

**THE EFFECT OF THE FAMILY MATHS INTERVENTION PROGRAMME
ON THE SCHOOL COMMUNITY**

BY

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In

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School of Education Studies
Faculty of Education**

UNIVERSITY OF THE FREE STATE

.

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Co-promoter: Dr Cobus van Breda

May 2021

DECLARATION

I, **Sibongile Beje**, declare that the thesis, **The effect of the Family Maths intervention programme on the school community** submitted for the qualification of **Doctor of Philosophy** at the University of the Free State, is my own independent work, done with the support of my promotor and co-promotor.

All the references that I used have been indicated and acknowledged by means of complete references.

I further declare that this work has not previously been submitted by me at another university or faculty for the purpose of obtaining a qualification.

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S Beje

14 September 2021

Date

ETHICS STATEMENT



Faculty of Education

24-Apr-2018

Dear Mr Sibongile Beje

Ethics Clearance: The effect of the Family Mathematics programme on the perceptions of a school community towards mathematics

Principal Investigator: Mr Sibongile Beje

Department: School of Education Studies (Bloemfontein Campus)

APPLICATION APPROVED

With reference to your application for ethical clearance with the Faculty of Education, I am pleased to inform you on behalf of the Ethics Board of the faculty that you have been granted ethical clearance for your research.

Your ethical clearance number, to be used in all correspondence is: **UFS-HSD2017/1007**

This ethical clearance number is valid for research conducted for one year from issuance. Should you require more time to complete this research, please apply for an extension.

We request that any changes that may take place during the course of your research project be submitted to the ethics office to ensure we are kept up to date with your progress and any ethical implications that may arise.

Thank you for submitting this proposal for ethical clearance and we wish you every success with your research.

Yours faithfully

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LANGUAGE EDITING

To whom it may concern

This is to state that the PhD study by Sibongile Beje titled "*The Effect Of The Family Maths Intervention Programme On The School Community*" has been language edited by me, according to the tenets of academic discourse. The final responsibility to implement any suggested language changes resides with the student.

Annamarie du Preez

A handwritten signature in cursive script, appearing to read 'Annamarie du Preez'.

B.Bibl.; B.A. Hons. (English)

17-06-2021

ABSTRACT

The persistent poor performance in Mathematics in the province of the Eastern Cape, South Africa, despite various interventions to alleviate its adverse effects, stimulated my interest in this study. I was particularly interested in understanding the effect of involving families in primary Mathematics education as an intervention rolled out by the University of the Free State in selected schools in the OR Tambo Education District. While literature revealed that such interventions are not always successful, the S4F FM (Science for the Future Family Math) programme rolled out by the University of the Free State had never been independently evaluated for its effect on the school communities' perceptions and learners' achievement marks in Mathematics. Thus, the dearth of knowledge of the efficacy of the S4F FM programme, despite the human, time and financial investments, was the gap I identified.

The overall aim of this study was to *explore and describe the changes brought about through an S4F FM programme in a rural school community in South Africa*. While I conducted the enquiry predominantly using qualitative methodologies, I also employed quasi-experimental research design strategies to triangulate and enhance confidence in the findings and conclusions of the study.

I used the assumptions of the pragmatism paradigm, namely that one should use a range of techniques to develop a clearer understanding of complex social issues, in order to guide the elements of this research enquiry. The first of these elements was to find a theoretical framework, which dealt with the perceptions of family involvement into children's education, and the alignment of school, home and community for optimal learning. The Hoover-Dempsey and Sandler (1997) and Epstein and Sanders (2006) models, as well as Vygotsky's Sociocultural theory and constructivism, served the purpose of framing the enquiry. In sum, the conceptual framework for this study recognises the centrality of the school both socially and academically speaking. It seeks harness this positioning for facilitating family involvement and learners' cognitive development, leading to the outcomes of attitudes, perceptions, and performance.

In the literature review, I demonstrated that the social context of the study area is characterised by teenage pregnancy, economic imperatives of temporary migration, HIV and AIDS-accelerated orphanhood. These all motivate for the adoption of the concept of family involvement rather than parental involvement. The background to the origins of the Family Math reveals that it was started as response to the observed lack of participation and achievement in Mathematics by minority groups, including women, in the USA. The literature study also highlighted the importance of school-to-home communication for optimal Mathematics education. Proper communication between the two spheres, school and home, facilitates family support and promotes positive perceptions about Mathematics. Improved children's and family members' perceptions are associated with higher achievement marks in the subject. Beliefs about what a family member should do to support a child's education (role construction), family members' perceptions about their abilities (self-efficacy), and perceptions of invitations from the school, are some of the psychological factors influencing family members' decision to become involved in a child's education. These factors are, in turn, affected by multiple factors such as socioeconomic situations, traditions and cultural background.

In line with the pragmatist view, I took a mixed methods approach to conduct this research. I specifically I used the sequential mixed methods, beginning with qualitative, followed by quantitative and ending with qualitative methods again. In the first qualitative part of the research, I interviewed three S4F FM programme staff members to understand the background to the programme. The Mathematics marks from 16 primary schools that participated in the S4F FM programme in the OR Tambo District of the Eastern Cape constituted the data for the quantitative aspect of the study. In the second qualitative part of the study, I conducted focus group interviews with 24 family members, 13 teachers and 36 learners, from three different schools.

The results of the exploration of the background to the S4F FM programme revealed that the programme, since its introduction more than 20 years ago, has been adopted, implemented and adapted. It continues to evolve and expand, while adhering to the basic tenets upon which the parent programme was founded. These tenets include improvement of participation and

performance in Mathematics for the marginalised groups.

Regarding learners' performance in Mathematics, the study found that participation in the S4F FM programme significantly improved learner achievement marks in Mathematics. The study further revealed that the intervention has a cascading effect, as the improved performance is experienced in grades beyond the grades of intervention. Lastly, the analysis of marks also revealed that other community-based variables affect performance in Mathematics.

Regarding the perceptions of the school community towards Mathematics education, the study revealed that the activities of the S4F FM intervention programme helped the rural Eastern Cape school community to favourably perceive Mathematics education. When viewed together with outcomes of the analysis of achievement marks in Mathematics, the results suggest that improving the school communities' perception ultimately leads to improved learner achievement in the subject.

In conclusion, the integration of analyses from the study revealed that the communities' socioeconomic situation, levels of community educational attainment and the language transition from the foundation to intermediate phases of primary education have the greatest effect on learners' Mathematics achievement marks. The recommendation that flowed from this study was that role players, including the State and Commerce, need to deliberately promote and support programmes that foster family involvement in children's education. The different spheres of government and different departments need to integrate school development.

Key words: Family Math, Mathematics primary education, school community perceptions, propensity score matching

ISISHWANKATHELO

Ukungaqhubi kakuhle okuthe rhoqo kwizibalo kubafundi bephondo lwe Mpuma Koloni, nangona kukho amangenela wokukhwebula imiphumela emibi yoku, kuko okuvuselele umdla wam kolu phando. Umdla wam ubusekuphuhliseni imiphumela yokungenelela kwamakhaya kwimfundo yabantwana besithili sase OR Thambo nanjengoko oko kuthazwa yi Dyunivesi yase Free State. Ukunqaba kolwazi ngemiphumela yalengqubo ye Dyunivesi yase Free State kuko endizakuphanda ngako.

Eyona njongo iphambili ngolu phando ibikukuphuhlisa kwaye ndichaze utshintsho oluvezwe yinkqubo yeDyunivesi yase Free State kufundo lwezibalo. Ndaye ndasebenzisa uphando lwezimvo nolwenkcukacha manani ukufezekisa le njongo.

Iingcinga ngobume benyaniso no bolwazi ngokwezimvo ze constructivism zizo endaye ndazisebenzisa njengomgqaliselo wokuseka amabakala wokuphanda. Ibakala lokuqala ibe sisisekelo se thiyori ngendlela amakhaya nabantwana ababona ngayo imfundo. Iithiyori zoo Hoover-Dempsey and Sandler 1997, Epstein and Sanders 2006, Vygotsky's Sociocultural zizo ezindinike esi siseko. Ekugqibeleni, ngokwe thiyori yolu phando, isikolo siso esise sazulwini ngokwezintlalo nezemfundo ekukhuthazeni amakhaya ukuze athathe inxaxheba ekufundeni kwabantwana. Imiphumela yoku kukukhula kwabafundi ngolwazi, utshintsho kwindlela ebonwa ngayo imfundo nakwiziphumo zemfundo.

