacher educators

	Question 5: How do you teach specialised mathematical vocabulary in your lectures?
TE1	- I talk about the mathematics register. - I also talk about the aspects of mathematics register that make it peculiar. - I make student teachers aware of the informal uses of mathematical terms. - I show the students how the lack of understanding of the mathematics register may impact negatively on the general understanding of mathematical concepts. - I make students aware on how different aspects of a language may be interchanged.
TE2	- I identify such vocabulary with the students and then discuss these terms on whole class basis. - They are also given tasks in which they are to identify various types of vocabulary used in the teaching and learning of mathematics. - Students are required to come up with a glossary of terms that are used predominantly at their level/phase.

The strategies for teaching specialised mathematical vocabulary suggested by the two teacher educator respondents as presented in Table 7.14 are very useful. However, they only loosely tally with strategies presented by the IP mathematics teachers in Chapter 5. The second teacher educator respondent encourages students '*to come up with a glossary of terms'*, a strategy which was used by one of the interviewee teacher respondents (T1: Table 7.4); however, Henkel (2007) indicates that compiling a list of words is not good enough, so this strategy needs to be expanded further to make the compiled words more meaningful to the English-language learners in an IP mathematics class:

> … a large passive vocabulary does not necessarily result in a better active vocabulary. Active vocabulary is one a language user can easily and readily draw on for productive language use whereas passive vocabulary is somehow distant and slightly hidden
>
> Henkel, (2007: 6)

This could mean that, in as much as these strategies are useful theoretically, for example, '*talking about mathematics register*', not many of them are sustained in everyday classroom practice, particularly in under-resourced settings. This may mean that the way these strategies are presented should change so that they become more practical, relevant and adaptable in the classrooms. Based on the example given above, teacher educators need to model good practice on how to cultivate an active mathematical vocabulary, instead of a passive vocabulary which is accumulated through the current strategies in use. Table 7.15 presents the responses to the sixth question on the teacher educator interview schedule.

Table 7.15: Teaching and learning resources recommended by teacher educators to address language-based mathematical problems

	Question 6: What teaching and learning resources do you recommend for use by in-service teachers to address language-based mathematical problems?
TE1	- Textbooks - Computer-based activities - Teachers may use multilingual dictionaries with caution because these are not standardised - Word walls and charts
TE2	- I have a few textbooks that were developed here in South Africa that I use when teaching this section. - I also have textbooks form other places outside South Africa that were developed to assist mathematics teaching of English Second Language (ESL) learners. These are mainly from countries like Australia, America, Malaysia and others. - There are journal articles that focus on this area. I also use them as reading material for my students.

As shown in Table 7.15, the first teacher educator interviewee's responses focus on the teaching and learning resources that the teachers can possibly use within a classroom context (practice), while the second teacher educator interviewee's responses focus on the teaching and learning resources that are use suitable for teacher education purposes (instruction). This disparity could indicate that there is no standardised module that guides teacher educators across different teacher education institutions on how to equip teachers with practical and relevant skills to address language-based mathematical problems and hence different institutions approach the task differently. Thus, in as a much as the resources suggested by both the teacher educator respondents are very useful in teacher education instruction and practice, they need to be coordinated. If teachers read widely on different strategies used globally to assist ELLs in addressing language-based mathematical problems, they will be better equipped to adapt these strategies to assist learners in their classrooms.

Four different classroom-based teaching and learning resources are presented in Table 7.15 as recommendations for addressing language-based mathematical problems. Textbooks, dictionaries and charts should be accessible in schools. Since multilingual dictionaries are 'yet to be standardised' teacher education programmes should provide information on how to use these resources, so that the 'use with caution' advice is left not only to the discretion of the teacher. Similarly, the use of word walls and charts, which seem to be a more accessible option among the four provided, should be interactive in nature for the purposes of benefiting the learners.

Considering that the current study focuses on under-resourced schools, computer-based strategies may not be practically applicable. However, they cannot be ruled out as electrification of rural areas in South Africa is an ongoing process and, and at some point in the future, these schools will eventually be in a position to use computers. Some educational partners are also in the process of providing computers and internet access to remote schools in South Africa, therefore teachers should be empowered with the skills of using computer-based activities to address language-based mathematical problems. Thus, teaching and learning strategies need to go beyond identification to encompass their application. Table 7.16 presents the responses to the last question on the teacher educator interview schedule.

Table 7.16: Major challenges experienced by teacher educators when lecturing / observing IP mathematics teachers using English as LoLT

	Question 7: What major challenges do you experience when lecturing / observing mathematics intermediate phase teachers using English as a language of learning and teaching?
TE1	- Teachers who are not aware on how language can impact the understanding of mathematics. - Teachers who battle with communicating in English. - Teachers who have the mathematical knowledge but have no language skills to explain the concepts. - Teachers who use code switching inappropriately, i.e. teachers who do not code switch to help the learners but to help themselves to continue with the sentence.
TE2	- Challenges are complex. - The teachers' English-language competence is not up to standard. - Teachers are struggling with English as a language for their own purposes. This coupled with their alarmingly low content knowledge makes the problem complex. - I work with in-service teachers who already have at least a diploma or certificate in education. At university there are assumptions that such teachers have the necessary basic competency in English language yet this is not always the case. - The other challenge is the way in which teachers are made / deployed to teach mathematics at IP. From the conversations I have had with most of my students (in-service teachers), they are not specialists in the subject, i.e. mathematics. They are either asked to volunteer because they have at least Standard Grade maths or they take up just to help out in their schools.

The challenges presented by both the teacher educator interviewees in Table 7.16 confirm information collected through the teacher educator questionnaire. In general, the information presented confirms that IP mathematics teachers' linguistic skills need improvement.

- *'Teachers who battle with communicating in English'*
- *'The teachers' English-language competence is not up to standard'*
- *'Teachers are struggling with English as a language for their own purposes'*

The two respondents both confirm that the IP mathematics teachers' language competence is English is significantly low. The second respondent highlights that, although the qualified IP mathematics teachers' English language competence is significantly low, teacher educator institutions offer CPTD courses assuming that the teachers' basic competence in English is sufficient, yet this is not the case. This study reiterates that teacher educator institutions cannot continue working on this assumption as competence in the language of instruction is fundamental for meaningful learning to take place. Thus, if the English-language competence of IP mathematics teachers, which this study regards as the primary challenge, is addressed adequately, the other secondary challenges such as when and how to code switch or translanguage, deployment and mathematical content knowledge would be manageable.

Of greater importance in the data presented is the notion of awareness in how language impacts on the understanding of mathematical concepts which further confirms a gap in teacher education. This awareness should not only be created during initial teacher education, but promoted and constantly revived through in-service programmes. In addition, the view that some teachers might have mathematical knowledge without the supporting language skills to convey the knowledge widens the gap and presents a missed opportunity to merge content knowledge and linguistic proficiency. The researcher further reiterates that it is the mandate of teacher education institutions to narrow these gaps.

The sections above presented, analysed and discussed data gathered through the interviews. Teacher interviews administered to 5 (10%) of the sampled IP mathematics teachers were presented first, followed by the presentation of data gathered from teacher educator interviews, administered to 2 (20%) of the sampled teacher educators. The section below presents, analyses and discusses data collected through classroom observations.

7.3.2 Classroom Observations

The classroom observations were the second-line cross-checking technique of the quantitative data collected from the participant teachers. The non-participant structured classroom observations were conducted only on the sampled IP mathematics teachers at the schools where the teachers are based in the Eastern Cape Province. The classroom observations were conducted only on the teachers and not on the teacher educator participants, because the teachers are the key respondents in this study whose English-language proficiency levels were explored in relation to their IP mathematics instruction. Data collected during the classroom observations was triangulated with data collected from other sources.

The section below presents the profiles of the observed teachers, followed by the linguistic profiles of the teachers and their learners and a brief contextual description of the schools and lessons observed before the presentation of the different linguistic practices observed in the classrooms. Table 7.17 provides the profiles of the observed teacher participants.

Table 7.17: Observed teacher participant profiles

S	P	G	AGE	Race Group	ETM (years)	Q
S1	T1	F	4	Black	15	- Primary Teachers' Diploma - Advanced Certificate in Education
S2	T2	F	4	Black	7	- Primary Teachers' Diploma - Bachelor's Degree in in Education - Advanced Certificate in Education
S3	T3	F	4	Black	9	- Primary Teachers' Diploma
S4	T4	F	4	Black	6	- Primary Teachers' Diploma - Advanced Certificate in education
S5	T5	M	2	Black	$1\frac{1}{2}$	- National Diploma in Adult Basic Education and Training - Post Graduate Certificate in Education

Key:
S – School
P – Participant
G – Gender
AGE – Age Group: {1: 25 and below; 2: 26 – 29; 3: 30 – 34; 4: 35 and above}
ETM – Experience Teaching IP Mathematics
Q – Qualifications

As illustrated in Table 7.17, the majority of the teachers were middle-aged females. Most of the teachers had been teaching other subjects such as Technology and Social Sciences at primary school level before they began teaching IP mathematics. The teachers' experience of teaching IP mathematics varied from several years to only a few years. In addition, all the teachers were qualified, having obtained pre-service diplomas formerly offered at Teachers' Colleges as their initial teacher education qualifications; some teachers had upgraded these initial teacher education qualifications to obtain further qualifications through in-service programmes offered at different universities in the country. The teachers' profiles confirmed demographic information collected in earlier sections of this study. Table 7.18 provides the linguistic profiles of the observed IP mathematics classes.

Table 7.18: Observed classes' linguistic profiles

	Grade	Teacher's 1st language	Learners' 1st languages					Topic of the lesson
			English	Afrikaans	isiXhosa	Other (Specify)	Total No. of learners in class	
T1	**4A**	IsiXhosa	✗	✗	✓	-	67	Quadrilaterals
T2	**6A**	IsiXhosa	✗	✗	✓	-	50	Numeric Patterns
T3	**5A**	IsiXhosa	✗	✗	✓	-	99	Transformations
T4	**6**	IsiXhosa	✗	✗	✓	-	42	Input – output machines
T5	**7**	IsiXhosa	✗	✗	✓	-	22	Multiplication

As indicated in Table 7.18, the lessons observed were all on the IP level (ranging from Grade 4 to Grade 7). One lesson (Grade 4) was at the entry level of phase, one lesson (Grade 5) was at the second level of the phase, two lessons (Grade 6) were at the third level and one lesson (Grade 7) was at the exit level in the phase.

In all the lessons observed the teachers' home language is isiXhosa, which further confirms the point made by Tshabalala (2012) that the majority of South African teachers are not first-language speakers of English. None of the learners in the observed lessons spoke English, Afrikaans or any other language as their home language. In all the lessons observed the learners' home language was isiXhosa, which meant that the teachers and the learners shared the same home language. The total number of learners in the classes varied, with the smallest class having 22 learners, while the largest class had 99 learners. Thus the class size in these schools is relatively large. **T1** taught a lesson on quadrilaterals, **T2** taught a lesson on numeric patterns, **T3** taught a lesson on transformations, **T4** taught a lesson on input-output machines, and **T5** taught a lesson on multiplication.

To get a clearer insight into the lessons taught, it is necessary to briefly describe the context of the observed classrooms. Although the observations where done in under-resourced schools in the Eastern Cape Province, the setting and environment of each school is unique. The contextual details of the observed classrooms thus provide information on the enrolment of each school as well as the staff complement and the conditions which may have a direct or indirect impact on what actually happens inside the classrooms regarding how each teacher presents his or her lesson. Table 7.19 provides an overview of the lessons that were presented in each of the IP mathematics classrooms observed against the backdrop of the contextual setting of each school.

Table 7.19: Brief description of schools and the observed lessons

Context	P	Lesson description
S1 **Enrolment:** 1,022 Learners (Grades R – 9) No Grade 8 **Staff Complement:** 30 Teachers	**T1**	**Topic: Quadrilaterals** Description of different polygons summarized on the board, the shapes described are drawn. Discussion of concepts to be learnt takes place before group work, practical activities and presentations of the words done in groups. Written work is done individually towards the end of the lesson.
S2 **Enrolment:** 903 Learners (Grades R – 9) No Grade 8 **Staff Complement:** 28 Teachers	**T2**	**Topic: Numeric Patterns** Very impressive rhymes of multiples done to introduce the lesson. Number patterns written are on the board and the teacher explains the difference between constant difference sequence and constant ration sequence.
S3 **Enrolment:** 802 Learners (Grades R – 9) **Staff Complement:** 25 Teachers (5 Mathematics Teachers)	**T3**	**Topic: Transformations** The lesson begins with an oral mental exercise. In addition, the teacher poses several questions to the learners as part of the introduction. The teacher reviews the learners' assumed knowledge by asking clarity-seeking questions.
S4 **Enrolment:** 454 Learners **Staff Complement:** 10 Teachers (Grade R – 9)	**T4**	**Topic: Input – Output machines** The teacher indicates right at the beginning of the lesson that the purpose of the lesson is to revise content covered earlier in preparation for examinations. After the announcement, the teacher continues to explain input and output machines.
S5 **Enrolment:** 103 (1 multi-grade class) **Staff Complement:** 8 Teachers	**T5**	**Topic: Multiplication** The teacher does not engage much with the learners at the beginning of the lesson, and goes on to explain the multiplication strategy that is going to be covered during the lesson.
Key: **P – Participant** **S – School** **T – Teacher**		

As indicated earlier in this section, the schools in which the teachers are based are under-resourced and are characterised by enormous class sizes due to a shortage of classes. In schools where there is *'No grade 8'* as indicated in Table 7:18 the ECDoE is currently separating primary and secondary schools, by moving Grade 8 and 9 learners previously based in primary schools to nearby secondary schools, a process which also impacts on teacher deployment.

At **S3** the school's administration block had been converted into classrooms and a smaller room was built by parents adjacent to the block to function as the principal's office and secure storage for the school's photocopying machine, screen and projector. The school is challenged by having a serious shortage of furniture and the large class sizes; there was no space to accommodate a teacher's table.

Figure 7.1: Break time at S3

Figure 7.2: School furniture situation at S4

At **S4** an educational development partner was in the process of constructing a road connecting the school to the main road. The road construction included a bridge which would ensure that learners can safely commute to school during the rainy season when rivers are flooded. Although the schools had well-maintained buildings, there is a serious shortage of furniture and in some classrooms learners sit on broken chairs.

S5 is a relatively small school compared to other schools in the vicinity, with one block of classrooms for all grades and another separate block housing the principal's office, administration office and a staff room. With only 103 learners and one multi-grade class (Grades 2 and 3 taught by one teacher in one classroom), parents in the community seem to prefer to spend money on transport to send their children to neighbouring schools with a reputation for better performance.

The demographic information of the sampled teachers in Chapter 5 of the study provided more details about the participants; the contextual settings of the schools where classroom observations were conducted provide more information on the under-resourced schools' environment against the backdrop of the South African education system.

The mathematics teachers identified in Table 7.17 are generalist teachers who are assigned to teach mathematics, not specialised to teach the subject. The teachers presented lessons on different topics. Although all the classroom observations were conducted in one week, from 12 to 16 September 2016, teachers were all teaching different topics, including teachers teaching the same grades, such as the two Grade 6 teachers observed. These variations could be attributed to the fact that the pace of the learners in the different schools was different. The brief lesson descriptions also provide a brief synopsis of how each teacher presented their lesson.

In general, the majority of the lessons were teacher-centred (**T3**, **T4**, and **T5**) and this could be attributed to the relatively large class sizes. Where learners were actively involved (**T1** and **T2**); there was a lot of chanting and rhyming, which indicated that rote learning dominated the classrooms. However, some teachers did bring practical activities into their lessons and their classrooms were organised into groups to promote discussion and interaction amongst learners.

The aim of conducting the classroom observations was to gather more information on the classroom environment in which the participant teachers practised as well as to assess the linguistic practices in each classroom observed. As a non-participant observer, the researcher broadly assessed the following: classroom organisation, teaching and learning resources, teacher activities, and interactions between the teacher and the learners as well as interaction amongst learners themselves.

- **Classroom Organisation**

  Learners construct solutions for mathematics through discourse. Therefore, it is important to organize learners in groups in order to encourage learner participation through talk. Dialogic teaching encourages learners' active participation (Mercer, 2006: 507; Alexander, 2000).

- **Classroom Resources**

  Learners understand content better if they use objects derived from their own environment in their learning. The use of resources encourages active learning by learners. This makes the learners active respondents in their own learning (Carruthers & Worthington, 2006: 74; Willis 1998; Crawford & Witte, 1999).

- **Teacher Activity**

  If a teacher and the learners understand concepts and procedures, the teacher will have better control of the classroom activities. In addition, learners should learn by understanding and not by rote. Therefore the learners' understanding of concepts helps to facilitate learning (de Corte 2004: 280; Even & Tirosh, 1995: 164).

- **Teacher-Learner interaction**

Teacher-learner interaction in which learners are actively engaged in the process of constructing numerical knowledge and understanding is effective in the learning process. The learners learn by doing and thus help to find the solutions to problems themselves. Learners construct mathematical knowledge as advised by teachers. Teachers therefore do not give learners solutions to problems, but guide the learners to find these solutions. Success gained this way would lead to more interest to participate in learning (van de Walle, 2007: 3; Schunk, 2005: 412).

- **Learner-Learner interaction**

Learner interaction enhances social interaction as learners can share how they arrived at the answers. Dialogue between learners and teachers is good for the learning process. This interaction helps the introverted learners to open up and participate in the learning process too (van de Walle, 2006; Vithal, 1992).

To gather detailed information on the components of the classroom environment listed above, and particularly on the classroom linguistic practices, the non-participatory observation guide (**APPENDIX G**) was used to gather specific data on the following variables: language of instruction in the mathematics lesson, learner participation, the teaching and learning of specialised mathematics vocabulary, chalkboard summary, learning and teaching resources used in the classroom, and the classroom environment. The section below presents the different variables and linguistic practices observed in the classrooms.

Language of instruction in mathematics lesson

The first variable focused on the language of instruction used in the IP mathematics classroom, with particular focus on the frequency of using English as the LoLT. Observations are presented in Table 7.20.

Table 7.20: Language of instruction in IP mathematics lessons observed

	Variable 1: Language of instruction in mathematics lesson ***{Language(s) used by the teacher to give instructions and ask questions}; comment on the frequency English is used as the LoLT.***	
	Language(s)	**Comment**
T1	English	- The teacher uses English to give instructions to learners
T2	English	- The teacher uses English to give instructions to learners - The teacher prompts learners to explain the difference between two ratios in English.
T3	English and isiXhosa	- The teacher uses English to present the lesson. - The teacher responds to some of the learners questions in isiXhosa. - The teacher reads the questions together with the learners in English.
T4	English	- The teacher uses English as the medium of instruction; however the teacher's utterances have some grammatical errors.
T5	English and isiXhosa	- The frequency of the teacher's use of both English and isiXhosa throughout the lesson is equally balanced.

As illustrated in Table 7.20, three of the teachers (T1, T2, and T4) explicitly used English during the lesson presentation, while T3 and T5 used both English and isiXhosa as languages of instruction. While T1 used English to give instructions to the learners, the teacher's utterances were limited (did not speak much), and the researcher wondered whether the exclusive use of English is an everyday occurrence or was it influenced by the presence of an observer in the classroom. The researcher also wondered if T1's exclusive use of English was the reason why the teacher did not speak much. T2's use of English as language of instruction was more extensive than T1's and the teacher prompted learners to give explanations in English. The teacher seemed to be at ease in conversing with the learners in English as well as to promote interaction with the learners in English.

T4 also used English as the language of instruction; however, the teacher's utterances had some grammatical errors. Without making generalisations, T4's linguistic competencies confirm Tshabalala's (2012) observation that the majority of South African teachers who are not first-language speakers of English are not fluent in the language, a point also confirmed in the English teacher language competency assessment presented in Chapter 6 of this study. Although T3 presented the lesson in English, isiXhosa was used occasionally to respond to the learner's questions or to provide further clarity on certain aspects of the lesson. T5 used English and IsiXhosa equally throughout the lesson.

In as much as the majority of the teachers are commended for conducting their lessons in English, it was evident that the teachers need more support in keeping up with the stipulations of the LiEP. Firstly, the teacher's proficiency in the language they are supposed to teach in needs to be improved, so that the teachers can teach comfortably in English themselves. Considering that the learners may not have much access to the English language outside the classroom, the teacher should model best practice by speaking grammatically correct English. For the teachers who used both English and isiXhosa in their instruction, it is clear that they were practising code switching and using the shared language as a resource in teaching IP mathematics. However, the practice needs to be standardised, so that the teachers know when and how to code switch and translanguage systematically, as suggested by Chitera (2016), for the purposes of meaningful mathematics teaching and learning.