Ingqwalasela kuphando lwangaphambili lubonakalisa ezintlalo kule ndawo yolu uphando abantwana abasuki kwintsapho kncasana, koko basuka kumakhaya apho bekhuliswa zizihlobo. Oko kokholele ekubeni ndisibenzise ingqiqo yamakhaya athatha inxaxheba indaweni yabazali abathatha inxaxheba kufundo lwabantwana. Uphando lwangaphambili lukwabonakalisa uku intethontethwano phakathi kwesikholo namakhaya wabafundi kukho okukhuthaza iimbono zintle ngemfundo zitsho zikhokelekwi kwiziphumo ezintle zofundo. Okwesibi, ingqiniseko ngokufenelekielyo ukuba bankwenze, abangakwenza ngempumelelo kunye nendlela iinstapho ezibona ngayo izimemo ezusuka eskolweni zizo ezithatha inxaxheba kwisigqibo selungu losapho ekubeni lithathe inxaxheba kufundo lomntwana. Imeko

yophuhliso, izithethe namasiko ziyasichaphazela isigqibo sokungenelela kwamalungu osapho kwezemfundo.

Ukwenza olu phando ndisebenzise umxube we wentolazimvo kunye nkcukacha manani ezenzeka ngaxeshanye. Kwintlobo zimvo ndenze udlowanondlebe neendidi ezintathu zabantu. Eyokuqala yabangabesenzi abathathu be S4F FM programme. Okwesibini yaba ngamalungu eentsapho a 24, ze ndagqibela nge 13 yootishala. Kwinkcukacha manani ndisebenzise amanqaku wabafundi kwezezibalo asuka kwizikolo ezi 16 ezazithatha inxaxheba kwi S4F FM programme. Ezi zikolo zicatshulwe kwezi 250 zesithili sase Mthatha (eseli siyinxalenya ye yesithili sase OR Tambo sephondo lwe Mpuma Koloni)

Uphando ngemvelaphi ye S4F FM lufumanise ukuba le nkqubo ikwazile ukuzinza kweli emva kweminyaka e 20 yabakho kweli ngenxa yokuba ngamaxesha onke iyalungiselelwa ukuba ilungelelane namaxesha, neemeko kunye nemigaqo karhulumente.

Iziphumo zoluphando zibonakalisa ukuba inkqubo ye S4F FM ibenemiphumela emihle kumanqaku wabantwana wezifundo zezibalo. Iziphumo zentlobo zimvo lona lobanakalise ukuba le nkqubo ye S4F FM iphuculo indlela uluntu lwesikolo elibona ngayo ufundo lwezibalo. Zombini izenkqubo zophando, inkcukacha manani nentlobo zimvo ziyangqinelana kwelokuba imo yokuziswa keenkonzo eluntwini nophuhliso ziyayichaphazela indlela amalungu osapho axhasa ngalo ezemfundo. Okwesibini Utshintsho lolwimi lokufunda nokukundisha ukusuka kwi Foundation Phase ukuya kwi Intermediate phase liyichapazela kakubi amanqaku wabafundi. Okokugqibela, inqanaba lemfundo kuluntu apho abafundi abaphuma kulo linonxumelelwano kwindlela abafundi abaqhuba ngayo kufundo lwezibalo.

Isigqibo solu phando sesokuba isisombululo seengxaki zofundo lwe zibalo alufumaneki kumasango wesikolo nakumagumbi wokufundisela kuphela, koko umgaqo-nkqubo wezemfundo, uphuhliso loluntu yeminye yimiba emayiqwalaselwe kakhulu. Ingcebiso esuka kolu phando yeyokuba urhulumente makabeyo indlela yokuxhasa iinkqubo ezikhuthaza abazali ukuba baxhase imfundo yabantwana babo. Okwesibini. Amasebe karhulumente mawadibanise iinzame zokuphuhlisa uluntu ngeenjongo zokuphucula ufundo nofundiso ezikolweni.

LIST OF ACRONYMS

ABSA: Amalgamated Banks of South Africa
AIC: Akaike information criterion
AIDS: Acquired immunodeficiency syndrome
ANA: Annual National Assessments
ATT: Average Treatment Effect on Treated
BODMAS: Brackets, Orders, Division/Multiplication, Addition/Subtraction
CAPS: National Curriculum and Assessment Policy Statement
CBD: Central business district
COUNT: Cooperative Organisation for the Upgrading of Numeracy Training
DBE: Department of Basic Education
DBST: District Based Support Teams
DF: Degrees of Freedom
ECD: Early Childhood Development
EMIS: Education Management Information System
EUP: Edinboro University of Pennsylvania
FET: Further Education and Training
FM: Family Math
GET: General Education and training
GLM: generalized linear model
HIV: Human Immunodeficiency Virus
HSRC: Human Sciences Research Council
IEA: Evaluation of Educational Achievement
IIEP: International Institute for Educational Planning
JICA: Japan International Cooperation Agency
LM: linear model
LMM: linear mixed models
LTSM: Learning and Teaching Support Material
MATH: Mathematics

MST: Maths, Science and Technology Schools Improvement
NCS: National Senior Certificate
NECT: National Education Collaboration Trust
NGO: Non-governmental organizations
NICLE: Numeracy Inquiry Community of Leader Educators
NSC: National Senior Certificate
OBE: Outcomes Based Education
ORTC: OR Tambo Coastal
ORTI: OR Tambo Inland
PS: Propensity Score
PSM: Propensity Score Matching
QUAL: Qualitative Research Methodology
QUANT: Quantitative Research Methodology
R:Statistical programming language
RIEP: Research Institute for Education Planning
S4F:Science for the Future
SACMEQ: Southern and Eastern Africa Consortium for Monitoring Educational Quality
SAIDE: South African Institute for Distance Education
SANRAL: South African National Roads Agency
SAQA: South African Qualifications Authority
SASAMS: South African School and Administration Management System
SGB: School Governing Body
SOL: School of Open Learning
TIMSS: Trends in International Mathematics and Science Study
UNESCO: United Nations Educational, Scientific and Cultural Organization
UNISA: University of South Africa
USA: United States of America
USAID: United States Agency for International Development
WMC: Wits Maths Connect–Primary project
PD: Zone of Proximal Development

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DEDICATION

Ndilunikezela ngentliziyo yam yonke olu phando kubazali bam, umama uMafakazi no tata uMfana Beje, ongasekhoyo, abaye bazinikela ekundifundiseni nangona babengafundanga bona, amandla wokundifundisa bengenawo, nemfundo ingeyiyo into ebalulekileyo kwindawo nexesha sasiphila kunye nabo.

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CHAPTER 1: AN OVERVIEW OF THE STUDY

1.1 INTRODUCTION

Mathematics education in the primary phase of the South African education system, as many researchers have observed, is failing to provide learners with the requisite skills and knowledge on the subject (Heyd-Metzuyanim & Graven, 2015: 351; Ally & Christiansen, 2013: 50; Spaull, 2013a: 17). An analysis of standardised assessments, from national to international levels, demonstrates this failure. First of these, at the international level, is the *Trends in International Mathematics and Science Study* (TIMSS) (Mullis, Martin, Foy & Hooper, 2016: 1), which has been written every four years since 1995. The second is the evaluation of the *Southern and Eastern Africa Consortium for Monitoring Educational Quality* (SACMEQ) at the regional level (Moloi & Chetty, 2011: 1; Spaull, 2011: 43), which was last written in 2013. Lastly is the *Annual National Assessments* (ANAs) (Van der Berg, 2014: 14; DBE, 2014b: 1) at the national level. Learners from South Africa tend to perform poorly in these international and regional assessments, when compared to their counterparts from around the world. In the case of local assessments, learners also predominantly underperform in ANAs, particularly in Grade 9.

As a result of poor learner performance in Mathematics in South Africa, many intervention programmes have been undertaken to improve learner achievement scores in assessments (Askew, Venkat, Barmby, Hansa, Mathews, Morrison & Ramdhany, 2018: 180; Stott & Graven, 2015: 315; Ndlovu, 2011: 420). Some intervention programmes are state-sponsored, as outlined in the *Report on the annual national assessments 2012* DBE (2012: 14). Others involve the Department of Basic Education in partnership with another entity (DBE, 2013: 13) or are sponsored privately. Examples of partnership programmes include The Rhodes University Mathematics Education Project (RUMEP), which is an outreach programme of Rhodes University and covers schools in the Eastern Cape (EC). The Wits Maths Connect-Primary project (WMC-P) by Wits University in Gauteng is another example of a privately sponsored intervention programme (Askew et al., 2018: 181). The University of Pretoria in Gauteng also hosts the Teacher Mentorship Programme, which has been running from 2004 (TMP) (Fricke, Horak, Meyer & Van Lingen, 2008: 65) to date (Ogude, Mathabathe, Mthethwa & White, 2020: 44), specifically in the townships of one of the capital cities of South Africa, Pretoria. However, the multiplicity of these intervention

programmes and their longevity are in stark contrast with the reported challenges in Mathematics education in South Africa. In fact, Fricke et al. (2008: 65) state that a review of many reports of intervention programmes aimed at learner intervention indicates limited success. The focus of this study is therefore to explore the effect of an intervention programme by the University of the Free State (UFS) in the rural schools of the Eastern Cape.