Learner participation

The second variable focused on learners' involvement in the learning activities, particularly focusing on the language(s) learners used when talking amongst each other and when communicating with the teacher, or when participating in class activities. How the learners used English in classroom activities was noted. Observations made are presented in Table 7.21.

Table 7.21: Learner participation in IP mathematics lessons observed

	Variable 2: Learner participation ***Learners' involvement in the learning activities, (focusing on the language(s) they use when talking amongst each other / when communicating with the teacher); or when participating in class activities. How are the learners using English in classroom activities?***	
	Language(s)	**Comment**
T1	English	- Learners respond to the teacher's instructions in English. - Learners use well-constructed and complete English sentences to respond to the teacher's questions. - Excellent learner participation – during presentations of work done in groups, learners present their work in English.
T2	English	- Learners respond to the teacher's instructions in English. - Learners use ***chorus answers*** to respond to the teacher. - During revision, learners attempt to explain their answers in English.

T3	English and isiXhosa	- Learner participation is above average. - As learners respond to the teacher's questions, the teacher discourages the use of chorus answers and asks learners to respond to questions individually.
T4	English	- Few learners who respond to the teacher's attempt to use English. - When the whole class responds to the teacher's questions, chorus answers in English are used.
T5	English and isiXhosa	- There is limited interaction among the learners. - The teacher demonstrates work on the board, and when questions are asked, learners respond in chorus answers. - Learners respond to the teacher's questions in isiXhosa and the teacher translates the responses into English.

The linguistic patterns observed in learner participation as illustrated in Table 7.21 above, loosely correlate with their respective teachers' frequency in using English as a language of instruction as noted earlier. In classrooms where teachers made an effort to use English as the language of instruction, learner participation was higher on average than in those where teachers used a mixture of English and isiXhosa. In addition, in classrooms where the teacher used English more frequently, the learners also strove to respond to the teacher's questions in English. Therefore, if the learners tend to emulate the teachers' linguistic practices, teachers always have to model best practices. Thus, in order for better English proficiency to filter down to the learners, teachers' proficiency must be of higher quality.

Learners in T1's class made an attempt to respond to the teacher's questions in English, using well-constructed sentences. Although there is a possibility that the learners could have been drilled in preparation for the observation, the mere fact that they attempted is commended. Learners in T2's class produced a lot of chorus answers, another indication that they could have been drilled beforehand. The chorus answers in T2's class went unchecked, while in T3 the teacher discouraged them and prompted learners to answer individually. The use of chorus answers could be a strategy used to manage extremely large classes (e.g. a class of 99 learners). Lee (2006: 36) describes chanting as an old-fashioned method that affords learners the opportunity to:

> use the mathematical language themselves, in order to get used to the way that expressions are used and to begin to use mathematical terms in order to express the web of concepts and ideas that are encompassed by those terms.

Thus, chanting allows learners to vocalise words that are often not easy for them (Lee, 2006) and also allows learners to think about the words and phrases that are used to express these mathematical ideas. For chanting to produce these positive results, the teacher (who is usually proficient in the language of instruction) would write on the board these unfamiliar phrases and initiate the chanting by voicing the words in unison with the learners. However, in the case of T4 as observed in Variable 1 (Table 7.20); where

> '... the teacher's utterances have some grammatical errors'

there is a danger in having learners chant grammatically wrong answers, as they would always remember these chants and choruses even in their higher grades and this creates further misconceptions.

In T5's class there was limited interaction among the learners and in most cases the learners responded to the teacher's questions in isiXhosa, even in cases where the question was posed in English. This practice could be an indication that the amount of communication that takes place in isiXhosa is usually higher. Considering the fact that T5 was teaching Grade 7 learners, who are at the exit level of IP, more utterances in English could have been expected. Although the teacher translated the learner responses that were provided in isiXhosa, the practice needs to be regulated and standardised.

When and comparing and contrasting the ***limited interaction*** among learners to the ***chorus answers*** provided by the learners; it is worth highlighting that although whole class aural work is important, it is also important for learners to practise working on their own, particularly reading and writing on their own as these are the skills that are expected of them and assessed in examinations. It is also important for learners not only to give the correct answer, but also to be able to explain their thinking. One way of encouraging this would have been to allow learners to talk to the learner next to them and explain their thinking. In addition, there is a need to support mathematical thinking. This could include strategies such as asking learners to notice patterns (what stays the same and what is different) and relationships and linkages across taught concepts, which can be used effectively to encourage learners to think mathematically. Thus, the teacher needs to promote learner participation in such a way that a web of mathematical discourse is created and discourse through the prescribed medium of instruction needs to be cultivated and promoted.

Specialised Mathematics Vocabulary

The third variable focused on the strategies used by the teacher to teach and explain specialised mathematics vocabulary for the concepts covered during the lesson. Observations are presented in Table 7.22.

Table 7.22: Strategies used to teach specialized mathematics vocabulary in IP mathematics lessons observed

	Variable 3: Specialised mathematics vocabulary ***What strategies does the teacher use to teach / explain specialised mathematics vocabulary for the concepts covered during the lesson?***
T1	- The teacher uses practical examples to revise the naming of different polygons.  **Figure 7.3: Models of 2-dimensional shapes used to reinforce content and mathematical vocabulary in T1's class**
T2	- The following new terms (***constant difference sequence, constant ratio sequence***) are introduced to the learners, but not much is done to explain the meanings of these new terms.
T3	- The teacher uses a chart to explain the following terms: ***rotation***, ***reflection*** and ***translation***.
T4	- There is no new mathematical vocabulary introduced to the learners during the lesson.
T5	- There is no new mathematical vocabulary introduced to the learners during the lesson. - The teacher explains the mathematical procedures involved in multiplication in isiXhosa.

As indicated in Table 7.22, in the majority of the lessons observed there was no specific focus on specialised mathematics vocabulary. T1's lesson involved some practical activities that could be manipulated for mastery of mathematics register.

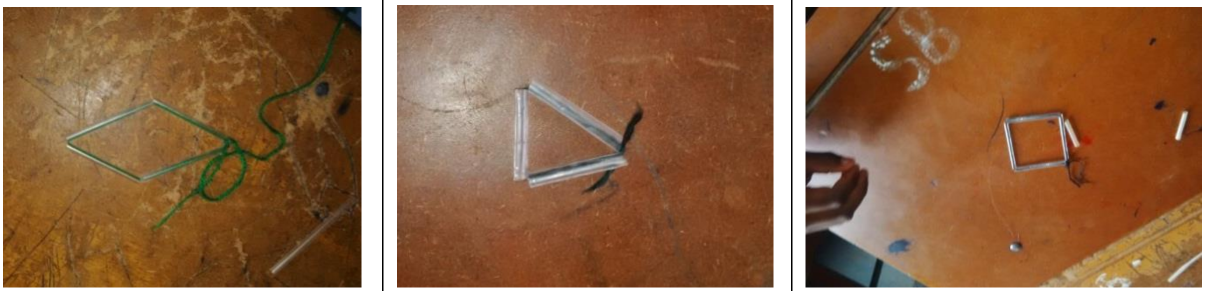


Figure 7.4: Models of polygons constructed by learners in groups in T1's class

The lesson was well presented and learner-centred and the teacher is commended for all the efforts in planning and preparing for the lesson. However, a lot more could have been done to assist learners to master the terms: ***quadrilateral, rhombus,*** and ***parallelogram***. In addition to merely writing these words on the board, the teacher could have further provided learners with the meanings of these words and asked them to write them at the back of the exercise books or written these words on a separate section of the chalkboard or even a word wall. As detailed in Chapter 2 of this study, such words are not part of everyday English and the chances of learners encountering them outside the mathematics classroom are very slim – and even slimmer for a mathematics classroom in an under-resourced community. Similarly, T2's lesson involved terms like ***constant difference sequence*** and ***constant ratio sequence,*** but there was no attempt to provide explicit meanings for these compound terms that do not occur in everyday English.

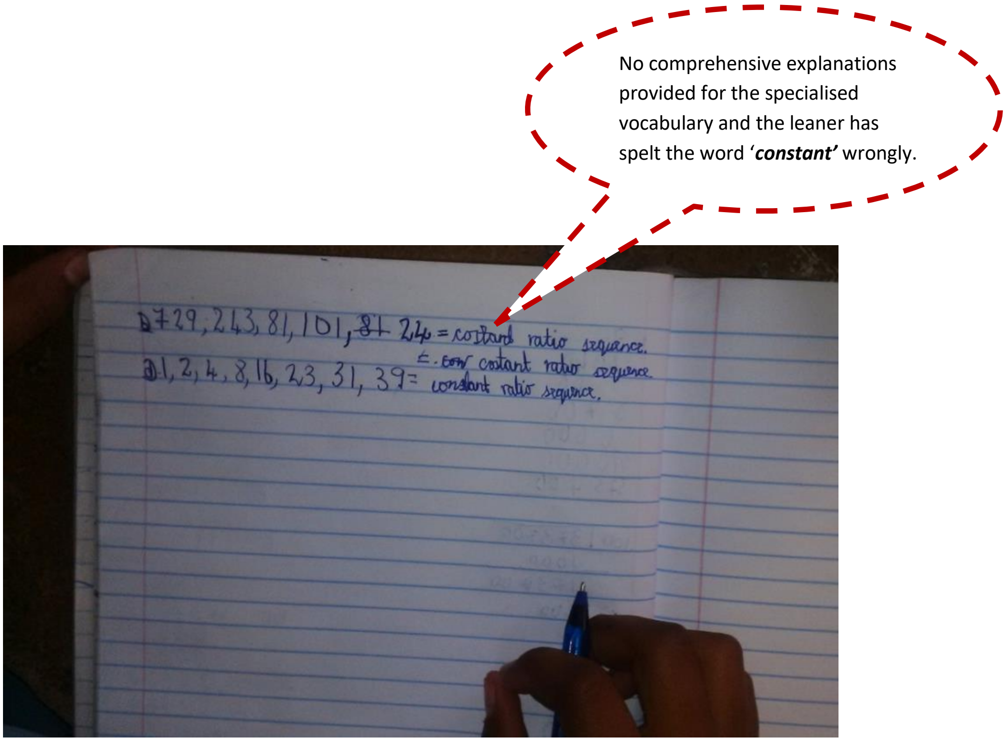


Figure 7.5: A sample of a learner's written work on '*constant ratio sequence'*

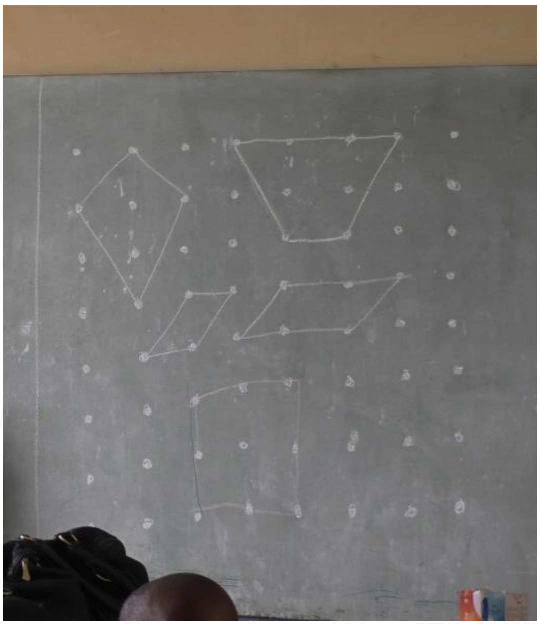
Barwell (2012) states that a mathematics teacher teaching ELLs must fulfil three main functions: to teach mathematical concepts and procedures, to teach the mathematics register, and to teach the language of instruction. In the observed classrooms it may appear that the teacher focused only on the first function of teaching mathematical concepts and procedure without paying much attention to the register or to the language of instruction. For the purposes of this study, it may be inferred that the teachers were not exposed to the other two linguistic functions during their own initial teacher education, and as a result do not afford them the warranted attention. In the observed classes the least the teachers could have done is to make learners aware of the specialised mathematics vocabulary. In better-resourced settings teachers could have made use of mathematics dictionaries to help learners understand the meanings of the words, and in such under-resourced classrooms the teachers could have encouraged learners to add these words in their ***learner-made dictionaries*** as illustrated in Chapter 3 of this study.

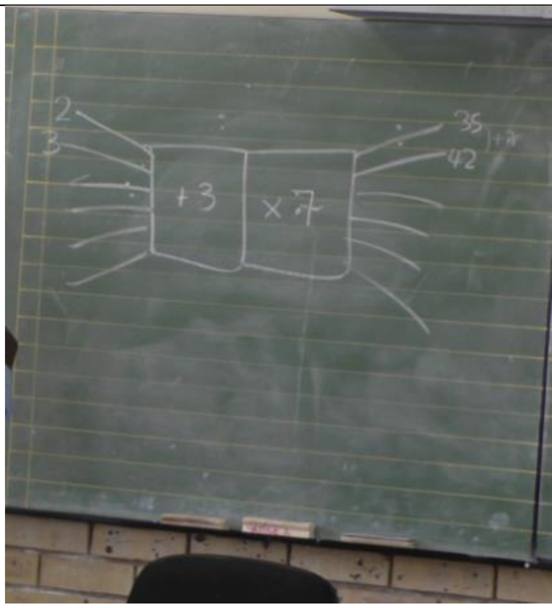
T3 used a chart to explain new mathematical vocabulary to the learners; however the use of the chart was not exhaustive. T3's reference to a chart to explain the terms ***rotation, reflection*** and ***translation*** is commended; however, more could have been done to ensure that the learners understand the vocabulary. Thus, the chart could have been used comprehensively to ensure that the learners fully understand the meanings of the new words. T4 could have reiterated the implications of the words ***input*** and ***output*** to assist the learners in understanding the mathematical concepts entailed; the same applies to T5. Ideally, during lesson preparation, the teacher should identify specialised mathematical vocabulary that may lead to misconceptions among ELLs and ensure that some attention is given to these words during lesson presentation.

Chalkboard Summary

The fourth variable focused on the language(s) the teacher used when writing on the chalk board during the lesson. Observations made are presented in Table 7.23.

Table 7.23: Languages used when writing on the chalkboard in IP mathematics lessons observed

	Variable 4: Chalkboard summary: ***Comments on the language(s) the teacher uses when writing on the chalk board during the lesson.***	
	Language(s)	**Comment**
T1	English	- The chalkboard is used extensively to illustrate drawings of different 2-dimensional shapes.  **Figure 7.6: A virtual geoboard drawn on the chalk board in T1's classroom**
T2	English	- Examples of the two types of ratios are written on the board. - The teacher uses the chalkboard to revise group work given to the learners. - Learners respond to the teacher's questions using chorus answers.
T3	English	- Only the new words are written on the chalkboard.
T4	English	- There are no new words written on the chalkboard except for calculations.

		 **Figure 7.7: A function machine drawn on the chalk board in T4's classroom**
T5	English	- The teacher is the only one who writes on the chalkboard. - Generally, the chalkboard is only used for calculations and nothing else throughout the lesson.

Variable 5 focused on the language(s) used to write on the chalkboard; all the teachers are commended for using English, the stipulated language of instruction, to write on the chalk board. As illustrated in Table 7.23, the chalkboard was mainly used for diagrams; there was not much text written on the board in all the five classrooms. However, there is always room for improvement.

It was noted that in all classes none of the teachers wrote the date and topic of the specific lessons taught at the beginning of their respective lessons. As trivial as this may sound, writing the date and topic of each lesson taught is one of the simplest ways of creating a text-rich classroom (and appreciation of it), and it also helps struggling learners to master spelling. In addition, learners have a tendency to copy whatever the teacher has written on the board; therefore, if the teacher writes the topic on the board, the learners will copy the correct spelling of the topic into their exercise books.

T3 used the chalkboard to write new words and there is a possibility that the learners copied what the teacher had written verbatim. In the observed lessons the chalk board could have been used extensively to note key aspects of the lesson, which the learners would then copy into their books for future reference or for revision purposes. Educational research reveals that learners have different learning styles. Learners who appreciate visual images benefitted from T1's and T4's lessons, where the chalk board was used for diagrammatic representations of concepts taught.

Although T1 is commended for simulating a geoboard on the board, had the names of the different quadrilaterals drawn on the virtual geoboard been written alongside the corresponding shapes, learners would have benefitted from the labels. In addition to using straight lines to produce neat and accurate diagrams, the chalkboard could have been used more extensively to illustrate the key terms that are used to describe quadrilaterals such as ***diagonal, parallel, perpendicular, bisect, opposite***, as illustrated in Figure 7.8 so that the defining properties of different quadrilaterals are understood with greater clarity.

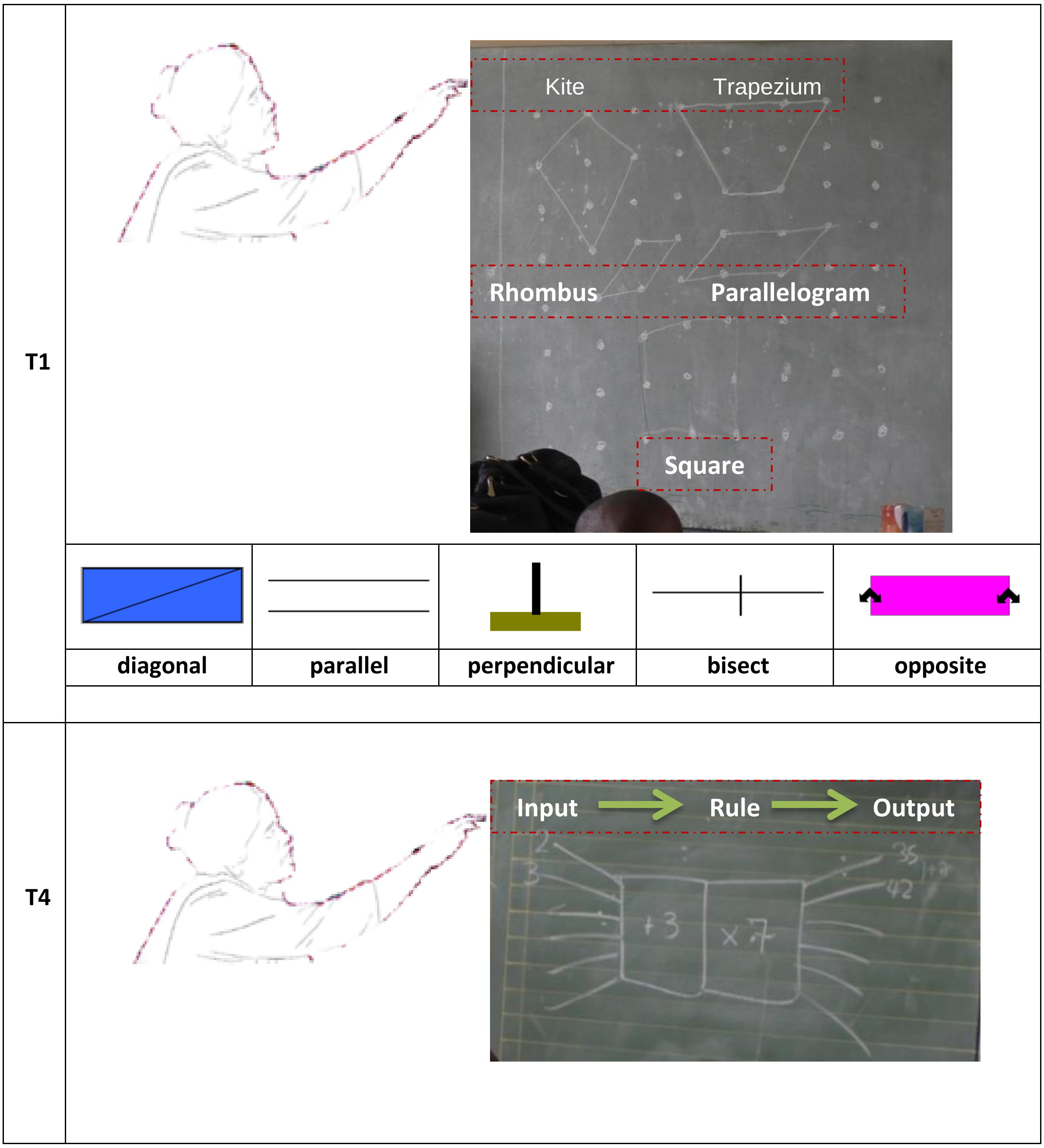


Figure 7.8: Examples of text that could have been written on the chalkboard to improve understanding of mathematical concepts in T1's and T4's classrooms

In T4's classroom, if the words ***input, rule, output*** had been used to label the function machine, learners could have made associations between the labels and the different parts of the function machine respectively; this would have made the diagram more meaningful than simple computations of numbers on the machine. Similarly, learners who appreciate text would have benefitted from chalkboard summaries highlighting key points from the lesson.