This programme is called Family Math (FM), and resorts under an umbrella body called Science for the Future (S4F), run by the University of the Free State. In this thesis, I refer to the programme as S4F FM. This study seeks to understand the effect of the S4F FM intervention programme with respect to two main elements, namely 1) learners' achievements and 2) the perception of Mathematics by stakeholders. I start by exploring the background to the programme, specifically related to its philosophy and objectives during implementation. Secondly, I analyse the effect of exposure to the programme on learners' achievement in Mathematics. Thirdly, the effects of the programme on the perceptions regarding Mathematics by learners, teachers and children's family members are explored. However, the learners' performance in Mathematics in the primary phase in South Africa, and the context of study area in particular, need further interrogation in this study. In the background section, I situate the S4F FM in the context of learner performance in Mathematics in the specific study area, namely the OR Tambo Education District (formerly Mthatha District), which is one of 12 in the Eastern Cape province of South Africa.

1.2 BACKGROUND

In this section I bring to the fore certain aspects of Mathematics education in South Africa, the Eastern Cape province and the OR Tambo District in order to highlight the context of the study area. In particular, I depict and explain the Mathematics achievement scores by South African learners in international, regional and local evaluations. The explanation sheds light on the underachievement and the need for intervention. The discussion on performance in Mathematics by South African learners, for the purposes of clarity, is divided into international and regional levels on the one hand, and local assessments on the other.

1.2.1 PERFORMANCE IN MATHEMATICS AT INTERNATIONAL AND REGIONAL LEVELS

International studies show that South Africa's Mathematics education compares poorly to that of other countries around the world. In this study I consider two international comparative studies in which South Africa participates, namely the World Economic Forum (WEF)'s Global Competitive Reports, and the TIMSS. I also pay attention to the regional SACMEQ assessments.

1.2.1.1 WORLD ECONOMIC FORUM

South Africa placed last in two consecutive World Economic Forum Global Competitive Reports on the quality of Mathematics and Science Education (Schwab, 2016: 317; Schwab, 2015: 459). The 2015 and 2016 reports rank South Africa on Maths education at 144 out of 144 and 140 out of 140 countries respectively. It would seem that the WEF has since ceased to assess South Africa on the quality of Mathematics and Science education (Schwab, 2019: 14). It is not clear whether this discontinuation is a result of the protest by South Africa's Department of Basic Education (DBE). The DBE issued a media statement challenging the credibility of the reports by the World Economic Forum (DBE 2014c.). The DBE argue that the rankings are not based on empirical research or the actual testing of learners.

The placing of countries on the WEF competitive index on the quality of Mathematics and Science education is based on a survey of the local business community. The survey question is "*In your country, how would you assess the quality of math and science education in schools?*" (Schwab, 2016: 317; Schwab, 2015: 459). The DBE contends that the survey is subjective. However, TIMSS, which involves the measurement of learners' competencies, imply concurrence with the perceptions of the business community as reported in the World Economic Forum.

1.2.1.2 TRENDS IN INTERNATIONAL MATHEMATICS AND SCIENCE STUDY

TIMSS was developed by the International Association for the Evaluation of Educational Achievement (IEA) to assess Grades 4 and 8 learners' competencies in Mathematics and Sciences from voluntarily participating countries around the world (Reddy, Prinsloo, Arends, Visser, Winnaar, Feza & Ngema, 2012: p.2) outline the chronology of administering o TIMMS in South Africa from 1995 to 2011. TIMSS was administered in 1995 and 1999 to

Grade 8 learners. In 2002 it was applied to Grade 8 and 9 learners, and to Grade 9 learners in 2011. In 2015 it was administered to Grades 5 and 9 learners (Mullis et al., 2016: 1), and to the same grades again in 2019 (Mullis & Martin 2020, p.18).

An examination of the TIMSS reports shows that South Africa has a history of poor performance in Mathematics as it was the lowest out of 50 participating countries in 2003 (Heyd-Metzuyanim & Graven, 2016: 351). In 2011, Grade 9 learners' performance in TIMSS assessments was below the international low benchmark of 400 (Reddy et al., 2012: 3). In TIMSS, 2015 both Grade 5 and 9 learners achieved below this benchmark at 376 and 372 in the subject, respectively (Reddy et al., 2015: 5). While the TIMSS 2015 performance shows a slight improvement when compared to previous tests, South Africa was still in the category of 11 out of a total of 42 participating countries that performed below the low international benchmark of 400 (Reddy et al., 2012: 4).

Even worse for the country is the fact that South Africa is in a group of three countries that agreed to administer the Grade 8 assessments to Grade 9, as the Grade 8 assessments were deemed to be too difficult (Martin et al., 2011: 36). In effect, the observed South African Grade 9 performance is based on a Grade 8 assessment (Martin et al., 2011: 36). South African learner's performance in TIMMS therefore gives credence to claims of systemic failure to provide optimum Mathematics education (Heyd-Metzuyanim & Graven, 2015: 351; Ally & Christiansen, 2013: 50; Spaul, 2013a: 17). It further warrants some form of intervention if improvement is to be realised.

1.2.1.3 SOUTHERN AND EASTERN AFRICA CONSORTIUM FOR MONITORING

EDUCATIONAL QUALITY

SACMEQ, a regional assessment body, is a consortium of the education ministries of 14 countries in the Southern and Eastern parts of Africa (Spaul 2013a, p.3). The consortium's primary mission, in collaboration with UNESCO's International Institute for Educational Planning (IIEP), is to provide the basis on which educational improvement, through integrated research, can be attained (Kaur & Singh, 2020: 3993). Literacy and numeracy were identified as key indicators that would produce such a basis. During a SACMEQ assessment project, a representative sample of Grade 6 learners from each of the participating countries is tested for their numeracy and literacy skills (Spaul, 2011: 6). So

far, four SACMEQ projects have been undertaken since the launch of the consortium in 1995, namely SACMEQ I, II, III and IV (Kaur & Singh, 2020: 3993).

Notwithstanding the slight improvement in performance from SACMEQ II of 2000 to SACMEQ III of 2007, South African Grade 6 Mathematics pupils performed below the SACMEQ III average score of 509.7 at 494.8 (Moloi & Chetty, 2011: 3). At this score, South African learners performed below their counterparts from the neighbouring Zimbabwe, Botswana and the former Swaziland (now Eswatini) (Spaull, 2011: 46). A similar scenario prevailed in SACMEQ II, where the score by South African Grade 6 pupils (486) was below the average SACMEQ II (500) score (Moloi & Chetty, 2011: 5).

However, Grade 6 learners from South Africa phenomenally improved, by a margin of 57, in the scores of SACMEQ IV of 2013 from those of SACMEQ III (Moloi & Chetty, 2017). Spaull (2016: 1) has raised some serious concerns about the credibility of these results, which emanate from the incomparable methodologies between SACMEQ III and SACMEQ IV. Further, despite the observed improvements, there remains an incongruence between learners' chronological ages and expected mathematical competencies, with the latter lagging behind (Aunio, Mononen, Ragpot & Törmänen, 2016: 2). Therefore, the SACMEQ results seem to correlate with those of TIMSS and further strengthen the claim of systemic failure of the education system in South Africa (Heyd-Metzuyanim & Graven, 2015: 351; Ally & Christiansen, 2013: 50; Spaull, 2013a: 17). Using the latest regional assessment, SACMEQ IV, I focused on the Eastern Cape province where the study area, OR Tambo Education District is located. In the section below, I highlight the context of Mathematics education in this province.

1.2.1.4 EASTERN CAPE PROVINCE PERFORMANCE IN SACMEQ

The Eastern Cape is behind other provinces on key SACMEQ performance indicators, according to the DBE report on SECMEQ IV (DBE, 2017: 27). For instance, the province obtained the second lowest score of 525,4 in SACMEQ IV, after Limpopo, which suggests that the Eastern Cape is amongst the provinces that are responsible for the observed South African poor performance in regional assessments (Heyd-Metzuyanim & Graven, 2015: 351; Ally & Christiansen, 2013: 50; Spaull, 2013a: 17). As could be expected, given the SACMEQ IV score, the province has the highest (7.9) non-numerate learners in the country (number of learners failing to acquire even the most basic numeracy skills) in Grade 6 (DBE,

2017: 27). Issues of poor Learning and Teaching Support Material (LTSM) provisioning may be partly responsible for this. For instance, the lowest score (57.2%) of learners who do not share a Mathematics textbook with other learners is found in the Eastern Cape. A further look at the DBE report on SECMEQ IV (DBE, 2017: 27) reveals that the basis for poor learner scholastic achievement can be found in a lack of necessary infrastructure and communities' low socioeconomic levels.

Regarding infrastructure, the highest percentage of Grade 6 learners who have to walk the greatest distances to schools is found in the province. In addition, the second highest number of learners without preschool exposure is found in the Eastern Cape, mainly because the children are too young to walk the long distances to school. Another indicator of poor infrastructure in the province is that 4% percent of Grade 6 learners, the highest in the country, use paraffin as the main source of lighting at home. This suggests a lack of electricity in the affected homes. Regarding communities' socioeconomic background, the Eastern Cape is in the bottom three provinces where parents pay for extra tuition for their children, suggesting that family members have little disposable income to spend on the education of their children. At 18.2%, the province also has the highest percentage of learners who reported that English, the language of teaching and learning for most learners, is never spoken at home, which may suggest low education levels of children's family members. Given these LTSM, infrastructure and community socioeconomic issues, it is not surprising that the province has the highest repetition rate (16.2%) in Grade 6 in the country. It is my considered view that the OR Tambo District, being a largely rural district, is no exception to these observations made about the province.

I must state that the main drawback of these international and regional assessments is that they lack currency. This prevents me from commenting on the current situation regarding learner performance in Mathematics. The lack of updated reports is also true for the standardised local assessments (ANAs), which were discontinued from 2015.

1.2.2 PERFORMANCE IN PRIMARY MATHEMATICS IN LOCAL ASSESSMENT

I must state upfront that I used the ANA results with caution, given the time lapse since the last ANAs was administered (2014) and concerns about the lack of precision criticism (Van der Berg, 2014: 14) against these assessments. The DBE (2014b, p. 36) also admits that the ANAs had some deficits in test design, which limits comparison across years. Locally,

learners' competencies in numeracy and literacy in the General Education and Training (GET) band, which is Grades 1 to 9, were tested using the Annual National Assessments (ANAs), from 2012 to 2014 (DBE 2014b, p.7).

These assessments were the only nationally standardised tests that measured progress in learner performance in the GET (DBE 2014b, p.7). In each year, the ANAs comprised of two categories. The first category was made up of Grades 1 to 6 and Grade 9 learners in all public schools and private schools benefiting from a state subsidy, writing school supervised ANAs, which were called universal ANAs (DBE 2014b, p.7). The second category was made up of a representative sample of schools at the exit grades of each phase, namely Grades 3, 6 and 9, writing the ANA tests under the supervision and monitoring of an independent agent, which was called the verification ANA (DBE 2014b, p.7). The results from the verification ANAs were used to confirm the dependability of the universal ANAs. There were no marked differences between the two (DBE, 2014b, p. 35).

Figure 1-1 illustrated the pass percentages over the three-year period that the ANAs were written, in negative chronological order for the OR Tambo District, the Eastern Cape Province, and nationally. The results show that except for Grade 3, there was a general poor performance in Mathematics in the District, province and nationally. The District Grade 6 learners' performance in the subject was below the national average for all the three years of ANAs, and differed minimally from that of the province. This observation is consistent with the performances reported in the SECMEQ IV of 2013, which also assessed Grade 6 learners (cf. 1.2.1.4) and depicts a comparatively low performance by learners in the Eastern Cape, as is the case with SECMEQ IV of 2013 DBE (2017: 27).

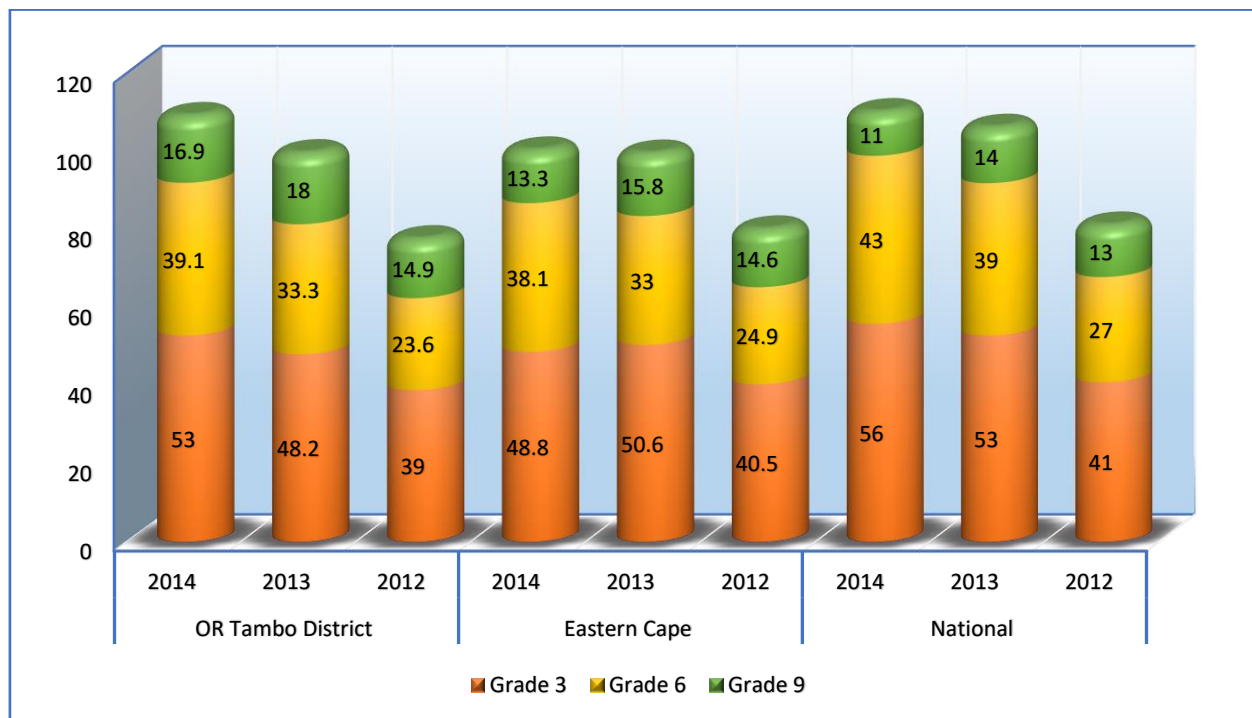


Figure 1-1: Average Mathematics percentage marks from ANAs for Grades 3, 6 and 9 between 2012 and 2014, inclusive.

Overall, there are three interesting observations that are evident from the performance trends (cf. Figure 1-1). The first is that in the Eastern Cape and OR Tambo Education District, beyond the Foundation Phase (Grades 1 -3), the average percentage marks in Mathematics never reached 40% for all three years of ANAs and all levels. Secondly, the results show a declining learner performance trend with increasing grade level to Grade 9. That is, the best performance is observed in Grade 3 and the worst in Grade 9. Thirdly, Grade 9 average percentage marks had been consistently below 20%, across the years for the OR Tambo Education District, the Eastern Cape as well as nationally. Interestingly, the National Senior Certificate (NSC) Examination results show more improved pass percentages in Mathematics Grade 12 learners' performance compared to Grade 9 learners in the ANAs. NSC is a secondary school-leaving certificate on which institutions of higher learning base their selection of students in South Africa. It is written by Grade 12 learners.

1.2.3 THE NATIONAL SENIOR CERTIFICATE AND ANAS CONTRAST

The NSC examinations are written during the months of October and November of every year, and the results are usually released early in January of the following year. I factored in the NSC here in an attempt to establish whether the poor performances in the primary

phase are carried through to NSC and so to draw inferences about the choices learners make when given an opportunity select either Mathematics or Mathematical Literacy in secondary school. To make these inferences I analysed a cross-sectional view followed by longitudinal analysis of the performance in ANAs and NSC.

1.2.3.1 A CROSS-SECTIONAL VIEW OF ENROLMENT AND PERFORMANCE TRENDS IN MATHEMATICS

The pass percentages from a cross-sectional view, based on the 2014 ANAs (DBE, 2014b: 60) and NSC (DBE, 2014a: 7) for Grades 9 and 12, respectively, suggest a great improvement in Mathematics performance for Grade 12 when compared to Grade 9 learners, as shown in Figure 1-2. The improvement was evident for the national, Eastern Cape and OR Tambo District levels. In contrast, the learner enrolments in Mathematics at national and provincial level seem to suggest that the majority of learners choose Mathematical Literacy over Mathematics when it becomes an elective in Grade 10 (cf. Figure 1-2).