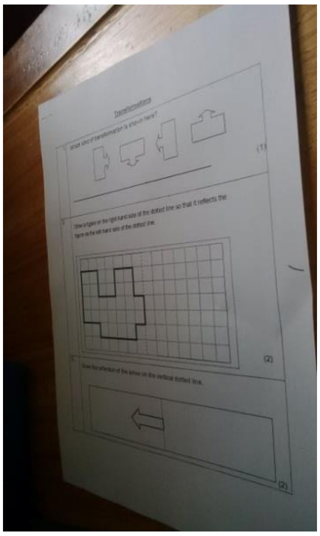
There is a possibility that the chalkboard summary was not as text-rich as the researcher expected because of the teachers' inadequate mathematical content knowledge rather than poor linguistic skills. Also, the teachers could have covered these mathematical terms in lessons preceding the observation, or were intending to cover the mathematical terms in the lessons after the observation. Either way, this information was not part of the review of assumed knowledge or the review of concepts learnt in the preceding lessons. As critical as this may be, a consideration of mathematical content knowledge falls beyond the scope of the current study.

Learning and Teaching Resources

The fifth variable focused on the presence and use of DBE workbooks, textbooks and other audio visual learning and teaching resources written in English used during the lesson. Observations made are presented in Table 7.24.

Table 7.24: Use of learning and teaching resources in IP mathematics lessons observed

	Variable 5: Learning and teaching resources ***Comments on any DBE workbooks, textbooks or other audio visual learning and teaching resources written in English used during the lesson?***			
	(a)	***(b)***	***(c)***	**Comment**
T1	X	X	✓	- In groups, learners use straws and wool to construct different models of 2-dimensional shapes.
T2	X	✓	X	- The group work done by the learners is from a textbook. - The teacher reads the questions together with the learners before learners attempt answering the questions in their groups.
T3	X	X	✓	- The teacher uses a chart to explain the new concepts. - The chart used during the lesson seems to have been made specifically for teaching the day's lesson. - There is no evidence that the chart has been on the classroom walls before. - Towards the end of the lesson, learners attempt questions on a worksheet provided.

				 **Figure 7.9: Learner worksheet on Transformations in T3**
T4	✓	X	X	- The work done by the learners is from the DBE workbooks.
T5	X	X	X	- There is no textbook or any form of written text for use throughout the lesson. - Learners follow what is written by the teacher on the chalkboard.
Key: *a* = DBE Workbooks *b* = Textbooks *c* = Audio visual learning and teaching material				

As indicated in Table 7.24, T1 used audio-visual teaching and learning resources to engage learners in the practical activity of constructing models of two-dimensional shapes using straws and wool. The teacher is highly commended for drawing on this kind of creativity. After constructing models in groups, learners presented their work to the class by describing the models they had made; thus, the activity prompted learners to use mathematical language in their class presentations. Since the lesson was practical, there was no reference to text-based teaching and learning resources, except for the names of the shapes that were written by the teacher on the chalk board. Perhaps in the following lesson, consolidating content learnt practically, the teacher used text-based teaching and learning resources.

T2's lesson revolved around a textbook written in English. All the activities done by the learners were from the particular textbook. The teacher read through the textbook instructions together with the learners. Although this promotes chorus answers, the teacher was at least modelling the correct pronunciation of the words written in the book. The teacher could have also asked different learners to take turns to read different sentences and correct their pronunciation if needs be. Although time consuming, in this way the teacher would have been able to identify learners who struggle to read and provide them with the relevant support. Such learners would be difficult to identify when the whole class reads the same text at once.

T3 used a chart to demonstrate different types of transformations. Although the teacher is commended for the efforts in preparing the chart, there was no evidence of any other charts displayed on the classroom walls. Text on the chart was written in English and the chart could have possibly been prepared for the observation session. In addition to the chart, a worksheet on transformations was provided to learners towards the end of the lesson.

T4's lesson on input and output machines was extracted from a DBE workbook written in English. The DBE workbooks are provided to schools to supplement textbooks and other teaching and learning resources available in schools. As documented in Chapter 6 of this study, different authorities have different views regarding the DBE workbooks; however, in under-resourced schools without textbooks, the DBE workbooks provide the absolute minimum form of text that can be used for teaching and learning purposes. What remained unestablished was whether T4 had access to other textbooks to supplement the work books.

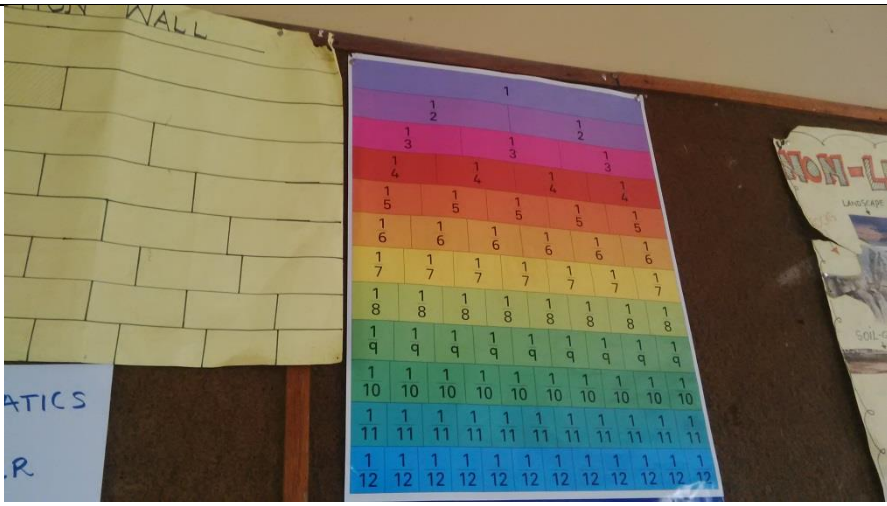
T5's lesson on multiplication did not make reference to any form of written text whatsoever. The lesson was a typical ***chalk-and-talk'*** lesson and the learners had to passively listen to the teacher throughout. The teacher did not even have any textbook at hand and at the end of the lesson learners were not given any homework to practise what had been taught during the lesson. There were no charts in the classroom and it was not clear whether the school had received any DBE workbooks, even though these are provided to all schools free of charge by the Department of Basic Education. Or it was sheer lack of preparation from the teacher?

Classroom Environment

The sixth and last variable was linked to Variable 5 above and focused on the presence or absence of charts/word walls around the classroom which indicated that mathematics is taught in English. Observations are presented in Table 7.25.

Table 7.25: Classroom environment in IP mathematics lessons observed

	Variable 6: Classroom environment *Are there any charts / word walls around the classroom which indicate that mathematics is taught in English?*	
	Yes / No	**Comment**
T1	Yes	- There are several charts on the classroom walls.  **Figure 7.10: Some of the charts displayed on the walls in T1's classroom**
T2	Yes	- There is only one isolated chart on multiplication tables in the entire classroom.  **Figure 7.11: A chart on multiplication tables in T2's classroom**
T3	Yes	- There are very few charts in the classroom on different subjects, and among these few charts, two of them are on mathematics.

		 **Figure 7.12: A fraction wall chart in T3's classroom**
T4	No	- Classroom walls are bare; there are no charts.
T5	No	- Classroom walls are bare; there are no charts.

As illustrated in Table 7.25, the classroom environment in the different classes observed varied, ranging from a lot of charts to no charts at all. T1's classroom had several charts on the walls, which created a text-rich environment for learners. The charts were for different subjects, including mathematics, and they were all written in English. T2's classroom had only one chart on mathematical tables and there is a possibility that this single chart had been displayed in class in preparation for the observation session. T3's classroom had a few charts on the walls. The charts were on different subjects, and among these, two were on mathematical concepts. Both mathematics charts represented the fraction wall; the only difference is that one was 'handmade', while the other was printed on glossy paper. Thus, the two charts were presenting exactly the same information. T4's and T5's classrooms were bare; in the absence of learners and the chalkboard, the classrooms would have resembled any other ordinary rooms.

In Chapter 5 of this study some teachers indicated that they used charts as teaching and learning resources; therefore the researcher was expecting to see some charts in the classrooms. In earlier sections it was also indicated that teachers usually receive charts as corporate gifts from textbook sellers or during CPTD workshops and conferences. The absence of charts in classrooms indicates that learners have very limited access to written texts within their learning environment. It was also suggested in earlier sections of this study that the teacher does not have to be the one who makes charts to be displayed in the classroom; learners' work which they produce in different lessons can be celebrated by being displayed on the classroom walls. In this way learners are motivated, the teachers' work load is reduced and the classroom environment becomes text-rich. The practice of displaying learner's work in class does not have to be limited to IP mathematics only, but cuts across the curriculum.

Although closely related but falling beyond the scope of this study, it would be valuable to establish how well teachers are trained in the production of authentic, text-rich charts for use as learning and teaching resources in their classrooms – another cross-cutting practice that is not exclusive only to IP mathematics education.

General Comments

The section on general comments was used to capture any noteworthy observations made in each of the classrooms observed. This section accommodated the differences in the classrooms, teachers and learners observed regarding the use of English as a LoLT. Observations are presented in Table 7.26.

Table 7.26: Classroom environment in IP mathematics lessons observed

	General Comments
T1	- The teacher moves around the classroom to distribute resources for constructing models of 2-dimensional shapes. - When learners speak to each other, they use English.
T2	- The conclusion of the lesson was not done. - There is very limited interaction amongst learners - learners do not discuss much amongst themselves, most of the work is done individually. - The teacher does not walk around the classroom to check learner' work. - Learners are seated in groups and the teacher explained that the seating arrangement is for facilitating learner interactions, though there isn't much discussion that takes place amongst learners.
T3	- Learner participation is above average. - Learners are encouraged to move to the front of the classroom to showcase their answers. - The lesson is relatively practical – learners have a chance to go to the chalkboard and illustrate their answers. - The teacher solicits questions from the learners and prompts learners to ask questions ***ngeSintu*** – to ask questions in isiXhosa. - The teacher promotes discovery learning throughout the lesson. - Learners use examples from the classroom to explain the term 'transformation'.
T4	- Both the teacher and learners seem to be demotivated throughout the lesson.
T5	- Without textbooks or any reference materials; learners seem to be struggling to follow and

	keep up with what the teacher is explaining on the board. - The teacher cannot get to the back of the classroom due the over crowdedness and does not seem to be concerned about how the learners are faring. - The lesson is rather teacher centred: dominated by the teacher talk, and the teacher does not pause to check if the learners are following. - A quick check through the exercise books of learners closest to the researcher reveals some misspelt words in the learners' work which have not been corrected.

As illustrated in Table 7.26, generally some teachers use English as a medium of instruction and encourage their learners to do the same, while other teachers practise code switching and encourage learners to ask questions in their home language, such as T3 who prompted learners to ask questions ***ngeSintu***, which means ***home language***. The general comments noted in the different classrooms indicate the prevailing challenges in under-resourced schools. These challenges include the prevalence of chanting and chorus answers, poor classroom organisation and large class sizes hindering learner-learner interaction as well as teacher-learner interaction, lack of adequate teaching and learning resources, text-poor classrooms and poor linguistic practices modelled by the teachers. The linguistic practices displayed by the observed teachers confirm data collected from other sources in the current study which indicate that teachers' proficiency in the language of instruction needs immediate attention.

The section above presented, analysed and discussed data gathered through the classroom observations conducted in the sampled under-resourced schools the Eastern Cape Province of South Africa. South Africa advocates a single, democratic education system with equal education opportunities for all learners without recognising under-resourced schools, as a separate category with unique needs. However, in under-resourced schools the learners' contexts and needs differ from those in urban and peri-urban schools. Du Plessis (2014: 1109) notes that "many rural areas are characterized by various factors that negatively influence the delivery of quality education". As such, the socio-economic realities of under-developed schools disadvantage learners and the classroom observations conducted in this section confirmed that the quality of teaching, particularly focusing on the linguistic practices, is compromised. Isolated conditions in under-resources communities do not attract highly qualified teachers; in this case classes are taught by teachers not proficient in English, the prescribed language of instruction at IP level.

7.4 Conclusion

This chapter presented, analysed and discussed the qualitative data collected in this study, namely the teacher interviews, the teacher educator interviews, and the non-participant classroom observations. All the qualitative data collected was recorded and transcribed by the researcher and analysed by the researcher using open and axial thematic coding. 10% of the study participants; 5 teachers and 2 teacher educators were interviewed; 5 IP mathematics lessons where observed to assess the linguistic practices of the teachers. Data collected from the interviews were presented first, followed by the data from the classroom observations.

Data from the double-pronged teacher interviews provided varying information. The first section, which sought to double-check information generated from the quantitative data, produced substantial data. The responses obtained for the second section, which meant to systematically assist teachers to identify errors in their written mathematics word problem tasks, based on Newman's hierarchy of error analysis method, were generally poor and not as detailed as they could have been. The teachers simply narrated what they had done without reflecting on why they had performed specific mathematical procedures, and thus obtained less than the expected results. One of the participants requested the interview to go ahead on condition that the error analysis section was omitted and this in a way reflected the teacher's perceptions regarding mathematical word problems. If the teacher was avoiding answering questions based on mathematical word problems, it may be assumed that the teacher does not teach that section explicitly to the learners. Nevertheless, data obtained from the teacher interviews generally tallied with the data obtained from the quantitative data.

Data from the teacher educator interviews confirmed the quantitative data discussed in Chapter 5 of the study. Although the majority of teacher educator institutions use English as the official language of instruction, there is not sufficient consideration given to teachers who are non-native language speakers of English in terms of equipping them with adequate skills to use English as language of instruction in their practice. Although teacher education institutions are aware of the linguistic challenges faced by the IP mathematics teachers in their daily practice, there is a gap between this awareness and what needs to be done to remedy the situation.

Data from the classroom observations indicated relatively poor linguistic practices, ranging from teachers speaking grammatically wrong English sentences; teachers code switching haphazardly; teachers encouraging learners to speak or ask questions in their mother tongue, isiXhosa, in order to promote teacher-learner interaction; lack of text-based teaching and learning resources such as textbooks and charts; as well as uncorrected wrong spellings in learner exercise books possibly because of the extremely large class sizes. Although teachers may not have control over the availability of resources such as textbooks and dictionaries, the relative absence of charts and word walls which can be made by the teachers with the help of their learners was particularly a cause of concern. The data reflected the teachers' low proficiency levels in English as established in earlier chapters of the current study as well as inconsistency in the use of code switching and translanguaging strategies meant to improve learners' understanding of mathematical concepts.

The final chapter provides a brief summary of the entire study, including the findings in response to the research questions, as well as making suggestions for future research.

CHAPTER 8

GENERAL CONCLUSION, FINDINGS AND RECOMMENDATIONS

8.1 Introduction

This chapter summarises the whole and provides concise findings as well as the recommendations of the study based on the different data-gathering techniques and sources used in the study. It provides a summative discussion on the relationships between teachers' English-language competency and IP mathematics instruction. It also provides a concise discussion of teachers' linguistic practices when teaching mathematics in under-resourced settings. These findings, conclusions and recommendations are discussed against the backdrop of the conceptual framing adopted in this study and the literature reviewed. The results and findings from semi-structured teacher and teacher educator interviews as well as those from informed non-participant classroom observations corroborate the results and findings from the teacher questionnaires, teacher educator questionnaires, and the English-language competency and Mathematics word problem assessments. These results and findings shed more light on the possible associations between teacher language competency in English, which is the prescribed language for them to teach in, and IP mathematics content delivery. They also illuminate the conditions in which linguistically disadvantaged IP mathematics teachers find themselves.

8.2 Synopsis of the study

Chapter 1 provided the general background of the current study including the study aim, objectives and research questions. The background reveals that the quality of South African mathematics education is constantly rated as significantly low by international standards. The various reason cited as contributing to this low quality include poor competence in the LoLT. The background information also revealed that most of these international assessments usually focus on learner language competency with very little attention being paid to teacher language competency in the LoLT; this disregards the fact that teaching and learning is a two-way process that involves both the learner and the teacher. Against this background, the current study contends that (inadequate) teacher language competency in the language they are prescribed to teach in contributes significantly to the (poor) quality of instruction.

Chapter 2 provided the study's key conceptual frameworks for investigating language issues in mathematics, namely Cummins's (2000) Linguistic Threshold Hypothesis; Ellerton's (1989) Framework for Interpreting Language Factors in Mathematics Learning; Gawned's (1990) Socio-Psycho-Linguistic Model; Newman's (1983) Approach for Analysing Errors on Written Mathematical Tasks; and Baker's (2011) Pedagogical Translanguaging Theory. Among many frameworks linking the various elements of language and mathematics, these conceptual frameworks were deemed significant in the current study as they can be employed in diverse language contexts, as is the case in South Africa.

The literature reviewed in Chapter 3 focuses on using language as a resource in mathematics teaching and learning. The chapter provides an investigation of the link between language and mathematics, linguistic features that influence mathematics instruction and strategies for teaching the mathematics register in multilingual settings. As a teacher educator, the researcher deemed a compilation of this literature to be of paramount importance, if equipping teachers with the linguistic skills to effectively deliver content in the prescribed language of instruction is going to contribute to raise the quality of mathematics education in South Africa, and specifically in the Eastern Cape Province, where 22.3% of the country's ordinary schools are located.

The literature reviewed in Chapter 4 focuses on perspectives regarding language competency and the language of teaching and learning mathematics globally, in Africa and in sub-Saharan regions. These different perspectives were discussed for the purposes of reviewing best practices on teacher language competencies that can sustain effective mathematics instruction in multilingual settings. The review of these perspectives loosely referred to theories of second-language acquisition and communicative competence, considering that English is a second (or third) language to the majority of teachers and learners in South Africa. The chapter also reviewed literature on mathematics teacher education with reference particularly to teacher language competence in South Africa.

Chapter 5 provided an exposition of the study's research methodology. The mixed methods research design incorporating both quantitative and qualitative strands is explained in the light of the philosophical paradigm, which is interpretivist-constructivist. The data-collection instruments are detailed and the collected demographic information is used to describe in detail the non-probability purposefully selected sample of IP mathematics teachers and teacher educators. The chapter also provided brief descriptions of the data collection and analysis processes, before indicating the relevant ethical considerations.

Chapter 6 presented, analysed and discussed the quantitative data collected, namely the teacher and teacher educator questionnaires and the teacher language competency and mathematics word problem assessments. The quantitative data were presented in their order of collection, followed by the analyses done independent by Stellenbosch University's Centre for Statistical Consultation using STATISTICA 13, as well as by JET Education Services' descriptive analyses. The chapter concluded by merging and discussing the quantitative data analyses. The teacher language competency and mathematics word problem assessments were the main data-collection instruments for this study. Data collected through other instruments served to triangulate the assessment results.

Chapter 7 presented, analysed and discussed the qualitative data collected, namely the teacher and teacher educator interviews and the classroom observations conducted in the Mthatha and Qumbu districts of the Eastern Cape Province in South Africa. The researcher was the sole data capturer and transcriber of both the teacher educator and teacher interviews and the classroom observation schedules. The qualitative data collected were analysed thematically using open and axial coding. The chapter concluded by discussing the qualitative data analyses. IP mathematics teachers were the key participants of the study as it is their language competence that was being investigated; information from the teacher educators enabled cross-checking of the self-reported data provided by the teachers.

Chapter 8, the present chapter, provides a consolidated interpretation of the study's findings as well as the researcher's own evaluation of the findings. It is hoped that the study will contribute significantly to the ongoing debate on linguistic practices in multilingual mathematics classrooms. The reviewed literature, the interpretivist-constructivist paradigm and conceptual framing guided and informed the research design, data collection, analysis as well as the interpretation of the data collected. The main concerns of the study were addressed and the research questions were answered. The central research question of the study was:

How (*if at all*) does language competency in the LoLT relate to content delivery by IP mathematics teachers?

The study concludes that teacher language competency in the language of instruction does ***indeed*** relate to IP mathematics content delivery. The study's research sub-questions were formulated to shed more light on the relationships between IP mathematics teachers' linguistic competencies in English and their delivery of mathematics content; the findings are detailed in the next section of the chapter.

8.3 Key findings measured against the research questions

The aim of the study was to analyse the relationship between IP teachers' linguistic competencies and mathematics instruction**.** To gain a deeper insight into the relationship between teacher English-language competencies and IP mathematics content delivery, the central research question was divided into five sub-questions. The findings of the five sub-questions are detailed below.

i. **To what extent does proficiency in the LoLT relate to IP mathematics teachers' content delivery?**

Proficiency in the language of instruction is directly related to mathematics content delivery. Teachers with a better mastery of the language of instruction are in a better position to explain new terms to their learners and to create language learning opportunities within mathematics content delivery. On the other hand, teachers with a poor mastery of the language of instruction are not confident enough to model good linguistic practices; they are unable to effectively assist learners to perform basic reading and writing skills or to guide learners to explain mathematical concepts in their own words; skills through which the mathematical content is often assessed.

ii. What aspects of IP mathematics teacher education focus on the use of English as LoLT?