According to the Curriculum Assessment and Policy Statements (CAPS), a policy document of DBE, Mathematics is compulsory in Grades 1 - 9 and learners can choose either Mathematics or Mathematical Literacy in Grade 10 (DBE, 2012). In the OR Tambo District, more learners chose Mathematics than Mathematical Literacy (cf. Figure 1-2). These observations on performance and enrolment seem to be upheld in longitudinal analysis.

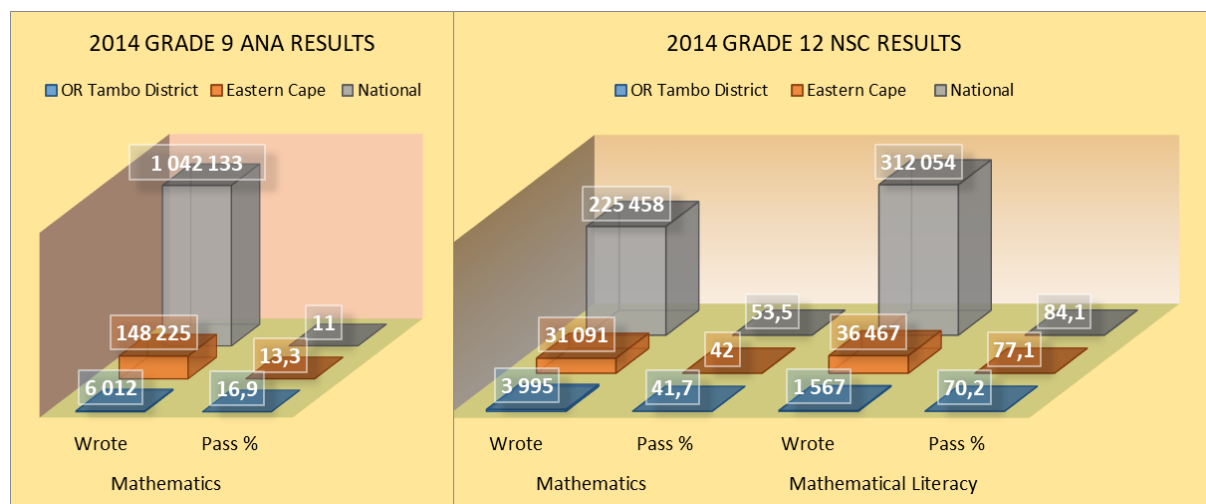


Figure 1-2: Total number of Grade 9 and 12 learners from District, Province and National levels who wrote and passed Mathematics and Mathematical Literacy in 2014 (cross-section).

1.2.3.2 LONGITUDINAL VIEW OF ENROLMENT AND PERFORMANCE TRENDS IN MATHEMATICS

In this section, I track enrolment and performance trends by comparing the 2014 Grade 9 ANA results and the 2017 NSC Grade 12 results (cf. Figure 1-3) of the district, province and national figures. I started from the premise that the Grade 9 learners of 2014 were more or less the same learners who went on to write the Grade 12 NSC in 2017. Therefore, the data comes from the same group of learners, but at different times, thereby constituting a longitudinal view (Cohen, Manion & Morrison, 2007: 142). I, however, treat this assumption with caution, given the high repetition and dropout rates in the country (Van der Berg, Wills, Selkirk, Adams & Van Wyk, 2019: 25; Grossen, Grobler & Lacante, 2017: 2).

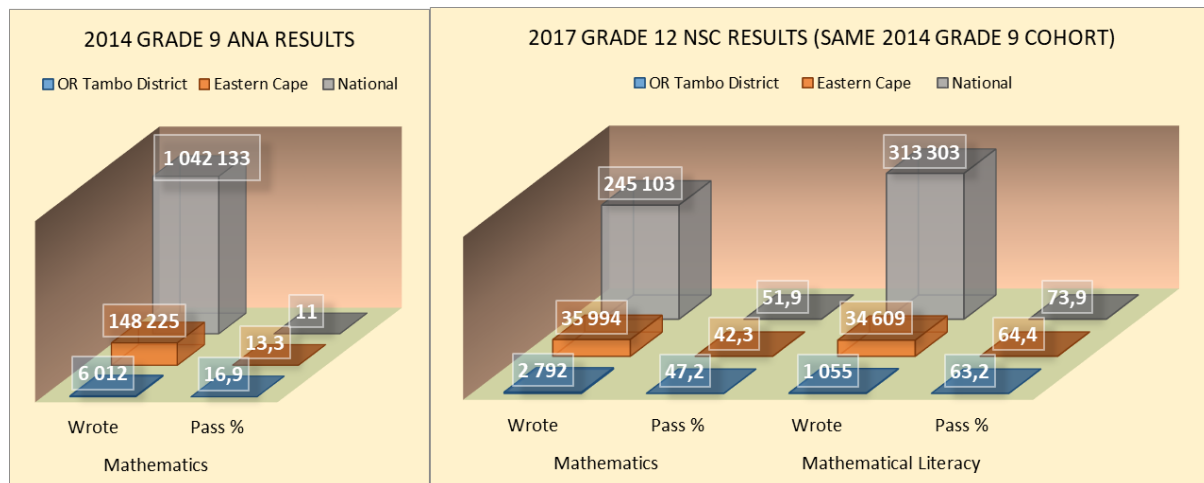


Figure 1-3: Total number of Grade 9 and 12 learners on District, Province and National levels, who wrote and passed Mathematics in the 2014 ANAs and Mathematics in the 2017 NSC (longitudinal) .

The observation from tracking the same cohort of learners in Grade 9 and again in Grade 12 is that except for the fact that more of the Grade 9 learners of 2014 went on to write NSC Mathematics in 2017 at the provincial level, contrary to the cross-sectional view (cf. 1.2.2.1), the same pattern in performance is observed here (cf. 1.2.2.2). That is, in the OR Tambo District, a great number of learners chose Mathematics over Mathematical Literacy. It would therefore seem that a poor performance in Grade 9 Mathematics does not necessarily influence learners' decision about choosing the subject when given the opportunity in Grade 10.

Lastly, tracking learner enrolments indicates that 36% (2165) of learners who wrote Mathematics in 2014 and should have written either Mathematics or Mathematical Literacy in 2017 are unaccounted for. The sum of the learners who wrote the two subjects in 2017 NSC ($2792 + 1055 = 3847$) is 2165 learners short of learners who wrote Mathematics in 2014 (cf. 1-3). The only possible explanation for this missing 36% is the high repetition rate, as indicated by SECMAQ IV of 2013 (cf.1.2.1.4) in the Eastern Cape, and the high dropout rate in the country (Van der Berg et al., 2019: 25; Grossen et al., 2017: 2). In addition, if I factor in the 2017 NSC failure rate in the two subjects in question, Figure 1-3 shows that 52.8% ($100 - 47.2$) of learners failed Mathematics and 38.2% ($100 - 63.2$) failed Mathematical Literacy, translating to 1474 and 1067 learners respectively, totalling 2541 learners. In other words, 2541 of the 3847 ($2792 + 1055$) learners who wrote the subjects in the 2017 NSC failed, which when added to the 2165 unaccounted learners, equals to 4706 learners. I therefore infer that 4706 of 6012 (number who wrote the ANAs in 2014) did not pass Grade 12 three years later. This means that 78% of those Grade 9 learners either dropped out, repeated a grade along the way, or failed the NSC.

I therefore argue that the severity of the challenge of Mathematics education in the study area of the OR Tambo District is much more serious than indicated by the enrolment and performance numbers, and the percentages. In fact, Van der Berg et al. (2019: 1) estimate the monetary value of learners repeating grades at R20 billion, nationally. This percentage of 36% of unaccounted for learners in the OR Tambo District is one of the major contributors to the reported high repetition and dropout rates. To obviate the fact that this argument is based on the assessments that were some years ago, I factored in the latest available NSC results, which is that of 2019 (DBE, 2019: 37). This provides the current enrolment and performance situation. The NSC further enjoys better credibility than the ANAs (Spaull, 2013b: 5) new insights emerge.

1.2.3.3 NSC RESULTS FOR 2014 AND 2019

Table 1-1 shows that the highest increase in Mathematics enrolment has been in the OR Tambo District, when compared to the Eastern Cape and national figures from 2014 to 2017. A 14.4% increase in the percentage of Mathematics enrolment occurred in this six-year period. The performance in Mathematics, however, remained almost the same at 42.6% and 41.9% in 2014 and 2019 respectively in the District. Performance in the subject did not change in the province (42% and 41.8%) and nationally (53.5% and 54.6%), while

the enrolment in the subject increased by 11.8% and 0.7% respectively (cf. Table 1-1). These increases in enrolment, with performance remaining the same, indicates that more learners failed the subject. The District comes out negatively, because of the highest percentage of growth in Mathematics there.

Table 1-1: NSC overall enrolment, Mathematics enrolment and performance (% Pass Maths) and % change in enrolment from 2014 and 2019.

	2014				2019				% Change
	Overall enrolment	No. wrote Maths NSC	% wrote Maths	% Pass Maths	Overall enrolment	No. wrote Maths NSC	% wrote Maths	% Pass Maths	
OR Tambo District	6826	3995	58,5	42,6	8 260	6 025	72,9	41,9	14,4
Eastern Cape	66923	29460	44,0	42	63198	35 270	55,8	41,8	11,8
National	532860	231180	43,4	53,5	504303	222304	44,1	54,6	0,7

In summary, the interrogation of performance and enrolment in the ANAs and NCS, as well as regional and international assessments, provide the educational context of Mathematics education in the country, the Eastern Cape province and the OR Tambo District. I narrowed my discussion of these to the Eastern Cape province in general and the OR Tambo District in particular, where the study area is located. Learners from the OR Tambo District are underperforming in Mathematics throughout both their primary and secondary school careers, while performance in NSC Mathematical Literacy is comparatively higher. Despite this poor performance, learners in the OR Tambo District are apparently not deterred from choosing Mathematics over Mathematical Literacy.

Regarding underperformance in Mathematics, the SACMEQ IV provides some insights into the factors that may be to blame for poor Mathematics education in the Eastern Cape and the OR Tambo District. The factors mentioned in SACMEQ IV include a high percentage of learners sharing Mathematics textbooks, suggesting LTSM provisioning challenges. Milligan, Koornhof, Sapire and Tikly (2018: 23) argue that the availability of LTSM for all learners is essential in improving learning outcomes, as it allows for the participation of teachers and learners in the learning process as partners. In addition, a great number of learners in the province do not have preschool exposure, due to the distances they must

walk to access preschools. In their report, Aunio et al. (2016: 1–6) draw a link between attending preschool, the language/s spoken at school and home, early numeracy skills and the prospects of mastery of Mathematics skills in later grades. According to these authors, weaknesses at the Early Childhood Development level in South Africa deny learners the opportunity to grasp early numeracy skills. These learners tend to be at risk of struggling in Mathematics in later grades. Lastly, factors such as a lack of electricity in Eastern Cape homes, as indicated by the number of learners who use paraffin as a source of lighting, is known to affect learners' academic achievement and access roads (Smith, 2011: 22; Collinson, 2010: 13).

Factors affecting educational achievement in South Africa are multifaceted and complex (Mlachila & Moeletsi, 2019: 5), and therefore not limited to those indicated by SACMEQ IV. The interest of this study is not the exploration of these factors. The study, instead, seeks to understand the effect of an S4F FM programme on the learners, teachers and family members within the social, political and economic contexts prevalent in the study area, namely the OR Tambo Inland Education District of the Eastern Cape. The above discussion on learner performance assists in outlining the educational context in the study area.

In addition, it is worth mentioning that the S4F FM programme rolled out by the University of the Free State (UFS) came to intervene in the OR Tambo District as a result of the Corporate Social Responsibility (CSR) initiative of one of the sponsors of S4F. I argue that the observed performance in Mathematics justifies the S4F FM intervention, which works with teachers and family members to optimise the opportunities for learning Mathematics in the District. So even though it may seem coincidental that as a result of CSR the S4F FM intervention programme landed in the OR Tambo District, the observed performance patterns still require some form of intervention. To complete my line of argument on the need for the S4F FM intervention, I need to discuss the enrolment patterns unearthed in the District (cf. 1.2.1).

It is obvious that the poor performance in Mathematics by learners in the OR Tambo District does not deter them from selecting Mathematics over Mathematical Literacy, even though the latter has comparatively favourable pass percentages in NSC, thereby improving a learner's chances of passing Grade 12. These learner preferences imply that the motivational variables for selecting Mathematics outweigh the motivational variables for

passing Grade 12 without the subject, the probability of which is improved if Mathematical literacy is chosen. One of the criteria for passing Grades 10 – 12 is that a learner must pass six of the seven subjects (ECDOE, 2018: 3). So, when the probability of failing one subject, Mathematics in this case, is increased, so is the probability of failing the grade.

One possible motivational variable for selecting Mathematics over Mathematical Literacy is that the higher education institutions (HIEs) in South Africa consider Mathematical Literacy less appropriate for entry, and very few of these institutions' programme offering require the subject, according to Baumgartner (2018: 9). This implies that learners may be more concerned about life beyond Grade 12 than an NSC certificate with limited opportunities of entry into a HIE. In this regard, Du Plessis and Ahmed (2020: 63) explored the career aspirations of secondary school learners from a rural setting in the Eastern Cape, which may more or less mirror the study area for this research.

Rural learners' aspirations for the future, which in this case influence the choice of Mathematics or Mathematical Literacy, are influenced by community, family and personal experiences (Du Plessis & Ahmed, 2020: 63–64). These learners' view of their current rural environment, which is shared by their family members, is that it is constraining in many respects. Their aspirations for the future are motivated by the desire to escape from this limiting environment (Du Plessis & Ahmed, 2020: 63–64). This emancipatory desire might be a stronger motivational variable for selecting Mathematics over Mathematical Literacy than passing a Grade 12 that becomes a dead end. Several other authors reported that affective issues such as motivation, beliefs, attitudes and perception, play key roles in learners' educational choices, and performance in the subjects of their choice (Almerino, Etcuban, De Jose & Almerino, 2019: 482; Mulendema, Ndhlovu & Mulenga, 2016: 15–16; Tekola, Getahun & Hagos, 2019: 105–106; Letsoalo, 2017: 9502–9203).

In this study, I needed to take cognisance of the perceptions of learners, teachers and families towards Mathematics education as part of the affective factors affecting education. Specifically, this study seeks to understand changes that the S4F FM programme made to the perceptions of these school community members as well as the changes to the learners' scholastic achievement in Mathematics. The above discussion (cf. 1.2), therefore highlights the reality of Mathematics education in the study area, and provides the social context from which the current study should be understood.

In conclusion, the context of the study area, the rural OR Tambo District, is beset with an abundance of obstacles to learning in general and the learning of Mathematics in particular. The confluence of poor provisioning of basic education necessities, the rurality of the environment and possible other factors result in higher dropout and rates and poor performance in Mathematics. These factors, in conjunction with learners' and families' desire to free themselves from the adversities that are inherent in the rurality of their environment, motivate learners enrol for Mathematics despite poor performance. Within this context, this study seeks to understand the changes brought about by the S4F FM programme regarding the perceptions of family members, teachers and learners towards Mathematics education, on the one hand, and learners' achievement marks in Mathematics on the other. I briefly discuss the background to the S4F FM programme for the reader to understand its background and the philosophy that drives the intervention.

1.2.4 S4F FM INTERVENTION PROGRAMME

The concept of Family Maths, from which S4F FM programme was derived, first originated in the USA as a result of the observed inequality in the participation and performance in Mathematics, which consequently led to the underrepresentation of the females and minority groups in careers that required the subject (Kreinberg, 1989: 127). It was initially called "EQUALS" to symbolically indicate the programme's primary mission, which was to assist in ways that would increase participation and performance in Mathematics by underrepresented groups (Anderson & Thompson, 200: 6; Aldrich, 1980: 12). EQUALS mainly targeted teachers for development, but lessons learnt along the way led to the need to involve families in the education of their children, which led to the establishment of the Family Math programme (Kreinberg, 1989: 127). The success of the programme led to its adoption in other countries (Kurz, 2011: 227), including South Africa.

In South Africa, the Family Math programme is rolled out in different forms by different institutions (Webb & Austin, 2009: 28; UFS, 2014) because of the programme's flexibility (Kurz, 2011: 227) and the differing contexts. The ultimate goal of the Family Math (FM) programme is to change, for the better, the quality of life of the affected community (Lopez & Donovan, 2009: 220) by addressing the inequalities that exist in the education system (Austin & Webb, 2011: 580).

Specifically, the S4F FM programme hopes to achieve these goals by improving the learners' attitudes towards Mathematics through removing the myth that only a selected few are capable of excelling at it. The programme also aims to improve learners' attitudes towards the subject (Lopez & Donovan, 2009: 220). Additionally, the programme aims to lay the basis upon which proficiency in Mathematics can develop at home (Kurz, 2011: 227). This foundation is laid by equipping family members with the skills and knowledge for learning Mathematics at home and reducing the frustration that children's family members (referred to as families in this document) usually experience with Mathematics (Vandermaas-Peeler & Pittard, 2014: 501).