Teacher educator institutions provide very little guidance towards coherent and systematic use of code switching / translanguaging in the classroom to enhance opportunities to learn. Only 1 out of the 10 sampled teacher educator institutions provided modules that focus on the use of English as language of instruction. Unfortunately, the modules are provided as electives at Master's Level; this is a level of education which the majority of teachers based in under-resourced schools would not have attained by the time they are deployed to schools. Chapter 2 of the study: ***Language as a Resource in Mathematics Teaching and Learning***, contributes towards addressing this need. The chapter serves as a platform for further developing the prerequisite linguistic skills needed by IP mathematics teachers. Data from teacher questionnaires revealed that a few teachers in their initial teacher education qualifications covered some aspects related to the use of English for communication purposes; the data in this study confirm that there is inconsistency in the guidance provided by teacher education systems on the use of English as a language of instruction.

iii. To what extent are IP mathematics teachers in ECDoE schools proficient in English, the prescribed LoLT?

With a maximum of 60% and a minimum of 11% obtained in the teacher English language competency assessment, teachers revealed a lower proficiency in English than what is expected of a Grade 7 learner. Similarly, with a maximum of 70% and a minimum of 16% teachers revealed a lower performance in mathematics word problems than is expected of a Grade 7 learner. In addition, statistical and descriptive analyses indicated a positive correlation between English language competency and mathematics word problem assessments. Even though English is a foreign language to the majority of the teachers who use it as language of instruction in South Africa, the mere fact that the current LiEP requires teachers to use English as the medium of instruction calls for high levels of proficiency in that language. The MRTEQ documents, which stipulate the minimum requirements for teacher education qualifications, requires IP teachers to at least have Additional Language proficiency in English (MRTEQ, 2011: 24); however, the answers provided by the teachers in the English language proficiency assessment as well as in the Mathematics word problems revealed grammatical and idiomatic errors and this study consequently infers that Additional Language proficiency in the medium of instruction is not good enough for an IP mathematics teacher.

iv. **How do IP mathematics teachers overcome language barriers in the teaching of mathematics?**

As a coping strategy IP mathematics teachers over-rely on explaining mathematics concepts and procedures in the first or home language (isiXhosa), which is not the official language of instruction/assessment. Learners may not know English, but they are not passive either. When a teacher over-relies on explaining concepts in the mother tongue, learners become passive because they know the teacher is going to translate and so they simply wait for the teacher's translation instead of paying more attention to the acquisition of the mathematical register in English. Teachers' classrooms are not text-rich environments and the lessons are teacher-centred; the classroom environment does not have enough linguistic features to support the use English as a language of instruction. Thus, very little is being done to overcome the language barrier in under-resourced classrooms. Evidently, the over-reliance on isiXhosa is a disservice to the learners, but this study contends that it is the teacher educator institutions that are actually performing a disservice to the nation by not serving teachers properly, who in turn are not equipped to serve the learners adequately.

v. **To what extent do teaching methods currently in use effectively overcome the language barriers in the delivery of IP mathematics?**

The methods currently in use are not effective in overcoming language barriers, because without systematic guidance, the teachers use code switching haphazardly or prompt learners to use their mother tongue during class discussions in order to promote interaction in their classrooms. Teachers who are not competent enough in English are unable to model the required fluency in the language of instruction, and hence risk leaving learners' mistakes in English uncorrected. The haphazard use of code switching indicates that the code switching is not incorporated into the planning of the lesson.

The clearest finding arising out of this study is that competence in English is necessary for teachers to engage in high quality mathematics instruction in English. However, it may not be sufficient. Other important components likely include: content knowledge, pedagogical content knowledge, and specific knowledge of how to teach mathematics to English learners.

Since research is important for signposting and informing the way ahead, the section below makes some recommendations based on the findings of this study.

8.4 Recommendations

The key findings discussed in this chapter highlight some crucial factors that policy makers, teacher education curriculum developers, teacher educators and teachers need to consider for the purposes of improving the quality of teaching and teaching primary mathematics.

As alluded to in Chapter 3 of this study, mathematics education begins and proceeds in a language, and it advances or stumbles because of language, and its outcomes are often assessed in language (Durkin & Shire 1991: 3). Although this observation is applicable to most of the ordinary school curricula, the interweaving of language and mathematics is particularly intricate and this study explored some aspects of this complex interrelationship. The better serve IP multilingual learners so that mathematical concepts are linguistically accessible to them, their teachers' English-language competence needs to be improved drastically; teacher education pedagogy needs to provide comprehensive guidance on code switching and translanguaging, the characteristics of English-language learners (ELLs) and ensuring that classrooms are text-rich.

The section below provides language-related recommendations stemming directly from this study, followed by some stemming more indirectly from the study.

8.4.1 Recommendations stemming directly from the study

Four recommendations stemming directly from the data collected and analysed in this study are listed below.

8.4.1.1 Improve mathematics teachers' English-language competence

Generally, mathematics teacher education in South Africa does not enforce mastery of the language of instruction. This study highlights competence in English as one of the most significant predictors of mathematics performance, particularly because the country's indigenous languages have yet to be fully developed to support mathematics instruction. In addition, language barriers result in gaps in content knowledge during the primary school years, which in turn usually contributes to lack of the intellectual growth necessary for high school learning (National Education Evaluation and Development Unit (NEEDU)**,** 2013). Any education system is only as strong as its teachers; therefore, promoting language competence during and after initial teacher education may significantly improve on the quality of mathematics education in South Africa.

Teachers may not possibly know all the content, but they can be skilled on how to learn new content through language. Evidence from the teachers' English language competency and mathematics word problem assessments revealed that the teachers' mastery of English is significantly low. This study reiterates that it is the duty of *all* university education departments as well as other teacher education institutions such as AIMSSEC to develop and improve IP mathematics teachers' English language competence.

Adesina (2017) notes that duty is to people not to establishments, and therefore in order to improve people's lives, there is a need to invest in brain power, that is the *grey matter infrastructure*. This study thus contends that one of the ways of improving the quality of IP mathematics education should include investing in the *linguistic infrastructure* of the teachers.

8.4.1.2 Provide guidance on the use of code switching and pedagogical translanguaging

Chitera (2016) notes that mathematics teacher education in developing countries provides minimal or no guidance towards coherent and systematic use of translanguaging and code switching in the classroom during or after initial teacher education. Pedagogical translanguaging and code switching take place when an individual uses more than one language or varieties of a language in conversation and these practices can be used by the teacher as resources for explaining mathematical content (Baker, 2011). Although Chitera focuses on indigenous language instruction, this study highlights the need not to assume that enough guidance is provided when a different lingua franca like English is used as a medium of instruction. Such a practice compromises the quality of content delivery, as pedagogically disadvantaged teachers may in turn perform a disservice to the majority of learners in public schools who are multilingual, in other words, those who are also ELLs.

Van der Walt (2016) deems language as a resource that can be used to access information; however, evidence from the classroom observations conducted in this study confirms that teachers were not sure when and how to code switch in a manner that benefits the learner. The teachers were not aware of practices such as translanguaging, which can guide them in how to use their African indigenous languages together with English for the purposes of effectively transferring mathematics content to the learners. This study seeks to highlight the importance of code switching effectively, not as a substitute or coping mechanism for incompetence, but bearing in mind that assessment will be done in the prescribed LoLT (Tshuma, 2016).

8.4.1.3 Provide knowledge about English-language learners

Current South African mathematics pedagogy does not foreground knowledge about ELLs, which reflects a gap in both practice and research. In mathematics the challenge faced by ELLs is threefold in that they have to acquire the new language of learning, as well as learning mathematics and its register (Barwell et al., 2002; Bohlmann, 2001; Setati & Adler, 2000). The mathematics register is the special vocabulary used in mathematics, as well as the phrases and methods of arguing within a given mathematics situation. The mathematics register allows learners to communicate their mathematical findings; provides analytical, descriptive and problem-solving skills; and improves their ability to listen to, question, discuss, read and record mathematical concepts.

Evidence from the classroom observations reveals that current teaching methods used by the teachers do not take cognisance of the distinguishing characteristics of ELLS. In the observed classrooms where teachers conducted most parts of the lesson in mother tongue, the teachers did not provide learners with sufficient opportunities to communicate their mathematical understanding in English. Even though using the mother tongue may be comfortable for both the teacher and the learners, the practice does not provide learners with opportunities to read, understand and interpret texts in the prescribed LoLT, the very skill which is ***always*** assessed through examinations.

8.4.1.4 Make classrooms text-rich

A classroom is an environment that must promote and reinforce learning. One of the linguistic features that influence mathematics teaching and learning include making a classroom a text-rich environment. This can be done by creating opportunities to read in the classroom environment, opportunities which in under-resourced communities may be difficult to create (understandably so) outside the classroom. Some classrooms observed in this study had very few or no charts or word walls displayed in the classrooms. Creating a text-rich classroom may encourage learners to practise reading the text as well as provide opportunities for engaging with texts outside of the conventional teaching and learning time.

To bypass a shortage of resources and to reduce the financial strain of buying ready-made charts, teachers may encourage learners to make word walls, an activity that may reduce the teachers' workload and simultaneously enhance learning opportunities for learners. Furthermore, instead of displaying ready-made charts that only serve as aesthetic artefacts rarely referred to during instruction, the teacher may celebrate the learners' work by displaying it on the walls to make the classroom text-rich.

This researcher contends that the first three recommendations above are largely dependent on the macro bodies of the country's education system, i.e. the policy makers, curriculum developers and teacher education institutions, while the last recommendation is dependent on the initiative of teachers, who are the foot soldiers of the education system.

8.4.2 Recommendations stemming indirectly from the study

Two recommendations stemming indirectly from the data collected and analysed in this study are listed below. These recommendations take form of questions emanating from the researcher's evaluation of the current study against the backdrop of other studies conducted in the field of language in mathematics education.

8.4.2.1 Declaration without implementation?

Findings from this study imply that teachers' competence in English needs to be improved. The researcher contends that this improvement needs to take cognisance of the following factors.

- Maybe there is no need to choose between English or an African Language to be used as the LoLT, but both are possible and desirable. Taking this direction would need an awareness of the concept of balanced instruction, which embraces the strongest components of both the foreign and indigenous languages as possible and desirable languages of instruction. If this route is taken, then teacher education programmes need to be aware of the concept of balanced instruction and teachers need to be well trained during and after initial teacher education, so that they are better prepared to function effectively in multilingual IP mathematics classrooms where the learners' home language is perceived as one of the teaching and learning resources.

- As a teacher educator, the researcher contends that whatever choice is adopted regarding the language of instruction – be it English, an indigenous language or a balance between the two – the choice must be supported by its implementation from the initial teacher education curriculum through to CPTD programmes.

8.4.2.2 Perceived versus Intended Needs?

Since teachers may not know that they need these linguistic skills for improved instruction at IP level, it is therefore the duty of policy makers to conduct needs analyses that will inform the teacher education curriculum on appropriate measures for bridging this gap, which may be threatening the quality of mathematics instruction. Policy makers know what the intended outcomes are, yet teachers may not know that they have a need, because they are not aware of the acceptable language proficiency levels expected of them. Therefore the way forward may involve policy makers reaching out to the teachers through the teacher educators (and the teacher education institutions) by redesigning the mathematics teacher education curriculum to include language proficiency modules. Teachers cannot still be trained the way they were trained decades ago; the mathematics teacher education curriculum needs to be constantly reviewed in order to keep up with best practices.

8.4.2.3 Deficiency versus Alternative Strategies?

Despite the data collected in this study, the findings and the interpretations, the researcher would nevertheless like to render all the due respect to the teachers who participated in this study and who could be taken as a representative sample of a larger population of teachers who are based in under-resourced communities. Data from the language competency assessments identified a deficiency in linguistic skills among IP teachers. This deficiency in understood in the light of the context the teachers find themselves in and most importantly with the intention of providing alternative strategies to remedy the situation. The work that is done by the teachers is viewed with utmost respect and treated with dignity, and, being a teacher educator, the researcher would like to see alternative strategies being put in place to develop the teachers' linguistic competencies for the purposes of improving their practice.

Being linguistically equipped and proficient in the prescribed LoLT is perceived as every teacher's wish; however, this is a task that teachers cannot perform or overcome on their own. When the teachers were trained, which could be on average 10 to 15 years ago, the curriculum might not have registered the need to equip the teachers with linguistic strategies to improve IP mathematics instruction. Moreover, chances are that mature teachers currently teaching primary school mathematics within the education system were trained before the advent of Foundation Phase (FP), Intermediate Phase (IP), Senior Phase (SP) and Further Education and Training (FET) band divisions. However, as the current practices in teacher educator institutions seem to be catching up (for example, one institution is providing a module in this regard); there is a need to match the intended needs of the curriculum with the current practices in teacher education institutions.

This can be achieved firstly by ensuring that (*all*) teacher education institutions provide a unified pedagogy, one that involves a module on using language as a resource in IP mathematics instruction. Such a module can be offered to both the pre-service and the in-service IP mathematics teachers. Secondly, for those teachers who might have received aspects or small portions of the information, they may well benefit from refresher courses focusing on this important aspect which significantly impacts on mathematics content delivery. Thirdly, in as much as prospective engineers and geologists usually undertake extended degree programmes and receive bridging courses in mathematics so that they can cope with their studies, a similar approach may be adopted for teacher education degrees. Research reveals that students enrolled for education programmes usually have low scores for mathematics, science and languages, and so do not qualify for their intended courses of choice. Therefore, great emphasis should be placed on rigorously preparing these students so that they do not continue the vicious circle of low-quality education. And lastly, it may be necessary to upgrade the entry qualifications for teacher education degrees in developing countries over a period of time, so that the teaching profession regains the prestige it once had.

8.5 Evaluation of the study: From the eye glass to the magnifying glass

The evaluations made from this study are classified as limitations and delimitations. The limitations are aspects of the study that the researcher had no control over, while delimitations are choices made by the researcher regarding the boundaries and scope of the study. The evaluation of the study also includes a critical analysis of the significance of the study as well as suggested future studies emanating from the current one.

8.5.1 Limitations

The section below details the limitations experienced in the different stages of the study; limitations are described by Vithal and Jansen (2010) as influences that could not be controlled by the researcher but exerted a restriction on the methodology and conclusions of the study.

8.5.1.1 Limitations: Data-Collection Procedures

As alluded to in Chapter 5, the data-collection techniques employed in this study are based on a multi-method approach, involving both quantitative and qualitative data; reflecting on this, a lot could have been done differently to improve on the quality of the study.

- Firstly, data collection produced huge amounts of data which the researcher struggled to sieve to obtain the relevant data answering the research question. It thus dawned on the researcher that this study could have been conducted by a team of researchers to improve on the vigour of the data collection and interpretation. In addition, different components of this study can be sub-divided to produce separate studies that can be conducted independently to provide more information towards advising on policy changes regarding the linguistic aspects in IP mathematics teacher education curriculum.

- Secondly, funds permitting, all the data collection could have been done in the Mount Frere District, the least effectively performing district in the country, as recorded by DBE (2015); however, because of financial constraints the researcher could not reach all the schools in the aforementioned district and had to supplement the number of schools visited by visiting the other schools in the neighbouring districts, namely Mthatha and Qumbu.

- Thirdly and most importantly, sampling of teachers for the qualitative data could have been done more objectively by choosing only 3 teachers instead of the 5 teachers. With hindsight, the researcher is of the opinion that if only 3 teachers – namely the highest, the lowest and the average performing teachers – from the language proficiency assessment could have been purposively sampled for the interviews and classroom observations, and data obtained from them compared, then extremely rich data would have been obtained. To avoid impoverishing the qualitative data, maybe 2 or thee teachers would have been selected from the three performance levels: highest, average and lowest and compared. Thus, if the study is to be replicated in a different province, this type of sampling would be recommended for obtaining rich data. Given another opportunity to redo the study, the researcher would definitely opt for the suggested model in sampling participants and compare the results obtained to the results in the current study.

Despite these limiting factors, the data were successfully collected, processed and analysed. It is worth noting that although the researcher managed to create some rapport with the study participants, there were traces of negative attitudes amongst some male teacher participants. Specifically, a participant would not answer all the questions on the interview schedule even after being politely requested to do so. The participant was not withdrawn from the study, but the refusal to answer some questions was interpreted by the researcher as a negative attitude towards interrogating one's competence in a language they are expected to be competent in, yet clearly they are not, which could have resulted in the participant feeling emasculated. However, the sample size does not merit making any generalisations in this regard.

The section below presents the limitations that the researcher chose to abide by: delimitations.

8.5.2 Delimitations

Participants in the study were 55 IP mathematics teachers based in the ECDoE and 10 teacher educators from different universities in South Africa. For the purposes of gaining a deeper insight into the relationship between primary school teachers' language competence in the prescribed LoLT and mathematics instruction, the study focused on only one province in the country, the Eastern Cape, yet there are other similar poorly performing provinces, such as Limpopo and KwaZulu-Natal. The ECDoE was partly chosen because the researcher had access to a large number of teachers from this province.

The study specifically chose to classify the schools where teacher respondents were sampled as 'under-resourced' rather than 'rural', because there was no significant difference in performance noted among the teachers from the different districts of the ECDoE.

8.6 Relevance of the study

Considering the fact that "language is not everything in education, but without language everything is nothing in education" (Wolf in Alidou et al., 2006), the current study addresses a highly significant issue. The explicit contribution made by this study is to supplement the current body of knowledge regarding language in mathematics education in general, and specifically on teacher language competencies in the prescribed language they are to teach in. As such, findings from this study have implications for the Department of Higher Education and Training (DHET) curriculum policies.

In as much as the current teacher education policy is under review by the DHET, this study contends that this review should ensure that teacher education courses pay particular attention to the inclusion of modules focusing on using English as a language of instruction. The current review of the primary teacher education curriculum should not only focus on initial teacher education, but, also include in-service teacher programmes, in order to accommodate practising teachers who did not get the opportunity to be upskilled in the language of instruction during their initial teacher education preparation.

The study makes a contribution to current knowledge on one of the factors that need attention in IP mathematics instruction. Language plays a pivotal part in accessing knowledge and this study highlights how language plays a critical role in IP mathematics instruction, specifically if the language of instruction is foreign to both the teachers and the learners. Numerous investigations have been conducted regarding language use in multilingual classrooms; however, the majority of these investigations focus on the learners with the assumption that the teachers' language competence is up to standard. Looking at the flip side of the coin entails paying significantly more attention to teachers' language proficiency. This study has confirmed that the teachers' competence in the language of instruction is not always up to standard, with specific reference to teachers deployed to under-resourced schools which cannot attract a better workforce.

Thus the purpose of this study was not to make generalisations about the prevailing relationships, but to fill a gap in the literature by examining the linguistic competencies of IP mathematics teachers in the Eastern Cape Province's under-resourced schools. The point of this research is to make a contribution and present a different focal lens to the existing literature by presenting a case that sheds light on an often overlooked aspect, the language competencies of the IP mathematics teachers in under-resourced schools.

8.7 Suggested future study

This study envisages providing a platform for future in-depth studies on these relationships, such as studies focusing on other LoLTs, like Afrikaans or the South African Sign Language (SASL), which is used as an LoLT in schools for the hearing impaired. This idea emanated from one of the national conferences for mathematics teachers where aspects of this study were presented; however, the idea was not followed up here as it fell beyond the scope of the present study; nonetheless, a seed was sewn.

In March 2014 and subsequently in June 2016 learners at Bartimea School for the Deaf and Blind in Thaba'Nchu, Free State Province protested and vandalised school property. A wide spectrum of reasons was cited for the cause of the protests, including sub-standard education. According to the learners, the teachers were not well trained in SASL, which is the language of instruction for the deaf section in the school (*Bloemfontein Courant*, 2016). Although the use of SASL as a language of instruction is beyond the scope of this study, the area needs further research for the benefit of improving the quality of instruction using the particular language across the curriculum. Even though hearing-impaired learners constitute a relatively small fraction of the learners within the ordinary education system in the country, they still need to be provided for linguistically.

Similarly, the majority of IP mathematics teachers who undergo initial teacher education in South African institutions should be linguistically empowered as a contribution to improving the quality of education in the Eastern Cape Province and in the country as a whole. Teacher education institutions should not miss the opportunity of joining hands between proficiency in the language of instruction and mathematics content knowledge. Metaphorically, this is like two people walking alongside each other and smiling without shaking hands – and that is a missed opportunity. In reality, the missed opportunity between language of instruction and mathematics content knowledge is not only a matter of kindness – it is an essential one for the sake of effective education.