There has been a positive uptake of the S4F FM programme by school communities, leading to the expansion of the programme to other provinces of South Africa beyond the Free State where it was initially piloted. The expansion is probably and partly because of the successes of the programme (Jaramillo, 1993: 84; Sadler, 1998: 78; Jacobbe, Ross & Hensberry, 2012: 1176). However, the S4F FM programme has never been formally studied, and this study aims to fill this gap. The rationale for this study is discussed next.

1.3 RATIONALE AND STATEMENT OF THE PROBLEM

The focus of this study was one of the many interventions that have been undertaken to address poor learner performance in Mathematics in South Africa (Askew et al., 2012; Stott & Graven, 2015: 313; Ndlovu, 2011: 420), namely the S4F FM programme. The focus in this study was specifically on the effect of the S4F FM intervention programme on a school community in the education OR Tambo education District in the Eastern Cape province of South Africa.

Affective factors like perceptions, attitudes, self-confidence, knowledge and motivation may play a role in children's education (Almerino et al., 2019: 482; Mulendema et al., 2016: 15–16; Tekola et al., 2019: 105–106; Letsoalo, 2017: 9502–9203). For example, Patel and Stevens (2010: 131) examined the families' and teachers' perceptions of the learners' academic ability. The two authors found that the greater the disparity between the perceptions of these two groups, the higher the likelihood of decreased parental involvement in their children's education. It is also a negative indicator of facilitation by teachers. Families' self-confidence, knowledge, language skills and motivation levels form the basis for them to become involved in their children's education (LaRocque, Kleiman &

Darling, 2011: 115). Dumont, Trautwein, Lüdtke, Neumann, Niggli and Schnyder (2012: 68) studied the families' ability to help with schoolwork as perceived by their children, and found that the ability to help was strongly associated with learners' self-concept.

On the other hand, Reddy (2006) as cited in Austin and Webb (2011: 52) points to a national concern regarding negative attitudes towards Mathematics in South Africa. Meanwhile, Jacobbe, Ross and Hensberry (2012: 1164) state that one of the primary goals of the Family Night programme, a precursor to S4F¹ in South Africa, is to reinforce positive attitudes towards Mathematics in learners (Jacobbe, Ross, & Hensberry, 2012:1164).

The FM programme in the USA has been found to positively reinforce learners' knowledge, skills and attitudes towards Mathematics (Jacobbe, Ross, & Hensberry, 2012). Successes of the programme elsewhere have been widely reported on (Jaramillo, 1993: 84; Sadler, 1998: 78; Jacobbe et al., 2012: 1176). There are no similar evaluation reports about the S4F FM programme in the study area, the OR Tambo District. Due to a radically different context, results from South Africa, the Eastern Cape and the OR Tambo District in particular, might prove to be very different, if interrogated. The contextual factors include but are not limited to political issues (Unterhalter, 2012: 6), the socioeconomic status of the families and the larger community (Neilson & Zimmerman, 2014: 4), the language of learning and teaching (Reddy et al., 2012: 7), families' education levels, and culture (Hartas, 2015: 609).

In light of the crisis nature of primary Mathematics education in South Africa (Heyd-Metzuyanim & Graven, 2015: 351; Spaul, 2013a: 17; Ally & Christiansen, 2013: 50) and the ensuing plethora of intervention programmes (Askew et al., 2012: 27, Stott & Graven, 2015: 313; Ndlovu, 2011: 420) including the S4F FM programme, it is vital that the effect of such programmes are evaluated. This is true specifically of the Mathematics education challenges in the study area, the OR Tambo District, as highlighted in the background above (cf.1.2). The S4F FM intervention programme in this District needs to be evaluated. In addition, the unavailability of research on the effects of the S4F FM programme on the school community, despite the financial, human and time investments made on the programme, makes it necessary to undertake this study, specifically to shed light on family

¹ A number of education intervention initiatives organised under the umbrella body called S4F

members', teachers and learners' perceptions, as well as learners' academic achievement in Mathematics.

The problem for this proposed study pivoted on the enormous challenges of Mathematics education in the country, province and OR Tambo District, and the S4F FM intervention programme that is meant to mitigate the adverse effects of these challenges. The manifestation of the effects of poor Mathematics education is in learner participation and performance in the subject, which in part are subject to affective factors including perceptions and attitudes of the family members, learners and teachers. In addition, performance, as indicated by learners' scholastic achievement in the subject, is the final outcome in a continuum of other intermediate outcomes, including improved perceptions and attitudes. One has to specifically consider what the effects of the S4F FM intervention programme are on the perceptions of these school community members and the learners' achievement marks in Mathematics in the unique context of the rural OR Tambo District in the Eastern Cape province. I therefore pose the following overarching research question for this study: *What changes were brought about through the S4F FM programme in a rural school community in South Africa?*

Given the preceding problem statement and rationale for the study, I posed specific sub-questions that the research answered to understand the effect of the S4F FM programme.

1.4 SECONDARY RESEARCH QUESTIONS

In an attempt to answer this central question, the study addressed the following sub-questions:

1. What is the background and nature of the S4F FM programme offered by the University of the Free State?
2. What was the effect of the S4F FM programme on the performance of learners in the OR Tambo District in the Eastern Cape?
3. What were the effects of the S4F FM programme on the perceptions of children's family members, teachers and learners towards mathematics?
4. What critical comments can be made on the S4F FM programme in the context of a rural community?

1.5 OBJECTIVES OF THE STUDY

The overall aim of this study was to *explore and describe the changes brought about through an S4F FM programme in a rural school community in South Africa*. I first formulated two objectives to focus my literature study. After that, I formulated objectives to guide my empirical work, and these are linked to the secondary research questions stated above (cf. Table 1-2):

Table 1-2: Research objectives, linked with methods.

Objective	Method	Chapter
1. To unpack the theories and concepts which helped me make sense of the effect of the FM programme on the community	Literature study	2
2. To review the literature on the perceptions of children's family members, teachers and learners towards mathematics education as a result of the intervention programmes	Literature study	3
3. To explore and describe the background and nature of the S4F FM programme in South Africa	Interviews; Document analysis	5
4. To analyse the effects of the S4F FM programme on the performance of learners in an Eastern Cape school district	Quantitative analysis of the results over some years	6
5. To understand the effects of the S4F FM programme on the perceptions of children's family members, teachers and the learners themselves towards mathematics	Interviews with different role players	7
6. To provide critical comments on the design and implementation of the FM programme	Interpretation and synthesis of the above	8

1.6 THEORETICAL FRAMEWORK

The S4F FM programme has many role players made up of children's family members, teachers and the learners themselves, with differing roles and activities, all aimed at Mathematics education (Lopez & Donovan, 2009). The multiplicity of role players and different roles and motivations posed a challenge in finding a single all-encompassing theoretical framework for the study. In this study a framework derived from four different models and theories guided the study in its entirety (cf. Figure 4). The models included the

Hoover-Dempsey and Sandler model (Hoover-Dempsey & Sandler, 1997: 4), Vygotsky's Sociocultural theory (Jaramillo, 1996), constructivism (Fosnot & Perry, 1996: 25) and Epstein's overlapping spheres of influence (Hornby & Lafaele, 2011: 39)

1.6.1 HOOVER-DEMPSEY AND SANDLER MODEL

In an S4F FM programme, teachers are trained to orientate family members on how to be involved, at home, with their children's mathematics education. Foundational mathematical skills and home materials are given to family members to use at home to assist children. A question that needs consideration is, if and how families become involved in their children's education based on orientation by teachers. The Hoover-Dempsey and Sandler model (Hoover-Dempsey & Sandler, 1997: 4) on the motivation for parental involvement deals with these questions.

According to Hoover-Dempsey and Sandler (1997: 4) model, parental involvement in children's education is a five-level process that begins with a decision to become involved in level 1 to children's outcomes in level 5. Hoover-Dempsey and Sandler (1997: 4) and Hoover-Dempsey et al. (2001: 201) state that three key factors influence the decision to become involved. Firstly, there is the belief of an obligation to become involved. This belief determines the activities that the parent engages in, once involved. Secondly, the belief that their involvement adds value to their children's education. This belief drives the goals set for involvement and the consistency of the involvement. Lastly, the perceptions of requests for involvement from their children and teachers as being needed to become involved.

I used this model in this study to guide the activities that attempt to explore the effects of the S4F FM programme on the perceptions of children's family members towards the Mathematics education of their children.

1.6.2 SOCIOCULTURAL THEORY

Vygotsky's Sociocultural theory posits that learning takes place within a social setting (Jaramillo, 1996). The young learn higher-order levels of thinking from their peers, while older children and adults learn through the medium of language, which is an extension of culture and symbols like letters of the alphabet and formulae (Kozulin, 2016: 10). Group interaction is therefore essential for the process of learning to take place. In the end, new

knowledge is constructed through the combination of social interaction on the one hand and the individual child's maturational processes on the other (Marshall & Jackman, 2015: 85).