8.8 Conclusion

This study explored the relation between language competency and IP mathematics instruction, but why does this matter? The importance of language for the purposes of teaching, learning, understanding and communication of mathematics cannot be left unattended, and the findings from the current study confirm the existence of an intricate relationship between language competency and mathematics content delivery.

The study thus contends that one of the factors directly linked to the substandard quality of mathematics education in the Eastern Cape Province's multilingual classrooms is the teachers' inadequate mastery of the language of instruction. Having established the fact that teacher education institutions do not insist on mastery in the LoLT during or after initial teacher training, there is a gap in the delivery of mathematics content in the IP years; this study intends to fill this gap. The value of the study is its empirically founded attempt to broaden understanding of the relationship between teacher language competence and IP mathematics instruction. The study will inform further research on appropriate interventions to facilitate effective delivery of mathematics content in the prescribed LoLT in the IP years.

In the light of South African history marred by apartheid policies, which saw, among other policies, the propagation of the Bantu Education Act of 1952, black South Africans may tend to feel negatively about any practices that seem to enshrine English, despite the established fact that English is undoubtedly the language of opportunity. As such, teacher education curricula, especially for the primary school level, which has a significant impact on the formative years of learners, need to support and promote the use of English beyond the currently required Additional Language proficiency level. Whether English (or any African Indigenous Language) is chosen as language of instruction, IP teachers need to be upskilled in using the chosen language beyond basic proficiency levels to include the use of that language as a resource in mathematics instruction. This means that language would be viewed through the educational lenses that are appropriate, instead of being viewed through political lenses.

In a nutshell, this study contends that the ECDoE is quite a long way from reaching the goals of quality education, and teachers cannot achieve this goal alone. In order to replace all the negatives identified in this study with positives, teachers need the support of their teacher education institutions as well as other educational development stakeholders. Adesina (2017) sums it best by stating that "**If you want development for a year, grow a grain; for ten years, grow a tree; for a lifetime, grow people".** Developing the linguistic infrastructure of IP teachers will go a long way towards improving the quality of mathematics instruction in under-resourced communities as well as in raising the quality of South African mathematics education in international rankings as well as in the international community at large.

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APPENDICES

APPENDIX A: Teacher Questionnaire

Teaching Intermediate Phase (IP) mathematics using English as a Language of Learning and Teaching (LoLT)

Instructions:

Please respond to *all* questions by making a tick (✓) in the shaded block next to the appropriate answer or by writing your answer into the shaded space provided.

1. What grade(s) are you currently teaching mathematics?

Currently teaching: (grade)	4		5		6		7		Other (specify)		

2. For how many years have you taught IP mathematics?

Experience in years:	

3. What is your mother tongue? Choose one.

English		Afrikaans		isiXhosa		Other(specify)		

4. What is the official language of learning and teaching in grades R to 3 (FP) at your school?

English		Afrikaans		isiXhosa		Other(specify)		

5. What is the official language of learning and teaching in grades 4 to 6 (IP) at your school?

English		Afrikaans		isiXhosa		Other(specify)		

6. How often do you use the official language of learning and teaching in mathematics lessons?

English			Afrikaans			isiXhosa			Other (specify).................................		
Always	Sometimes	Never	Always	Sometimes	Never	Always	Sometimes	Never	Always	Sometimes	Never

7. Do your learners understand the language you use in mathematics lessons? Choose one.

Always		Sometimes		Never	

Give reasons for your answer: ....

....

8. How often do you allow learners to ask or answer questions in their home language during mathematics lessons? Choose one.

Always		Sometimes		Never	

Give reasons for your answer: ....

....

9. When learners do not understand the language used in mathematics lessons, what do you usually do? Choose one.

Explain differently in English		Explain in their mother tongue		Ask another learner to explain	

Other(specify):...

....

10. How do you teach specialised mathematical vocabulary in your lessons? Choose one.

Explain differently in English		Explain in their mother tongue		Ask another learner to explain	
Other(specify):……					

……

……

11. What mathematics teaching resources written in English do you have available for use in the classroom?

Workbooks provided by the Department of Education	Yes		No	
Textbooks	Yes		No	
Mathematics dictionaries	Yes		No	
Computer based activities	Yes		No	
Word walls / charts	Yes		No	

Other(specify):……

12. What major challenges do you experience when teaching mathematics using English as a language of learning and teaching?

a)……

b)……

c)……

d)……

e)……

13. What formal education qualification(s) do you have?

Period		Name of University / Technikon / College / Institution	Name of Degree / Dipl / Cert	Completed
From Yr:	To Yr:			Yes / No

14. Did any of your qualifications include a module focusing on English as a Language of Learning and Teaching? Choose one.

Yes		No		If yes, name of module: ……

15. What other form(s) of in – service training in using English as a Language of Learning and Teaching mathematics have you attended?

Period		Name of University / Technikon / College / Institution	Name of Degree / Dipl / Cert	Completed
Months	Days			Yes / No

16. **What grade did you achieve in English Language at ordinary school level? Choose one.**

Matric B+		**Matric C**		**Matric D**		**Matric E**		**Matric F** (and below)		**Below Matric**	

17. **Would you like to receive additional training and resources in using English as a Language of Learning and Teaching IP mathematics?**

Training:	**Yes**		**No**		**Resources:**	**Yes**		**No**	

18. **Suggest other ways that could improve the teaching of IP Mathematics using English as a Language of Learning and Teaching.**

a)..

b)..

c)..

d)..

e)..

THANK YOU FOR YOUR INPUT

APPENDIX B: Teacher Educator Questionnaire

Teaching Intermediate Phase (IP) mathematics using English as a Language of Learning and Teaching (LoLT)

Instructions:

Please respond to *all* questions by making a tick (✓) in the shaded block next to the appropriate answer or by writing your answer in the shaded space provided.

1. What is the official language of learning and teaching at your institution?

English		Afrikaans		isiXhosa		Other(specify)		

2. For how many years have you offered in-service IP mathematics education?

Experience in years:	0 – 3 years		4 – 6 years		7 – 10 years		More than 10 years	

3. What in-service IP mathematics qualification(s) does your institution offer?

Duration (years)	Name of degree / diploma / certificate	Inclusion of methodology modules Yes / No

4. What other in-service short courses in methodology of teaching IP mathematics does your institution offer?

Duration		Name of degree / diploma / certificate	Inclusion of language of instruction modules Yes / No
Months	Days		

5. How do you teach specialised mathematical vocabulary in your lectures?

a)..

b)..

c)..

d)..

e)...

6. **What teaching resources do you recommend for use by in-service teachers to address language based mathematical problems?**

GDE workbooks	**Yes**		**No**	
Textbooks	**Yes**		**No**	
Mathematics dictionaries	**Yes**		**No**	
Computer based activities	**Yes**		**No**	
Word walls / charts	**Yes**		**No**	

Other(specify)**:**...

....

7. **What major challenges do you experience when lecturing and observing IP mathematics teachers using English as a Language of Learning and Teaching?**

a)..

b)..

c)..

d)..

e)..

8. **Suggest other ways that could improve the teaching of IP mathematics using English as a Language of Learning and Teaching.**

a)..

b)..

c)..

d)..

THANK YOU FOR YOUR INPUT

APPENDIX C: English Language Proficiency Assessment

JET EDUCATION SERVICES

Initial Teacher Education Research Project

INTERMEDIATE PHASE

TEACHER ASSESSMENT

ENGLISH

Biographical Questionnaire

Please complete the biographical questionnaire before starting the test.

1. **Gender:** 1. Male 2. Female

2. **Age Group**: 1. Below 25 2. 26 – 29 3. 30-35 4. 35+

3. **Race Group:** ____

4. **Home Language:**_______________________________________

5. **Additional Language/s Spoken:** __________________________________

6. **At which higher education institution did you complete your studies?**

____

7. **Which degree did you complete?**

1	BED		
2	PGCE		
3	Other (please specify)		

8. **If PGCE, which undergraduate degree/certificate did you complete?**

____

9. **Which Phase did you specialise to teach?**

1	FP		
2	IP		
3	IP & SP		
4	SP		
5	SP & FET		
6	FET		
7	Other (Please specify)		

Instructions for the assessment

1. You have up to 2 hours to complete this assessment, however if you require more time, please let the researcher know.
2. The test consists of two parts:
   a) Part One tests aspects of your knowledge of language and literature
   b) Part Two tests aspects of your knowledge of teaching English to Intermediate Phase learners
3. Answer all questions in both parts of the test

Part One

Section A. Read the extract from *Long Walk to Freedom* and then answer the questions that follow it.

"The schoolhouse consisted of a single room, with a Western-style roof, on the other side of the hill from Qunu. I was seven years old, and on the day before I was to begin, my father took me aside and told me that I must be dressed properly for school. Until that time, I, like all the boys in Qunu, had worn only a blanket, which was wrapped round one shoulder and pinned at the waist. My father took a pair of his trousers and cut them at the knee. He told me to put them on, which I did and they were roughly the correct length, although the waist was far too large. My father then took a piece of string and drew the trousers in at the waist. I must have looked a comical sight, but I have never owned a suit I was prouder to wear than my father's cut-off trousers.

On the first day of school my teacher, Miss Mdingane, gave each of us an English name and then thenceforth that was the name we would answer to in this school. That day, Miss Mdingane told me that my new name was Nelson. Why she bestowed this particular name on me I have no idea. Perhaps it had something to do with the great British sea captain Lord Nelson, but that would only be a guess."

Mandela, Nelson. (1994) Long Walk to Freedom. Randburg, South Africa: MacDonald Purnell. Page 13

1. Circle the best answer. This book is an autobiography because…

a. it is about events that really took place in the past.

b. it is written in the third person about events that really happened.

c. it is written in the first person about events that really happened.

d. it is a story that combines factual information with fiction. (1)

2. **What is the main idea in Paragraph 1 of the extract? Circle the correct answer**.

a. Nelson Mandela's father gave him a pair of trousers for school.

b. Nelson Mandela's school was a single room with a Western-style roof.

c. Nelson Mandela's first school was in the district of Qunu.

d. Nelson Mandela was seven years old when he went to school. (1)

3. '*He told me to put them on, which I did and they were roughly the correct length, although the waist was far too large.'*

Circle the correct answer. In this sentence the word roughly means …

a. exactly

b. precisely

c. accurately

d. approximately (1)

4. **Circle the best answer to this question: Why did Mandela feel proud of his new trousers?**

a. They were roughly the correct length.

b. They made him look very comical.

c. They had been his father's trousers.

d. They were his first 'Western' clothes. (1)

5. **Circle the statement that is a fact.**

a. Nelson Mandela was named after a British sea captain.

b. Nelson Mandela was given an English name by his teacher.

c. Nelson Mandela was given an English name by his father.

d. Nelson Mandela was named after his teacher. (1)

6. **Write a <u>synonym</u> for each of these words used in the extract.**

a. comical ________________ (1)

b. bestowed ________________ (1)

7. 'Miss Mdingane gave Nelson Mandela his new name.' **Rewrite this sentence so that the verb is in the passive voice.**

____

____ (2)

8. **Choose the correct underlined word to complete the sentence below.**

Some members of Nelson Mandela's family still **<u>live</u> / <u>lives</u>** in the district of Qunu.

______________________ (1)

9. **Write a suitable heading or title for the extract you have just read.**

____

____ (1)

10. Write a description of your parent or another family member. Use 4-6 sentences. You should say who the person is and include details such as what he or she looks like, what he or she likes doing and what makes him or her special to you.

Before you begin: Study the 10-mark rubric on the next page that will be used to mark your answer.

(10)

Rubric for marking your paragraph

Criteria	Description (all of the following descriptions should be met to receive the mark)	Mark
Paragraph format	Minimum of 4 sentences that are logically connected.	1
Content	Must identify the person, give a description of physical appearance, activities the person enjoys and provide a reason why he or she is special.	5
Descriptive language	The words used assist the reader to imagine what the person is like and why he or she is special.	2
Grammar	Sentences are correctly constructed and punctuated and grammar is used correctly.	2
Total		10

Total marks for Section A = 21

Section B: Read the poem and then answer the questions that follow it.

STOP ALL THE CLOCKS – W.H. Auden

Stop all the clocks, cut off the telephone,
Prevent the dog from barking with a juicy bone,
Silence the pianos and with muffled drum
Bring out the coffin, let the mourners come.

Let aeroplanes circle moaning overhead
Scribbling on the sky the message He Is Dead
Put crêpe bows round the white necks of the public doves,
Let the traffic policemen wear black cotton gloves.

He was my North, my South, my East and West,
My working week and my Sunday rest,
My noon, my midnight, my talk, my song;
I thought that love would last forever: I was wrong.

The stars are not wanted now: put out every one;
Pack up the moon and dismantle the sun;
Pour away the ocean and sweep up the wood.
For nothing now can ever come to any good.

11. Suggest why this poem is titled *Stop all the clocks.*

(1)

12. 'The speaker doesn't want anyone to know about the death of his lover.' Circle either TRUE or FALSE and give a reason for your answer

TRUE / FALSE

Reason____

____

(2)

13. Re-read line 9. 'North, South, East and West' are literally directions. What is the <u>figurative</u> meaning of this line of the poem?

____

____

(1)

14. Reread lines 9 to 11 and then complete the sentence below by writing one word in the gap.

He was____________________________to the speaker. (1)

15. The speaker describes aeroplanes as 'moaning' overhead and 'scribbling' on the sky. State what figure of speech the poet has used here.

__________________________________ (1)

16. Reread lines 13 to 16 and then explain <u>what</u> the speaker wants to happen to the world and <u>why</u> he wants this outcome.

What:____ (1)

Why: ____ (1)

17. Study images A and B and then write an answer to this question in the space on page 8, after the images: Which one of these two images best captures the atmosphere of the last stanza of the poem? Motivate your answer by referring to <u>both</u> images.

Image A.

(www.beenlooking for the magic.com)

Image B

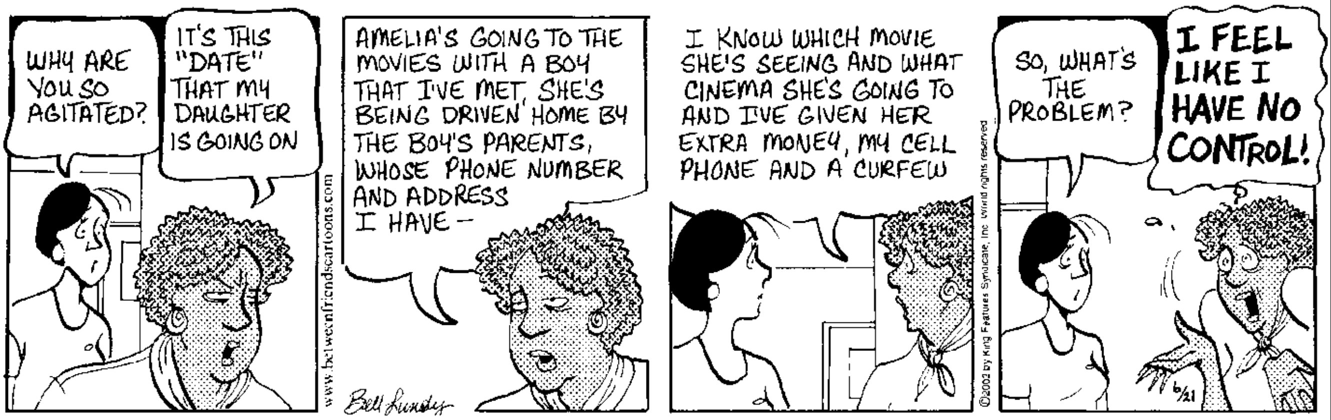
(www.wallpaperscraft.com)

(4)

Total marks for Section B = 12

Section C. Study the cartoon strip and then answer the questions underneath it.

FRAME 1 FRAME 2 FRAME 3 FRAME 4



(www.betweenfriendcartoons.com)

18. Write the noun form of the adjective 'agitated' (Frame 1)

__________________________ (1)

19. Report the mother's words in Frame 1 by filling in the blanks in the sentence below.

The mother said that it___________that date that ____________daughter__________going on. (3)

20. Write the name of the punctuation mark that has been used at the end of Frame 2.

_______________________________ (1)

21. Suggest why the cartoonist used this punctuation mark.

____

____ (1)

22. Explain the difference in meaning between *the boy's parents* AND *the boys' parents.*

____

____

(2)

23. Look at the <u>format of the words</u> spoken by the mother in Frame 4. Write down <u>two</u> techniques or features that the cartoonist has used to show how the mother was feeling.

____ (1)

____ (1)

24. Describe <u>two</u> features of the mother's body language in Frame 4.

____

____

____

(2)

25. What does the mother's body language suggest about how she was feeling?

____

____

(1)

26. Reread the four frames in the cartoon strip and then explain why the mother's final words are an example of <u>irony</u>.

____

____

____

(2)

Total marks for Section C = 15

Total marks for Part One = 48

Part Two
Teaching learners to read and write different types (genres) of texts

Section D. Read the text below and then answer questions 27 to 36 in the space provided

Kangaroos by Edward Osmond is a short information book of 32 pages. It is published in the 'Animals of the World' series by Oxford University Press, and is specially written for children under the age of twelve. The author presents a lot of information about kangaroos in a very interesting and readable way. In describing the habits of these animals, he naturally tells us much about Australia, the home of the kangaroo. The book is illustrated by lovely black and white drawings that clearly support the information provided. It would have been easier to find the information I was looking for if the book had an index. Nevertheless the book is good value for money.

27. What type of text have you just read in the box above? Circle the correct answer.

a. a recount

b. a book review

c. a description

d. a report (1)

28. Write a question that you could ask learners about this text to help them to understand one of the main features of this type of text.

____

____

(2)

29. Write two words to complete this sentence: Although the writer of the text likes the book very much, he or she criticizes it for not having________________________.

(1)

30. If you asked learners to *'Find the continent named in the text about the book Kangaroos', w*hat reading strategy would you be targeting? Circle the correct answer.

a. skimming a text to get an overview of its content

b. making inferences based on a detailed reading of a text

c. determining meaning based on a detailed reading of a text

d. scanning a text to locate a particular item of information (1)

31. Which of these questions would you ask learners to help them recognise the purpose and audience of the text? Circle the correct answer.

a. When do you think the text was written?

b. Who do you think would read this text?

c. Do you think the text was published?

d. Did more than one person write the text? (1)

32. Some learners may be confused about the difference between the words habits and habitats. Write one example of a good habit and one example of a bad habit that could help grade 4-6 learners to understand the meaning of habits .

A good habit: ____ (1)

A bad habit ____ (1)

33. Briefly describe a pair work activity that could help learners to understand the meaning of the word habits.

____

____

____ (2)

34. Use the word habitat in a sentence so that the meaning of this word will be clear to learners.

____

____ (2)

35. Write the phrases you would use to complete this sentence about the position of a table of contents and an index in a book.

A table of contents is found at the ________________________
An index is found at the ________________________________. (2)

36. Describe an activity you could ask learners to do in order to practice using an index.

____
____
____ (2)

Total for Section D = 16 marks

Section E. Read the table of results from a survey which asked children about their favourite foods. Note that they could choose more than one food item and many did so.

Food item	**Percentage of children who chose the item**
Chips	**36%**
Fresh vegetables	**15%**
Toasted cheese	**25%**
Chicken	**65%**
Hamburgers	**27%**

Table 1: Children's favourite foods

37. Write two questions that you could ask Grade 4 to 6 learners about the information in the table.

a.____
____
(2)

b.____
____
(2)

Total marks for Section E = 4 marks

Section F. Read the extract from a children's book and then answer questions 38 to 43.

Dealing with feeling left out

Being interested in what other people can do makes them feel that they belong.

Tami and Neo were talking about the new boy at school.

'I've never known anyone in a wheelchair,' Neo said.

'I wonder if he plays sport,' Tami said.

'Why not ask him?' Neo asked.

Later, Tami told Neo, 'The boy's name is Samuel. He plays wheelchair sports.'

Adapted from 'Dealing with feeling left out', by Don Middleton, Awareness Publishing SA (Pty) Ltd, 2005.

38. Write an explanation of the words 'feeling left out' that you could give to grades 4-6 learners.

____

____

(2)

39. Explain why the present simple tense (plays) has been used in the sentence 'He plays wheelchair sports.'

____

____

(1)

40. Much of the extract consists of sentences written in direct speech. Write what you would ask learners to notice about the punctuation of these sentences. You may write questions or statements about the punctuation.

____
____
____ (2)

41. Write the instructions you would give grade 4-6 learners for a <u>personal or expressive</u> writing task based on the photograph of Tami talking to Samuel.

____
____
____
____ (3)

42. Suggest why teachers should give learners opportunities, at the beginning of a writing lesson, to discuss ideas about a topic and vocabulary to use when they write.

____
____
____(2)

43. When doing formative assessment of learners' writing teachers should give learners feedback on the <u>content</u> of their writing before they comment on grammar and punctuation. Explain why teachers should first comment on content.

____
____
____

(2)

Total marks for Section F = 12 marks

Total Marks for Part Two = 32

Total marks for Assessment = 80

Part A

Section A

1. C (1)
2. A (1)
3. C (1)
4. D (1) C is not directly supported in my view so A and C is incorrect
5. B (1)
6. a. funny / amusing / humorous b. conferred / gave (max 1 mark for each part = 2)
7. Nelson Mandela was given his new name by Miss Mdingane. (2)
8. has (1)
9. The focus of both paragraphs is starting school so: Starting school / First school days (or something similar) (1)
10. Mark the paragraph according to the rubric on the question paper.

Criteria	Description (all of the following descriptions should be met to receive the mark)	Mark
Paragraph format	Minimum of 4 sentences, main sentence and supporting sentences.	1
Content	Must identify the person, give a description of physical appearance, activities the person enjoys and provide a reason why he or she is special.	5
Descriptive language	Minimum of 3 descriptive words demonstrating a rich vocabulary.	2
Grammar	No spelling, punctuation, tense or grammar errors made.	2
Total		10

Total marks for Section A: 21

Section B

11. When the speaker's loved one died, time stopped. / According to the speaker, with his loved one dead, all time / clocks might as well be stopped. (This key idea can be expressed in several ways.) (1)
12. FALSE
The speaker wants the public to be aware of his loved one's death. He wants skywriting aeroplanes to write a message in the sky, crepe bows to be placed on monuments (doves) and traffic policemen to wear black gloves. (2)
13. 'He was my North, my South, my East and West,' (1)
14. everything (1)
15. personification (1)
16. The speaker would like the world to come to an end because nothing good can happen now that his loved one has died. (These two ideas can be expressed in different words.) 1 + 1 = 2
17. The answer must focus on one image but refer to both images in the motivation and the images must be described in some detail.
For example:
I choose Image A because the man looks lonely and sad (1) and it looks as though the ocean is pouring away (1). In Image B there are too many clouds (1) and there is a definite light coming through and there is no mention of such light in the last stanza (1).

OR
I choose Image B because both the moon and the sun are fading away (1)and there are no stars to be seen (1). The man in Image A looks interested in the waves that are coming in (1)and does not appear to be wishing them away (1). (4)
Total marks for Section B: 11

Section C
18. one of upset / irritated / disconcerted / anxious (1)
19. was …. her …. was (1 each: total 3)
20a. dash (1)
20b. The dash indicates a pause while the mother thinks about all the details of what she has organised in regard to her daughter's date. (1)
21. The boy's parents means the parents of one boy while the boys' parents means the parents of more than one boy. (2)
22 The cartoonist uses an exclamation mark (1) and EITHER bold type (1) OR larger font (1).
23. The mother's mouth is open in a shout (1) and her hands are flapping (1), suggesting that she is feeling out of control of her daughter's life. These ideas could be expressed in other words.
24. In Frames 2 and 3 the mother has given a long list of actions she has taken to control her daughter's life while she is on a date so it seems ironic that in Frame 4 she claims to have no control over her daughter. (2) These ideas could be expressed in other words.
Total marks for Section C: 13

Part B
Section D
25. B (1)
26. Note: Even if the test takers answer question 1 incorrectly, they could still be awarded marks for question 2 if they ask questions that are clear and that relate well to the answer given in question 1.
There are many possibly acceptable questions that could guide learners to an understanding of features of a book review. Examples include: How do you usually find out whether you would like to read a particular book? (ask a friend; read what's written on the cover; read what someone has written about the book) What sort of information do you try to find out? (subject matter; length of the book; illustrations or not; cost of the book …) Why would the writer of the paragraph about *Kangaroos* include information about the publisher? (2)
27. The book does not have an index. (1)
28. D (1)
29. A (1)
30. B (1)
31. Habits are actions that people or animals usually do / regularly do / often do, usually without thinking about them. Habits can be good (e.g. exercising regularly) or bad (e.g. biting one's nails). (2)
32. Talk to a partner about actions that you do regularly and decide which of these could be called habits. Be prepared to share your ideas with the class (2). NB: There could be other acceptable activities.
33. An index is an alphabetical list of names or subjects that is found at the back of a book, with the number of the page on which the information about the name or subject can be found. (2)
34. Learners would need books with an index -many textbooks have these as do many information books. A likely activity is one in which the teacher asks learners to look in the index and tell her / him on which page in the book they can find information about X. (Credit could be given for other plausible activities such as an activity that focuses on establishing that learners understand alphabetical order.) (2)
Total marks for Section D: 15

Section E
35. A percentage is an amount that is expressed as if it is a part of a total that is 100. For example, 65 percent chose chicken means that roughly 65 of every 100 children in the survey chose chicken. (2)

36. The questions should require learners to engage with information in the graph: (i) Which food did most children like best? (ii) 'More children liked vegetables than toasted cheese.' Is this statement TRUE or FALSE? (iii) Which were more popular: hamburgers or chips? (There are many possibilities: 2 + 2 for appropriate and clearly written questions)

Total marks for Section E: 6

Section F

37. Several possibilities but the question must relate to what is shown in the photograph and stated in the caption. Examples: Why is the girl bending down rather than standing up straight? How do you think the boy in the wheelchair is feeling? (2)

38. The simple present tense is used for statements that are always true / that remain the same (e.g. Samuel is always / remains the boy's name. (1) The simple present tense is used for actions that are done regularly (e.g. The soccer team trains on Tuesdays.) (1) Credit can be given for this information expressed in different ways.

39. In direct speech the first or opening quotation mark must be placed in front of the first word that the person speaks and the second or closing quotation mark must be placed after the last word that the person speaks and after the punctuation mark (e.g. comma or question mark). (2)

40. Personal or expressive writing task

There are many possibilities but all should involve scaffolding the task. Two examples:

(i) Teacher asks the class to look at the two children in the photograph and to talk to a partner about what they might be saying to each other. Teacher asks class to share ideas. (1)Then teacher explains the writing task: You are going to write a conversation between the two children. You can choose names for them and then you write the names like this:

Tami:

Neo: (1)

Next to each name you write what one child said and then what the other child replied. Try to write three sentences for each child. (1) Any other reasonable and correct answers should be accepted. Discuss them with the Subject Expert/Moderator in order to confirm the correctness of the answer.

OR

(ii) Teacher asks learners to think about a time when they experienced being left out, or not belonging to a group (e.g. classmates; family).(1) Teacher asks them to make notes to answer each of these questions: How did you feel? When did you have these feelings and where were you? Did you, or someone else, try to improve the situation? What happened? (1)Teacher asks learners to use their notes to write the first draft of a paragraph titled 'Dealing with feeling left out'. (1) Any other reasonable and correct answers should be accepted. Discuss them with the Subject Expert/Moderator in order to confirm the correctness of the answer

Total marks for Section F: 9

Section G

41. (5 3 1 6 2 4) (1/3 x 6 = 2 marks) None to 2 sentences correct = 0 marks; 3 to 5 sentences correct = 1 mark and 6 sentences correct = 2 marks

42. When giving feedback to learners on their writing it is important to focus firstly on the content of their writing because this shows interest in and respect for their ideas and is likely to encourage them to be interested in writing. (Other answers can be accepted. The key point is that engaging with meaning comes before technical aspects such as grammar and spelling.) (2)

Total marks for Section G: 4

Total marks for Part Two: 34

APPENDIX D: Mathematics Word Problem Assessment

JET EDUCATION SERVICES

JET EDUCATION SERVICES
Initial Teacher Education Research Project

INTERMEDIATE PHASE

TEACHER ASSESSMENT

MATHS

Biographical Questionnaire

Please complete the biographical questionnaire before starting the test.

1. **Gender:** 1. Male 2. Female

2. **Age Group**: 1. Below 25 2. 26 – 29 3. 30-35 4. 35+

3. **Race Group:** ____

4. **Home Language:**_______________________________________

5. **Additional Language/s Spoken:** _________________________________

6. **At which higher education institution did you complete your studies?**

____

7. **Which degree did you complete?**

1	BED		
2	PGCE		
3	Other (please specify)		

8. **If PGCE, which undergraduate degree/certificate did you complete?**

____

9. **Which Phase did you specialise to teach?**

1	FP		
2	IP		
3	IP & SP		
4	SP		
5	SP & FET		
6	FET		
7	Other (Please specify)		

Instruction for the assessment

1. **You have up to 2 hours to answer all the questions. If you would require more time, please let the researcher know.**
2. **For questions requiring calculations space has been provided for your working, but the final answer must be placed in the box provided.**
   ONLY THE FINAL ANSWER WILL BE MARKED.
3. **For questions requiring explanation please provide full, clear explanations.**
4. **Calculators may not be used.**
5. **Blank paper is provided at the end of the assessment for your rough work.**
6. **If you require assistance, please raise your hand and one of the invigilators will come to your aid.**

1	A choir has 35 members. The ratio of girls to boys is 5:2. How many girls are there in the choir? FINAL ANSWER:	**1**

2	$1\frac{1}{4} \div \frac{3}{4} =$ FINAL ANSWER:	**1**

3	a) Calculate 53,08 times 100 FINAL ANSWER: [ ] (1)	b) Express 0,4 as a fraction in simplest form. FINAL ANSWER: [ ] (1)	
	c) Calculate 2495 + 760,7 FINAL ANSWER: [ ] (1)	d) Calculate 5000 -1093 FINAL ANSWER: [ ] (1)	**4**

4a	Circle the number nearest in size to:			
	i) 181 A 82 B 180 C 190 D 200 (1)	ii) 2,9 A 3 B 30 C 2 D 20 (1)	iii) 0,18 A 0,1 B 0,02 C 0,2 D 20 (1)	**3**
4b	Circle the number that is nearest in size to the answer (do not work out the arithmetic)			
	i) 2,9 x 7,1 = A 0,02 B 0,2 C 2 D 20 (1)	ii) 0,29 x 7,1 = A 0,002 B 0,02 C 0,2 D 2 (1)	iii) 59 ÷ 190 = A 0,003 B 0,03 C 0,3 D 3 (1)	**3**

5	For each scenario given below, write the calculation you would need to do in order to get the answer. **You do NOT need to do the calculation**. For example, for the scenario: *I have 53 marbles and I win another 24 marbles, how many do I have all together.* You would simply write "The calculation I would need to do is: **53 + 24**"		
5a	A table is 92,3cm long. About how many inches is this length (1 inch is about 2,54 cm)?	The calculation I would need to do is:	**1**
5b	Your friend lends you R6,44 so that you can pay a bill for R8,37. How much money did you put in?	The calculation I would need to do is:	**1**
5c	A farmer's cost for milk production is 88,2 cents for each litre. What are his costs for producing 0,58 litres of milk?	The calculation I would need to do is:	**1**
5d	The cost of 6,22 litres of petrol in England was £4,86. What would the price of 1 litre be?	The calculation I would need to do is:	**1**

6	Circle the correct answer: 12,3 ÷ 0,15 has the same answer as A 123 ÷ 0,015 B 123 ÷ 1,5 C 123 ÷ 15 D 123 ÷ 150	**1**

For questions 7a and 7b fill in the number indicated by the arrow on the numberline.
Give each answer as a DECIMAL number

7a

This number is [ ] **1**

7b

This number is [ ] **1**

7c What number is halfway between 14,6 and 14,7?

FINAL ANSWER: [ ] **1**

7d Calculate 1 ÷ 5 and write your answer as a decimal number.

FINAL ANSWER: [ ] **1**

8a	6% of children in a grade get school fee exemption. There are 250 children in the grade. How many children get school fee exemption? FINAL ANSWER:	**1**
8b	A newspaper says that 24 out of 800 Avenger cars have faulty engines. What percentage of the 800 cars have faulty engines? FINAL ANSWER:	**1**
8c	The price of a scarf is R20. In a sale, it is reduced by 5%. How much does it cost now? FINAL ANSWER:	**1**

9 My monthly salary has been increased by 20% and is now R24 000. How much was my salary before the increase?

FINAL ANSWER: ______ **1**

10 Without working the two answers out, say which is larger and why you say so.

A: $72{,}4 \div \frac{7}{8}$ B: $72{,}4 \times \frac{7}{8}$

____

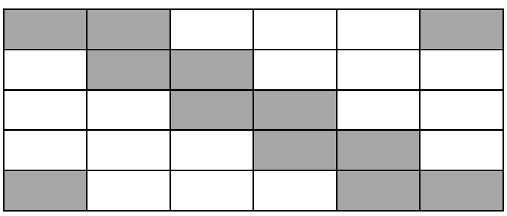
____

____

____

____ **1**

11



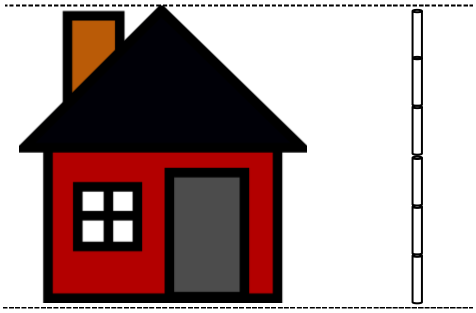
What percentage of the grid is shaded?

FINAL ANSWER: ______ **1**

12

I've drawn a big house and a small house on the blackboard.

The small house:



You can see that the small house is 6 pieces of chalk high

When I measure the height of the houses using pencils,
the small house's height is four pencils
and the big house's height is six pencils.

How many pieces of chalk do we need for the big house's height?

FINAL ANSWER:

1

13 ai	Solve the word problem, showing all working clearly: I want to divide 3 pizzas between two children fairly. How much pizza will each child get? __________ __________ __________ __________	**1**
13aii	Would the word problem "I want to divide 3 pizzas between two children fairly. How much pizza will each child get?" be a good word problem to illustrate 3 divided by ½? Explain why you say so. __________ __________ __________ __________ __________ __________ __________	**1**
13bi	Solve the word problem, showing all working clearly: A child has 3 chocolates. The number of chocolates the child has is doubled. How many chocolates will the child have now? __________ __________ __________ __________	**1**
13bii	Would the word problem "A child has 3 chocolates. The number of chocolates the child has is doubled. How many chocolates will the child have now?" be a good word problem to illustrate 3 divided by ½? Explain why you say so. __________ __________ __________	

	____ ____ ____ ____ ____ ____ ____	1
13ci	Solve the word problem, showing all working clearly: I have 3 metres of ribbon. I am making bows that each require $\frac{1}{2}$ metre of ribbon. How many ribbons will I be able to make? ____ ____ ____ ____	1
13cii	Would the word problem " I have 3 metres of ribbon. I am making bows that each require $\frac{1}{2}$ metre of ribbon. How many ribbons will I be able to make? " be a good word problem to illustrate 3 divided by ½? Explain why you say so. ____ ____ ____ ____ ____ ____ ____ ____ ____	1

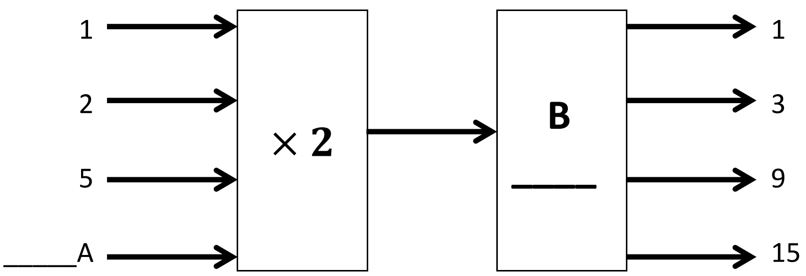
14a	A learner in your class calculates that 2,6 + 3,7 = 5,13 and that 4,5 + 12,6 = 16,11. Explain what this learner is doing incorrectly. ____ ____ ____ ____ ____ ____ ____ ____ ____	**2**
14bi	How you would correctly calculate 2,6 + 3,7? Show all steps clearly. ____ ____ ____ ____ ____ ____	**1**
14bii	The learner, who did the calculation incorrectly in the way shown in question 14a, in your class says “I don’t understand why your way is right and my way is wrong.” What diagrams, models or explanations could you use to help the learner **understand** why your way is correct and their way is incorrect. ____ ____ ____ ____ ____ ____	**2**

	____	
15	Provide a realistic word problem that would lead to the calculation $\frac{1}{2} - \frac{1}{6}$. Pay attention to how you phrase the word problem so that it is clear and unambiguous. ____	**2**

16	A learner says that she doesn't understand why $2\frac{1}{4} = \frac{9}{4}$. Show how you could use **pictures** to help her understand **why** this is true. Provide a brief explanation alongside your pictures.	**3**

17	If 630 × g = 420 what is the value of: 630 × g + 80 Circle the correct answer: **A** 1130 **B** 510 **C** 500 **D** 710	**1**

18 Replace A with a number and B with a rule in the flow diagram below.



2

19 Chip packets cost R8 each and tins of soup cost R6 each.

If c stands for the *number of chip packets* bought and t stands for the *number of tins of soup* bought, what does the expression

8c + 6t stand for ____

Write an expression for the total number of items bought? ______________________

1

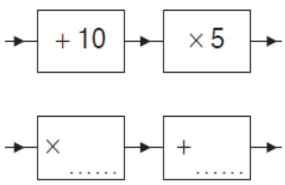
20 Piet wrote down a pattern using As and Bs. The pattern repeats itself after every four letters. Below is the beginning of this pattern with a few of the letters left out. Fill in the missing letters.

A B __ __ A __ B __ __ __ __ A

1

21 When you feed a number into this machine, it does the operations shown, and passes the answer out.

Can you find another machine that has the same overall effect, whatever number you put in?



1

22 Write down the smallest and the largest of these five expressions.

					Smallest	Largest
n + 1	n + 4	n – 3	n	n – 7	________	_________

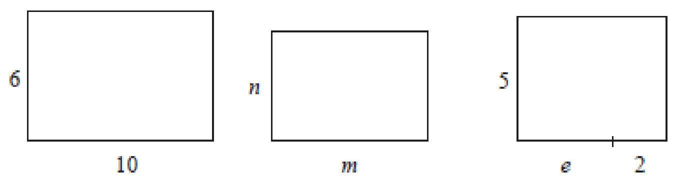
2

23	Determine the value of x: $(2 + 2x) \times 6 = 48$ Circle the correct answer: **A.** 3 **B.** 6 **C.** 2 **D.** 25	**1**
24a	You ask your grade 5 learners to fill in the missing number: $23 + 36 = \_\_\_\_ + 19$ To answer it **correctly**, what number should they fill in?	**1**
24b	What common mistake do you think learners might make and why do you think they might make this mistake? ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____	**2**

25	A tray of food is placed in the oven at 07:40. It needs to bake at a low temperature for 2,5 hours. At what time must the tray be taken out of the oven? FINAL ANSWER:	**1**

26	Two friends are walking around a field which is a rectangle 90m long and 50m wide. They leave the starting point at the same time and walk in the same direction. One friend walks 1 ½ times as fast as the other. How many times will the slower friend have walked around the field before they meet again at the starting point. FINAL ANSWER:	**1**

27 What are the areas of each of these shapes?



A = ... A = ... A = ...

(3)

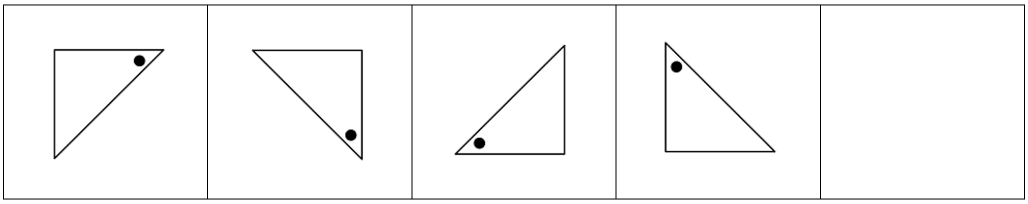
And what is the perimeter of each of these shapes?

P = ... P = ... P = ...

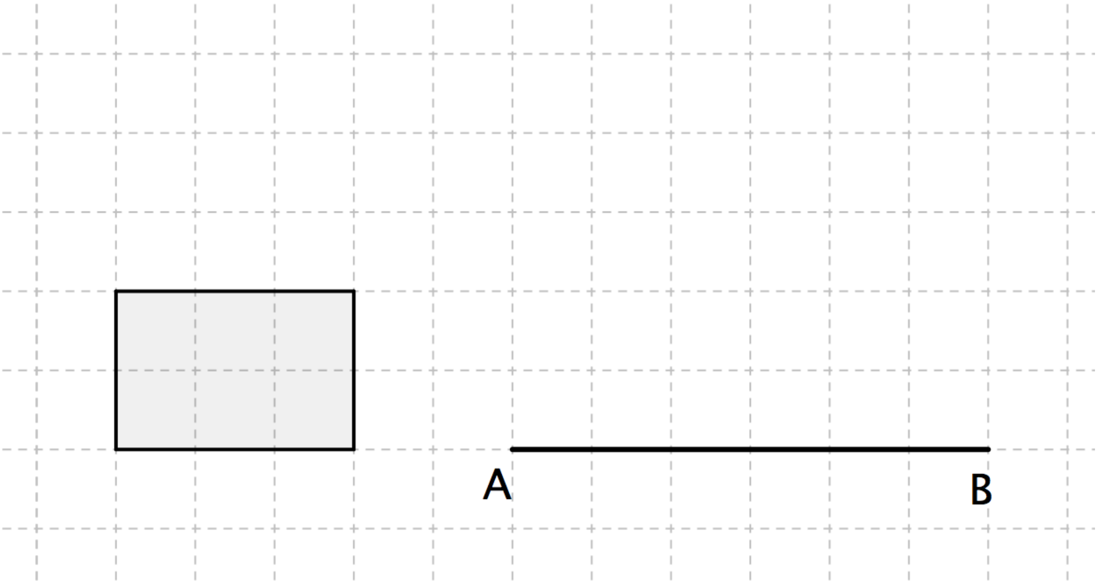
(3)

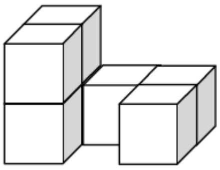
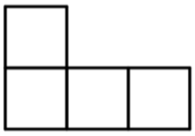
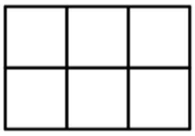
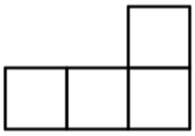
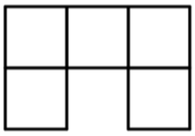
6

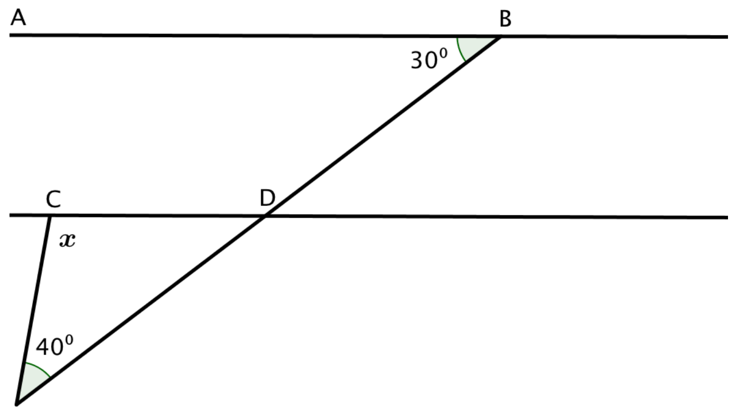
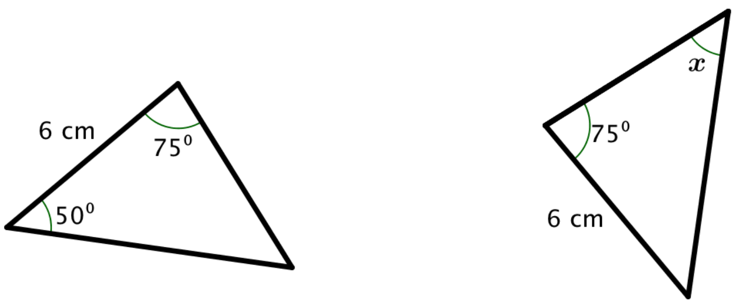
28 Draw the next figure that follows in the space provided: **1**



29 Rectangle 1 has been drawn on the grid below. Draw a rectangle with length AB, so that its area is twice the area of rectangle 1 **1**



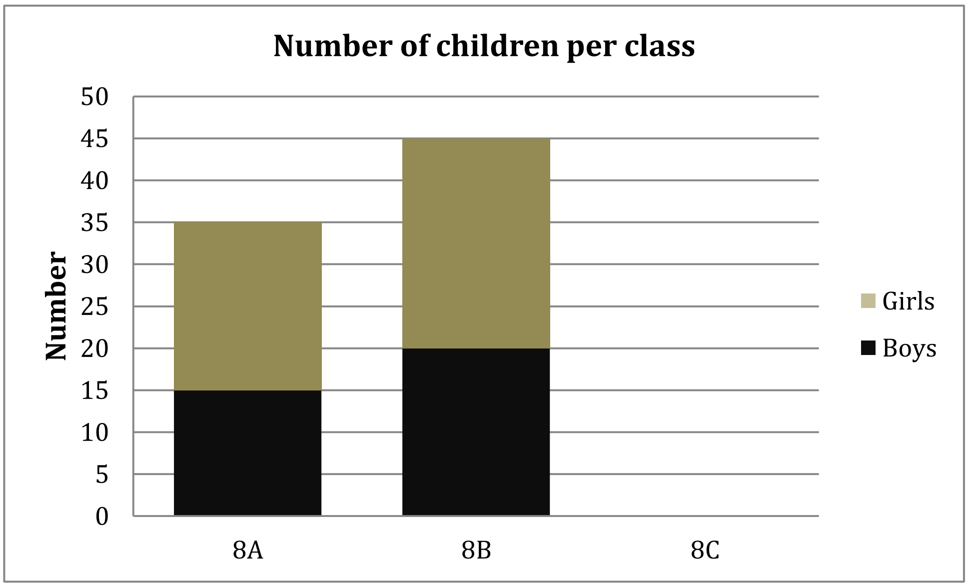
30	Which 2-D shape below shows the top view of the 3-D object?  Front view A  B  C  D 	**1**

31	In the diagram below, AB is parallel to CD. What is the size of the angle marked x?  FINAL ANSWER:	**1**
32	The two triangles below are congruent. They are not drawn to scale, but measurements of some of their sides and angles are shown. What is the value of x?  FINAL ANSWER:	**1**

33a	A learner believes that since 1 cm = 10 mm it must follow that 1 cm^2 = 10 mm^2. Fill in the number to show the correct way to convert cm^2 to mm^2 1 cm^2 = _________mm^2	1
33b	Use pictures and explanations to show how you would help the learner to correct the misconception and **understand** the correct conversion? ____________________	2

34

A graph is used to summarise the number of boys and girls in Grade 8. The information for class 8C is missing.



34a There are 126 children in Grade 8 and 18 girls in 8C. How many boys are there in 8C? **1**

34b How would you demonstrate the way to work this problem out to grade 6 learners?

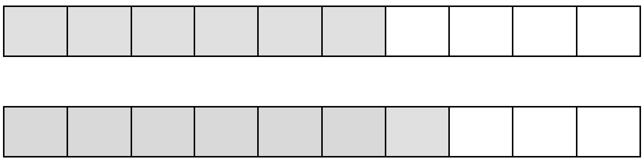
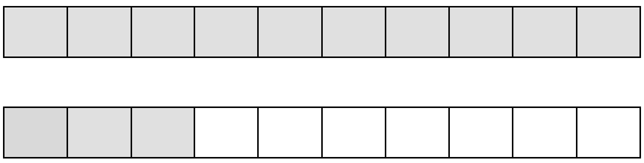
Show the solution step by step.

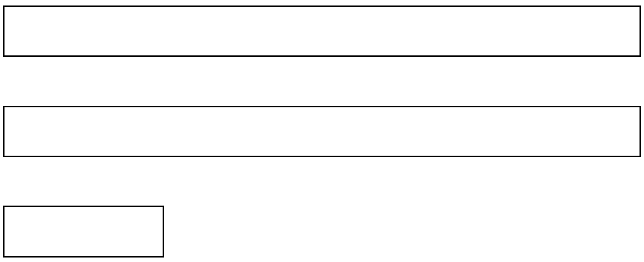
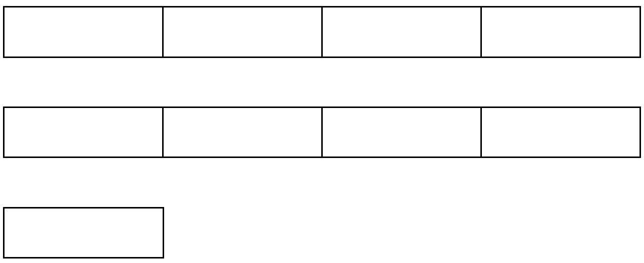
	____________________ ____________________ ____________________ ____________________ ____________________ ____________________ ____________________ ____________________ ____________________	3
35	Each week Sihle writes a maths quiz which is out of 10 marks. The mean mark for her first 10 quizzes was 4,5. For her 11th quiz she gets 7 out of 10 and for her 12th quiz she gets 8 out of 10. What is her mean mark for all 12 quizzes? FINAL ANSWER:	**1**

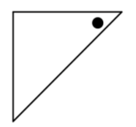
END OF ASSESSMENT – THANK YOU

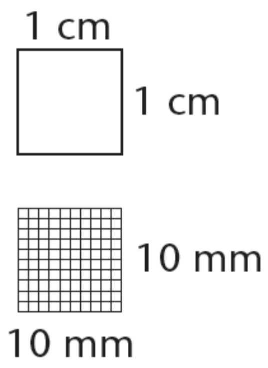
APPENDIX D1: Mathematics Word Problem Assessment Memorandum

ITERP Maths Assessment Memo			
Qu	Answer		Marks
1	25		1
2	$\frac{5}{3}$ or $1\frac{2}{3}$		1
3a	5308		1
3b	2/5		1
3c	3255,7		1
3d	3907		1
4a.i	180	B	1
4a.ii	3	A	1
4a.iii	0,2	C	1
4b.i	20	D	1
4b.ii	2	D	1
4b.iii	0,3	C	1
5.a	92,3 ÷ 2,54		1
5.b	8,37 - 6,44		1
5.c	0,58 × 88,2		1
5.d	4,86 ÷ 6,22		1
6	B 123 ÷ 1,5	B	1
7a	5.8		1
7b	2.74		1
7c	14.65		1
7d	0.2		1
8a	15		1
8b	3% (give mark if they just write 3)		1
8c	R19 (give mark if they just write 19)		1
9	R20 000 (give mark if they just write 20 000)		1
10	72,4 ÷ $\frac{7}{8}$ is larger than 72,4 × $\frac{7}{8}$ since 7/8 Is less than 1. The reason might be expressed differently e.g. dividing by a proper fraction makes the number bigger or multiplying be a proper fraction makes the number smaller or $72{,}4 \div \frac{7}{8} = 72{,}4 \times \frac{8}{7}$. These are all acceptable.		1 (must identify that 72,4 ÷ $\frac{7}{8}$ is larger than 72,4 × $\frac{7}{8}$ and give a reason)
11	40%		1
12	9		1
13a	i) 1 ½ ii) No, This story would lead to the calculation 3 ÷ 2		1 1 for reason
13b	i) 6 ii) No. This story leads to the calculation 3 x 2. Although		1

	this calculation has the same answer as 3 ÷ ½, the story does not have the concept of division in it. i.e. there is no idea of seeing how many halves there are in 3.	1 for reason
13c	i) 6 ii) Yes. This story asks how many halves there are in 3.	1 1 for reason
14a	The learner is adding the numbers before and after the decimal comma separately and treats the digits after the decimal comma as if they are numbers. i.e. he say 6 + 7 = 13 and 5 + 6 = 11. He thus has not understood place value in relation to decimals. The learner sees the of decimal marker as separator and not as a continuation of number beyond the integers	1 mark if provides an explanation that the problem is doesn't consider place value.
14b	i) 2,6 + 3,7 = 6,3 (Would need to show the steps of how to do this either using vertical column method with carrying or some explanation) Understanding the 0,5 = 5/10 and 0,6 = 6/10 would help the learner. ii) The learner could then see that 0,6 + 0,7 can be represented as follows:  Where the rectangles represent 1 whole When the shaded pieces are added together One gets  Which is 1 whole and 1/10 i.e. 1,1. This set of diagrams will help learners see how the digits after the decimal comma relate to units in the same way as units relate to tens (they had understood this part of place value relating to the natural numbers)	1 2 for a clear description that indicates the use of diagrams or dienes block or some other base 10 representation to show that ten 1/10s will make a whole so 0,6 + 0,7 makes 1 whole and 0,3. 1 for some attempt to get across the idea that ten 1/10s will make a whole, but no use of models. 0 for explanation that just states if you do 6 + 7 you get 1 carry 1 (i.e. that just references the addition algorithm with no explanation of why it works)
15	I have ½ kg of flour in my pantry. I use 1/6 kg of this flour in a recipe. How much flour do I have left. The idea is quantity not fractions of an notional object (contexts with measurements i.e. km, m, kg etc are likely to be most realistic.) It is possible to create other contexts but the wording is	2 marks for a realistic, clearly worded problem. 1 mark for a correct problem, but where the context is either unrealistic or the wording is clumsy.

	tricky e.g. I have ½ a bar of chocolate. I eat 1/6 of a bar of chocolate. How much chocolate do I have left. (Here this is not a natural way of talking because the 1/6 relates to the original bar of chocolate and not the chocolate I have. So although technically correct it is not a really good example for a REALISTIC problem and hence gets only 1 mark) Clarifying the idea that you are referring to the original bar of chocolate leads to very clumsy wording so only gets 1 mark: I have ½ a bar of chocolate. I eat an amount of that chocolate which is equivalent to 1/6 of a bar of chocolate. What fraction of a bar of chocolate do I have left. BUT it would not be correct to say: I have ½ a bar of chocolate and I eat 1/6 of it AND it is ambiguous to say I have ½ a cake and I eat 1/6 of the cake	No marks for incorrect or ambiguous contexts.
16	I would first check the learner understands that 9/4 means 9 quarters. This might mean I'd need to start by say ¾ means 3 quarters etc and that they could picture what that looks like (i.e. take a whole, cut it into 4 pieces each piece is then 1 quarter). I'd then look at what 2 ¼ is: 2 ¼ is made up of 2 wholes and ¼ so looks like:  We can then have a look and see how many 1/4s that is by dividing each of the wholes up into 4 pieces  This partition shows us the we have 21 quarters (1/4s) i.e. we have $\frac{21}{4}$=21*(1/4)	3 marks for clear description and illustration of what 9/4 is and what 2 ¼ is and discussion that makes it clear an attempt is made to link to the learners understanding. 2 marks if the description and illustration is accurate but not entirely clear. 1 mark if an illustration is provided without description or a description is given with no clear illustration. 0 marks if algorithm for converting between mixed numbers and improper fractions is the only "explanation" provided.
17	500	1

18A	8	1
18B	-1	1
19a	The total cost of the items bought in rands	1 (give the mark even if "in rands" is omitted)
19b	c + t or t + c	1
20	**A B B A A B B A A B B A**	1
21	X 5 +50	1
22	Smallest n-7 Largest n+4	2 (1 mark each)
23	3	1
24	a) 40 b) Learners might say 59. This response is because they do not understand the = sign. Learners see = as an instruction to calculate rather than as indicating equality. If a different error is indicated that is not a common mistake but a reasonable explanation for that error is provided, you can give 1 mark for explanation.	1 2 (1 for error, 1 for reason: the reason just needs to indicate that it is a lack of understanding of the meaning of = that is the problem)
25	10: 10 (or 10:10 or 10 past 10 or 10h10)	1
26	Twice (or 2 or 2 times)	1
27a	60	1
27b	mn	1
27c	5(e+2) = 5e+10	1
27d	32	1
27e	2n + 2m (2(n+m) or n + m + n + m)	1
27f	14 +2e (or 2(7 + e))	1
28		1
29	Rectangle with breadth of 2.	1
30	D	1
31	x = 110°	1
32	55°	1
33	a) 100 They first need to understand that 1 cm^2 is a measurement of area and is the area of a square that is 1 cm by 1 cm in size. And 1 mm^2 is the area of a square that is 1mm by 1mm in size. A drawing like that shown below can then be used to show that 100 little 1mm^2 squares fit into the larger 1 cm^2	1 2 marks for clear explanation and illustration. 1 mark for explanation that has

	square.  	the right idea but is incomplete or not completely clear. 0 for incorrect or incoherent explanation.
34a	28	1
34b	How many children are there in 8A? 35 How many children are there in 8B? 45 How many children are there in 8A and 8B combined? 35 + 45 = 80 So if there are 126 children in grade 8, how many children are there in 8C = 126 – 80 = 46. If there are 18 girls in 8C, how many boys are there? 46 – 18 = 28.	3 for logically ordered, clear and correct steps. 2 for correct answers but without clear explanation or logical ordering. 1 for some correct steps with explanation.
35	5	1

APPENDIX E: Teacher Interview Schedule

Teaching Intermediate Phase (IP) mathematics using English as a Language of Learning and Teaching (LoLT)

1. (a) Is your mother tongue and that of your learners the same?

   (b) Is this an advantage or a disadvantage in your teaching IP mathematics using English?

   (c) Provide a reason to your answer in (b) above.

2. On arrival at school, what home language(s) do the learners already speak? (You may mention more than one).

3. Would you say English is a barrier to IP learners' understanding of mathematics?

4. (a) Would you rate your frequency in using code switching when teaching mathematics lessons as never, sometimes, always?

   (b) Give reasons for your answer?

5. The following questions are based on the **JET mathematics word problems** you solved earlier: **(Question 13 or 14 or 15).**

   a) Read the question. (*Reading / Decoding*)
   b) What is the question asking you to do? *(Comprehension)*
   c) Suggest a method that can be used to find an answer to the question. *(Transformation / Mathematising)*
   d) Explain how you worked out the answer *(Processing)*
   e) Write down the answer to the question. *(Encoding)*

6. What forms of in – service CPTD would you like to receive to become more efficient in teaching IP mathematics using English as the LoLT?

THANK YOU FOR YOUR INPUT

APPENDIX F: Teacher Educator Interview Schedule

Teaching Intermediate Phase (IP) mathematics using English as a Language of Learning and Teaching (LoLT)

1. What is the official language of instruction at your institution?
2. For how many years have you presented in – service (IP) mathematics teacher education?
3. What in – service (IP) mathematics teacher education qualification(s) does your institution offer?
4. Do any of your IP mathematics teacher education qualifications include a module focusing on English as a Language of Learning and Teaching?
5. How do you teach specialised mathematical vocabulary in your lectures?
6. What teaching resources do you recommend for use by in-service teachers to address language based mathematical problems?
7. What major challenges do you experience when lecturing / observing mathematics intermediate phase teachers using English as a language of learning and teaching?

THANK YOU FOR YOUR INPUT

APPENDIX G: Classroom Observation Guide

Non – participant structured observation sheet

Teaching mathematics using English as a Language of Learning and Teaching (LoLT)

Grade	Teacher's 1st language	Learners' 1st languages				
		English	Afrikaans	isiXhosa	Other (Specify)	Total
Totals where applicable						
Topic of the lesson:						

Lesson description: …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… ……………………………………………………………………………………	
Variables to be observed	
1	**Language of instruction in mathematics lesson**: {language(s) used by the teacher to give instructions and ask questions}. Comment on the frequency English is used as the LoLT? …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… ……………………………………………………………………………………
2	**Learner participation**: pupils' involvement in the learning activities, (focusing on the language(s) they use when talking amongst each other / when communicating with the teacher); or when participating in class activities. How are the learners using English in classroom activities? …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… ……………………………………………………………………………………

3	**Specialised mathematics vocabulary**: What strategies does the teacher use to teach / explain specialised mathematics vocabulary for the concepts covered during the lesson? ………………………………………………………………………………………………………... …… …… ……
4	**Chalkboard summary**: Comment on the language(s) the teacher use when writing on the chalk board during the lesson. ………………………………………………………………………………………………………... …… …… …… ……
5	**Learning and teaching resources**: Comment on any textbooks, GDE workbooks, audio visual learning and teaching aids etc written in English used during the lesson? .... ………………………………………………………………………………………………………... …… …… ……
6	**Classroom environment:** Are there any charts / word walls around the classroom which indicate that mathematics is taught in English? .... ………………………………………………………………………………………………………... …… …… ……

General comments:

……..…..

…….

…….

……

……

APPENDIX J: Letter Requesting Permission to Observe Lesson: Stellenbosch University

UNIVERSITEIT•STELLENBOSCH•UNIVERSITY
jou kennisvennoot • your knowledge partner

STELLENBOSCH UNIVERSITY
CONSENT TO PARTICIPATE IN RESEARCH

Multiple levels and aspects of language competency in English and Intermediate Phase mathematics teachers: An analysis of case of the Eastern Cape Province[1]

Classroom Observation Schedule

You are asked to participate in a research study conducted by **Lindiwe Tshuma – PhD Student** from the **Department of Curriculum Studies** at Stellenbosch University. The results will be contributed to doctoral thesis. You were selected as a possible participant in this study because you are an **Intermediate Phase (IP) Teacher**.

1. PURPOSE OF THE STUDY

The researcher is responsible for lecturing Advanced Certificate in Education (ACE) and Advanced Certificate in Teaching (ACT) IP mathematics modules to in-service teachers at the African Institute for Mathematical Sciences Schools Enrichment Centre (AIMSSEC). Most of the teachers with whom the researcher is in contact are based in the Eastern Cape, Limpopo and KwaZulu Natal Provinces and are non-specialist teachers, recruited into IP teaching positions to alleviate the nationwide shortage of mathematics teachers. The majority of the teachers' proficiency in English, as evidenced in their written assignments, is below average and the research contends this as a reflection of the quality of learning and teaching that takes place in the teachers' classrooms. Research analysing initial teacher education across five South African universities reveals that the situation with respect to the language of learning and teaching, predominantly English, is of particular concern.

This study is motivated by the inference that language plays a crucial role in content delivery. In a mathematics classroom, language is used to construct meaning, to express understanding and to develop mathematical thinking skills. However, there is a danger that this role may be interpreted superficially without taking into consideration some underlying linguistic factors that may influence understanding of mathematics. In the IP years, these factors include, among others, the teacher's mastery of the LoLT, the switch from mother tongue instruction at FP to the use of English as the LoLT and the teacher's use of code switching. It therefore follows that for improved mathematics instruction teachers need first to acknowledge and recognise the importance of language in mathematics learning and teaching, as well as be proficient in the LoLT. Only then can the quality of mathematics instruction improve.

The purpose of the research is to inform curriculum design for in-service IP mathematics teacher education in order to empower teachers to effectively overcome language barriers in content delivery.

2. PROCEDURES

If you volunteer to participate in this study, we would ask you to do the following things:

[1] To encompass the depth of the data collected and the multilevels analysis thereof: the examiners unanimously agreed to change the title of the study from ***Relationship between language competency and Intermediate Phase mathematics instruction*: *A case of the Eastern Cape Province***

to

Multiple levels and aspects of language competency in English and Intermediate Phase mathematics teachers: An analysis of case of the Eastern Cape Province

- A**llow the researcher to observe you while teaching an IP mathematics lesson** at a time and place convenient to you.

3. POTENTIAL RISKS AND DISCOMFORTS

The research does not involve any foreseeable risks, discomforts, or inconveniences to you. The research does not involve any physical or psychological risks to participation that might cause the researcher to terminate the study.

4. POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

As a classroom observation respondent, **you will not benefit from participation**; however, the potential benefits expected from the study are to improve curriculum design for IP mathematics teacher education.

5. PAYMENT FOR PARTICIPATION

As a classroom observation respondent, **you will not receive payment for participation**.

6. CONFIDENTIALITY

To ensure that the research is carried out with due consideration to ethical producers, the rights and identities of all participants in the study will be protected. Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. The participant has the right to review and edit the copies of the classroom observation schedules. Confidentiality will be maintained by means of numerically coding all completed classroom observation schedules and safely stored in the AIMSSEC safe, accessible to the researcher and Academic Director at AIMSSEC. The data will only be removed from the safe for recording, collation and transcription. The data will be kept until the degree has been awarded to the researcher, after which all data will be destroyed. To maintain confidentiality numerical codes will be used when publishing results of the study.

7. PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you don't want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so.

8. IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact
Principal Investigator: Miss Lindiwe Tshuma
Cell phone: 0795619424
Telephone: 0217879265
Address: African Institute for Mathematical Sciences Schools Enrichment Centre, 6 – 8 Melrose Road, Muizenberg, 7845
Email Address: Lin.Tshuma@gmail.com

Supervisor: Prof MLA Le Cordeur
Cell phone: 0828578067
Telephone: 0218082265
Address: Stellenbosch University, GC Cillie Building Room 4026, Private Bag X1 Matieland, 7602
Email Address: mlecorde@sun.ac.za

9. RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact Ms Maléne Fouché [mfouche@sun.ac.za; 021 808 4622] at the Division for Research Development.

SIGNATURE OF RESEARCH SUBJECT OR LEGAL REPRESENTATIVE

The information above was described to me by Lindiwe Tshuma in English and Xhosa and I am in command of this language or it was satisfactorily translated to me. I was given the opportunity to ask questions and these questions were answered to my satisfaction.

I hereby consent voluntarily to participate in this study. I have been given a copy of this form.

____
Name of Subject/Participant

______________________________________ ______________
Signature of Subject/Participant or Legal Representative **Date**

SIGNATURE OF INVESTIGATOR

I declare that I explained the information given in this document to ___________________ [*name of the participant]*. *[H*e/she] was encouraged and given ample time to ask me any questions. This conversation was conducted in *****English** *and ****Xhosa** and **no translator was used***.*

______________________________________ ______________
Signature of Investigator **Date**

Province of the
EASTERN CAPE
EDUCATION

STRATEGIC PLANNING POLICY RESEARCH AND SECRETARIAT SERVICES
Steve Vukile Tshwete Complex • Zone 6 • Zwelitsha • Eastern Cape
Private Bag X0032 • Bhisho • 5605 • REPUBLIC OF SOUTH AFRICA
Tel: +27 (0)40 608 4773/4035/4537 • Fax: +27 (0)40 608 4574 • Website: www.ecdoe.gov.za

Enquiries: NY Kanjana Email: nykanjana@live.co.za Date: 04 November 2016

Ms. Lindiwe Tshuma

65 Main Road

Muizenberg

Cape Town

7945

Dear Ms. Tshuma

PERMISSION TO UNDERTAKE DOCTORAL THESIS: RELATIONSHIP BETWEEN LANGUAGE COMPETENCY AND INTERMEDIATE PHASE MATHEMATICS INSTRUCTION – A CASE OF THE EASTERN CAPE PROVINCE [1]

1. Thank you for your application to conduct research.
2. Your application to conduct the above mentioned research at Head Office and 19 Schools including 50 Intermediate Phase Mathematics teachers of the Eastern Cape Department of Education (ECDoE) is hereby approved based on the following conditions:

   a. there will be no financial implications for the Department;

   b. institutions and respondents must not be identifiable in any way from the results of the investigation;

   c. you present a copy of the written approval letter of the Eastern Cape Department of Education (ECDoE) to the Cluster and District Directors before any research is undertaken at any institutions within that particular district;

   d. you will make all the arrangements concerning your research;

   e. the research may not be conducted during official contact time;

   f. should you wish to extend the period of research after approval has been granted, an application to do this must be directed to Chief Director: Strategic Management Monitoring and Evaluation;

[1] *To encompass the depth of the data collected and the multilevels analysis thereof: the examiners unanimously agreed to change the title of the study from Relationship between language competency and Intermediate Phase mathematics instruction: A case of the Eastern Cape Province*

to

Multiple levels and aspects of language competency in English and Intermediate Phase mathematics teachers: An analysis of case of the Eastern Cape Province

PGDP EASTERN CAPE

g. the research may not be conducted during the fourth school term, except in cases where a special well motivated request is received;

h. your research will be limited to those schools or institutions for which approval has been granted, should changes be effected written permission must be obtained from the Chief Director: Strategic Management Monitoring and Evaluation;

i. you present the Department with a copy of your final paper/report/dissertation/thesis free of charge in hard copy and electronic format. This must be accompanied by a separate synopsis (maximum 2 – 3 typed pages) of the most important findings and recommendations if it does not already contain a synopsis.

j. you present the findings to the Research Committee and/or Senior Management of the Department when and/or where necessary.

k. you are requested to provide the above to the Chief Director: Strategic Management Monitoring and Evaluation upon completion of your research.

l. you comply with all the requirements as completed in the Terms and Conditions to conduct Research in the ECDoE document duly completed by you.

m. you comply with your ethical undertaking (commitment form).

n. You submit on a six monthly basis, from the date of permission of the research, concise reports to the Chief Director: Strategic Management Monitoring and Evaluation.

3. The Department reserves a right to withdraw the permission should there not be compliance to the approval letter and contract signed in the Terms and Conditions to conduct Research in the ECDoE.

4. The Department will publish the completed Research on its website.

5. The Department wishes you well in your undertaking. You can contact the Director, Ms. NY Kanjana on the numbers indicated in the letterhead or email nelisakanjana@gmail.com should you need any assistance.

NY KANJANA
DIRECTOR: STRATEGIC PLANNING POLICY RESEARCH & SECRETARIAT SERVICES

FOR SUPERINTENDENT-GENERAL: EDUCATION

APPENDIX L: Approval to Conduct Research Stellenbosch University Research Ethics Committee

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jou kennisvennoot • your knowledge partner

Approval Notice

Stipulated documents/requirements

11-Nov-2016

Tshuma, Lindiwe L

Ethics Reference #: SU-HSD-002065
Title: **Multiple levels and aspects of language competency in English and Intermediate Phase mathematics teachers: An analysis of case of the Eastern Cape Province**

Dear Miss Lindiwe Tshuma,

Your Stipulated documents/requirements received on 20-Sep-2016, was reviewed and accepted.

Please note the following information about your approved research proposal:

Proposal Approval Period: 24-Mar-2016 - 23-Mar-2017

Please take note of the general Investigator Responsibilities attached to this letter.

If the research deviates significantly from the undertaking that was made in the original application for research ethics clearance to the REC and/or alters the risk/benefit profile of the study, the researcher must undertake to notify the REC of these changes.

Please remember to use your proposal number (SU-HSD-002065) on any documents or correspondence with the REC concerning your research proposal.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

We wish you the best as you conduct your research.

If you have any questions or need further help, please contact the REC office at .

Sincerely,

Clarissa Graham
REC Coordinator
Research Ethics Committee: Human Research (Humanities)

National Health Research Ethics Committee (NHREC) registration number: REC-050411-032.

The Research Ethics Committee: Humanities complies with the SA National Health Act No.61 2003 as it pertains to health research. In addition, this committee abides by the ethical norms and principles for research established by the Declaration of Helsinki (2013) and the Department of Health Guidelines for Ethical Research: Principles Structures and Processes (2nd Ed.) 2015. Annually a number of projects may be selected randomly for an external audit.

Investigator Responsibilities

Protection of Human Research Participants

Some of the general responsibilities investigators have when conducting research involving human participants are listed below:

1.Conducting the Research. You are responsible for making sure that the research is conducted according to the REC approved research protocol. You are also responsible for the actions of all your co-investigators and research staff involved with this research. You must also ensure that the research is conducted within the standards of your field of research.

2.Participant Enrolment. You may not recruit or enrol participants prior to the REC approval date or after the expiration date of REC approval. All recruitment materials for any form of media must be approved by the REC prior to their use.

3.Informed Consent. You are responsible for obtaining and documenting effective informed consent using **only** the REC-approved consent documents/process, and for ensuring that no human participants are involved in research prior to obtaining their informed consent. Please give all participants copies of the signed informed consent documents. Keep the originals in your secured research files for at least five (5) years.

4.Continuing Review. The REC must review and approve all REC-approved research proposals at intervals appropriate to the degree of risk but not less than once per year. There is **no grace period**. Prior to the date on which the REC approval of the research expires, **it is your responsibility to submit the progress report in a timely fashion to ensure a lapse in REC approval does not occur**. If REC approval of your research lapses, you must stop new participant enrolment, and contact the REC office immediately.

5.Amendments and Changes. If you wish to amend or change any aspect of your research (such as research design, interventions or procedures, participant population, informed consent document, instruments, surveys or recruiting material), you must submit the amendment to the REC for review using the current Amendment Form. You **may not initiate** any amendments or changes to your research without first obtaining written REC review and approval. The **only exception** is when it is necessary to eliminate apparent immediate hazards to participants and the REC should be immediately informed of this necessity.

6.Adverse or Unanticipated Events. Any serious adverse events, participant complaints, and all unanticipated problems that involve risks to participants or others, as well as any research related injuries, occurring at this institution or at other performance sites must be reported to Malene Fouche within **five (5) days** of discovery of the incident. You must also report any instances of serious or continuing problems, or non-compliance with the RECs requirements for protecting human research participants. The only exception to this policy is that the death of a research participant must be reported in accordance with the Stellenbosch University Research Ethics Committee Standard Operating Procedures. All reportable events should be submitted to the REC using the Serious Adverse Event Report Form.

7.Research Record Keeping. You must keep the following research related records, at a minimum, in a secure location for a minimum of five years: the REC approved research proposal and all amendments; all informed consent documents; recruiting materials; continuing review reports; adverse or unanticipated events; and all correspondence from the REC.

8.Provision of Counselling or emergency support. When a dedicated counsellor or psychologist provides support to a participant without prior REC review and approval, to the extent permitted by law, such activities will not be recognised as research nor the data used in support of research. Such cases should be indicated in the progress report or final report.

9.Final reports. When you have completed (no further participant enrolment, interactions or interventions) or stopped work on your research, you must submit a Final Report to the REC.

10.On-Site Evaluations, Inspections, or Audits. If you are notified that your research will be reviewed or audited by the sponsor or any other external agency or any internal group, you must inform the REC immediately of the impending audit/evaluation.

JET EDUCATION SERVICES

Education Hub,
6 Blackwood Avenue,
Parktown
Johannesburg
PO Box 178, Wits
2050
Tel +27 11 403 6401
Fax +27 11 339 7844
Email info@jet.org.za
www.jet.org.za

Transformation through Knowledge

Miss Clarissa Graham
Research Ethics and Committee Coordinator
Research Ethics and Committee: Human Research (Humanities)
Stellenbosch University
Private Bag X1, Maitland
Stellenbosch
7600

REFERENCE: Proposal # HSD - 002065

Name: Lindiwe Tshuma

Student Number: 19150458 - Faculty of Education, Department of Curriculum Studies

Doctoral Thesis Title: Relationship between language competency and Intermediate Phase mathematics instruction: A case of the Eastern Cape Province[1]

Dear Miss Graham

This letter serves to confirm that formal permission was granted to Ms Lindiwe Tshuma to make use of the JET Education Services (JET) tests which were developed and standardised for administration on qualified mathematics and English teachers specialising to teach the said subjects at the Intermediate Phase level in South African Schools.

The arrangement is that she will share the data with JET so that JET could maintain a bank of data that will be used to further analyse teacher performance on the tests.

Please note that this test is copyrighted, hence only Ms Tshuma has been given permission to use the tests, on condition that she does not distribute the tests with other interested parties, except with her immediate supervisor who in turn will respect the confidentiality of the tests and will not distribute them to any party whatsoever.

Attached is a copy of the non-disclosure form that was signed by Ms Tshuma.

Regards

Dr James Keevy

CEO

[1] **To encompass the depth of the data collected and the multilevels analysis thereof, the examiners unanimously agreed to change the title of the study from Relationship between language competency and Intermediate Phase mathematics instruction: A case of the Eastern Cape Province**

to

Multiple levels and aspects of language competency in English and Intermediate Phase mathematics teachers: An analysis of case of the Eastern Cape Province

APPENDIX N: Non-disclosure Agreement JET

JET EDUCATION SERVICES

NON-DISCLOSURE AGREEMENT

This Agreement is made between **Lindiwe Tshuma,** identity number **EN340112** (Zimbabwean Passport), of **African Institute for Mathematical Sciences Schools Enrichment Centre / PhD Student Stellenbosch University** (the Receiving Party), and JET Education Services, VAT number 4830188704, a company having its office at the Education Hub, 6 Blackwood Avenue, Parktown (the Disclosing Party). The Agreement involves the material exchange of confidential information and shall be effective from **18 September 2015.**

Introduction

The Receiving Party understands that the Disclosing Party has disclosed or may disclose confidential or otherwise sensitive information or material including, without limitation:

(i) The JET English and Mathematics Tests for Intermediate Phase School Teachers, and

(ii) any other confidential or otherwise sensitive information or material including, without limitation, know-how, processes, ideas and other technical, business, financial and product development plans, forecasts, strategies and/or information

which to the extent previously, presently, or subsequently disclosed to the Receiving Party, is hereinafter referred to as ..Confidential Information.. of the Disclosing Party.

The Parties accordingly hereby agree as follows:

1) The Receiving Party agrees and undertakes:

   (a) to hold the Disclosing Party's Confidential Information in confidence and to take all necessary precautions to protect such Confidential Information including, without limitation, all precautions the Receiving Party employs with respect to its own confidential materials;

   (b) not to divulge any such Confidential Information or any information derived there from to any third person; and

   (c) not to make any use of such Confidential Information, other than as agreed upon with or expressly authorised by the Disclosing Party in writing.

2) If the receiving Party is not sure whether certain information is Confidential Information or not, the receiving Party agrees to approach the disclosing Party about the nature of the information in question before taking any measures which might compromise the confidentiality of said information.

3) The Receiving Party shall hold in confidence all Confidential Information acquired from the Disclosing Party and shall not to any extent disclose it to any third parties without a written permission from the Disclosing Party, or as required by law. The obligation of non-disclosure shall cover the disclosure of information in any form, including but not limited to oral, written, and electronic forms.

4) The Disclosing Party agrees that the foregoing obligations shall not apply with respect to information that:

   (a) is in or becomes in the public domain without violation of this Agreement by the Receiving Party,

(b) is already rightfully in the possession of the Receiving Party, as evidenced by written documents, prior to the disclosure thereof by the Disclosing Party, or

(c) is rightfully received from a third entity having no obligation to the Parties and without violation of this Agreement by the Receiving Party.

5) Immediately upon a request by the Disclosing Party at any time, the Receiving Party will turn over to the Disclosing Party all Confidential Information of the Disclosing Party and all documents or media containing any such Confidential Information and all copies or extracts thereof and will promptly and permanently delete any Confidential Information which is electronically or optically recorded or stored.

6) The Receiving Party acknowledges and agrees that any breach of its obligations hereunder may allow the Receiving Party or third parties to unfairly compete with the Disclosing Party or otherwise result in irreparable harm to the Disclosing Party, and therefore, that upon any such breach or any threat thereof, the Disclosing Party shall be entitled to seek appropriate relief in law, including but not limited the claiming of damages. The Receiving Party will notify the Disclosing Party in writing immediately upon the occurrence of any such unauthorised release or other breach.

7) Neither party acquires any intellectual property rights under this Agreement or any disclosure hereunder, except the limited right to use such Confidential Information in accordance with this Agreement.

8) All provisions and the various clauses of this Agreement are, notwithstanding the manner in which they have been grouped together or linked grammatically, severable from each other. If any of the provisions of this Agreement are found to be unenforceable, the remainder shall be enforced as fully as possible and the unenforceable provision(s) shall be deemed modified or otherwise treated as *pro non scripta* to the limited extent required to permit enforcement of the Agreement as a whole.

9) This Agreement constitutes the entire agreement between the parties with respect to the subject matter hereof. No waiver or modification of this Agreement will be binding upon either party unless made in writing and signed by a duly authorized representative of such party, and no failure or delay in enforcing any right will be deemed a waiver. This Agreement shall be governed by the laws of the Republic of South Africa.

SIGNED AT Muizenberg, Cape Town ON THIS 18th DAY OF September 2015

M. CHAPWANYA

Witness

Lindiwe Tshuma

SIGNED AT Parktown ON THIS 18 DAY OF September 2015

Witness

For and on behalf of

JET Education Services

Teaching mathematics using English as a Language of Learning and Teaching (LoLT)

Grade	Teacher's 1st language	Learners' 1st languages				
		English	Afrikaans	isiXhosa	Other (Specify)	Total
Totals where applicable						
Topic of the lesson:						

Lesson description: ……

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Variables to be observed

1	**Language of instruction in mathematics lesson**: {language(s) used by the teacher to give instructions and ask questions}. Comment on the frequency English is used as the LoLT? …… …… ……
2	**Learner participation**: pupils' involvement in the learning activities, (focusing on the language(s) they use when talking amongst each other / when communicating with the teacher); or when participating in class activities. How are the learners using English in classroom activities? …… …… …… ……
3	**Specialised mathematics vocabulary**: What strategies does the teacher use to teach / explain specialised mathematics vocabulary for the concepts covered during the lesson? …… …… …… ……
4	**Chalkboard summary**: Comment on the language(s) the teacher use when writing on the chalk board during the lesson. …… ……

	……………………………………………………………………………………………………… ………………………………………………………………………………………………………
5	**Learning and teaching resources**: Comment on any textbooks, DBE workbooks, or other audio visual learning and teaching resources written in English used during the lesson? .... ……………………………………………………………………………………………………... ……………………………………………………………………………………………………… ………………………………………………………………………………………………………
6	**Classroom environment:** Are there any charts / word walls around the classroom which indicate that mathematics is taught in English? .... ……………………………………………………………………………………………………... ……………………………………………………………………………………………………… ………………………………………………………………………………………………………

General comments:
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