This primary tenant of Vygotsky's sociocultural theory is in congruence with the beliefs held in social constructivism, to the point where Vygotsky's work is considered to have laid the foundation for the development of constructivism (Jaramillo, 1996- 133). These beliefs hold that learners co-construct knowledge in the learning community they find themselves in, based on the understanding already appropriated and their interactions with their immediate environment. I therefore also assimilated concepts from social constructivism into the framework that guides this study.

1.6.3 CONSTRUCTIVISM

I must mention upfront that social constructivism is believed have developed from Vygotsky's Sociocultural Theory (Liu & Matthews, 2005: 391–392). As a theory of learning, constructivism provides the framework for researchers to study how and why people learn (Jaramillo, 1996). Fosnot and Perry (1996: 25) further describe constructivism, as applied in the classroom, as a theory of learning in which teachers create a learning environment where learners are encouraged to generate their ideas, critically examine those ideas for viability, and enter into a discussion about the ideas in communities of discourse. Discourse communities are defined as a group of individuals who share the same goals, communicate amongst themselves and ensure participation and feedback (Swales, 1990: 473).

Based on the preceding discussion, there are various social levels on which social interaction can take place in the context of the S4F FM programme, other than the formal classroom. First, at home with family members. Second, in the community like the neighbourhood, church or sports fields, and lastly at a school outside the formal teaching and learning setting. In this regard, this theory guided the research activities of this study that sought to understand learners' perceptions of their family members' ability to assist them with their Mathematics schoolwork at home. Considering that learners are at the centre between what happens at school and home regarding their education, some form of overlap in communication is needed.

1.6.4 EPSTEIN'S OVERLAPPING SPHERES OF INFLUENCE

The model of overlapping spheres of influence was developed by Epstein, as cited in Hornby and Lafaele (2011: 39). Epstein's 2001 model of three overlapping spheres of influence considers the confluence of these spheres to be very important in the educational development of the child. The three spheres are made up of family, school and community. The family sphere is composed of such factors as the beliefs families hold about parental involvement, how do they perceive invitations to be involved by both their children and teachers, social and economic class, ethnicity and gender. The school sphere, on the other hand, is made up of teacher-parent goals and agendas, attitudes and language used. Societal politics, economy, history and demography constitute the factors in the community sphere. Children's educational development benefit when the three spheres of influence work together, resulting in a significant overlap between them. In this scenario, families and schools share common goals and similar communication patterns, while social values associated with education are reinforced. This leads to congruence amongst the spheres (Lopez & Donovan, 2009: 220).

Epstein's model was integrated and synthesised, together with the other theories and models mentioned above, into a conceptual framework for this study. Imenda (2017: 188) makes a distinction between a theoretical and a conceptual framework. The former refers to the use of a single theory or concepts derived from it to guide the research, while the latter refers to the synthesis of different theories or concepts to build a guide for research (Imenda, 2017: 188). The objective of a conceptual framework, according to Rocco and Plakhotnik (2009: 3) is to describe and sort concepts applicable to the study and plot the relationships among them. This model is used to pull together different research aspects of this study and provide critical comment on the design and implementation of the S4F FM programme in the context of the Eastern Cape. This model was also used in conjunction with others to derive a composite theoretical framework for this study. The derived theoretical framework, among others, informed the research methodology for the study.

1.6.5 A FRAMEWORK FOR THE STUDY

The consolidated theoretical framework for this study was derived from the Hoover-Dempsey and Sandler (1997: 3) and Epstein and Sanders (2006: .86) models, as well as Vygotsky's Sociocultural theory (1978 as cited in Louis, 2009: 20) and social constructivism

theories (cf. Figure 1-4). The framework places the school at the centre of role playing in creating a collaborative atmosphere amongst the school itself, family and community, which constitute the child's learning environments. The school plays the role of synergising in the learning environments through categorised involvement activities. It is important, though, to note that the researcher's worldview of reality and knowledge informed the derivation of this consolidated framework, and therefore, those paradigms deserve clarification.

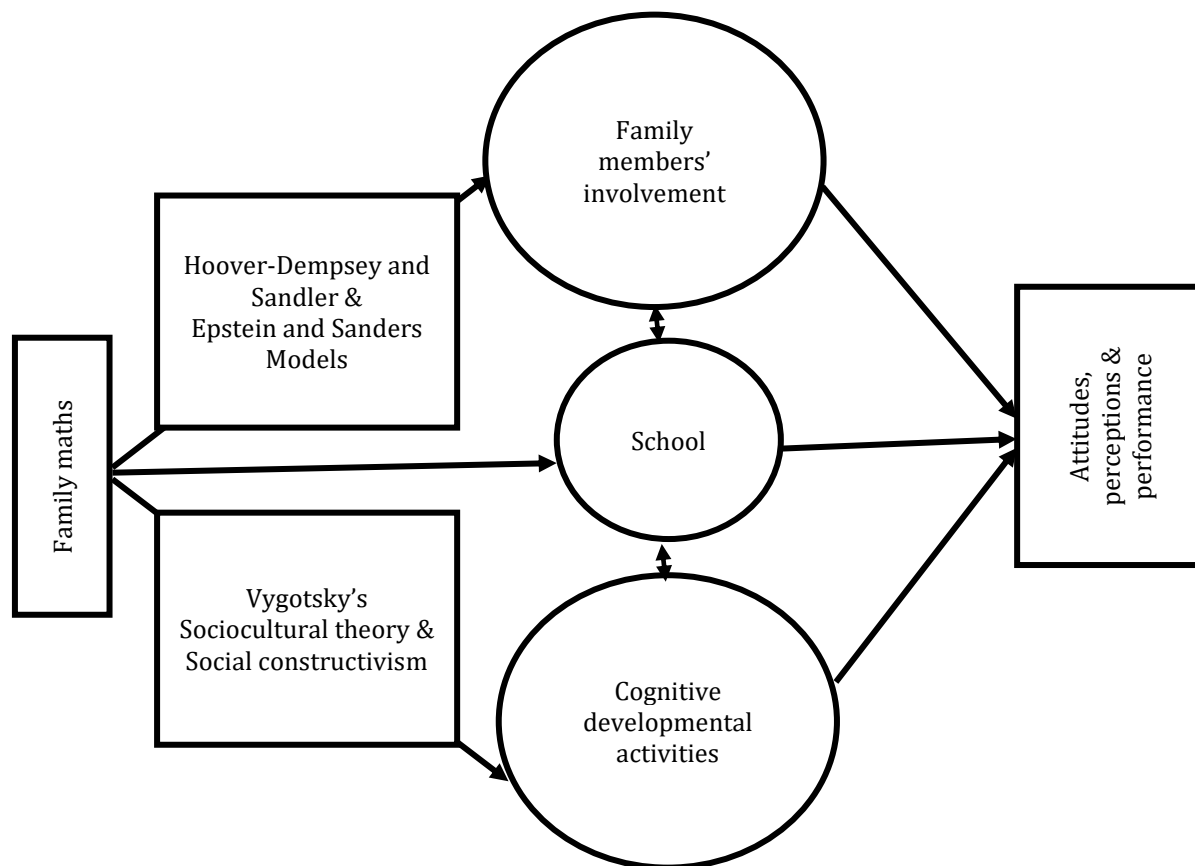


Figure 1-4: Theoretical framework

1.7 PARADIGM

Scotland (2012: 9) does well to explain the importance of understanding research paradigms in educational research and practice, and of grounding one's work within a paradigm. According to this author, understanding research paradigms enables a researcher to comprehend other researchers' work, to participate in academic debates and to be able to report his/her research findings. Here, the ontological, epistemological and

methodological components of the espoused paradigm are explained in the context of the overall objective of this study.

The overall aim of this study was to *explore and describe the changes brought about through an S4F FM programme in a rural school community in South Africa*. Although I leaned heavily on social constructivism overall, I took a pragmatism position, based on my assumptions that:

- All the necessary approaches should be used to fully understand the changes brought about by the programme;
- Our education system quantifies education performance, although I am convinced that social reality is constructed socially through society (Mack, 2010: 9) and is subjective and mediated through our senses (Scotland, 2012: 11).
- Tests and examination scores are not absolute truths, yet they are used as indicators of knowledge and insight by learners.
- All information shared by participants during interviews remain partial, and selective, yet triangulating the views from different stakeholders, with quantitative data available, may provide us with a realistic understanding of the phenomenon under study.

In terms of how learning takes place, I aligned myself with the constructivism learning theory, built on Vygotsky's socio-cultural theory, as adopted in this study. Succinctly put, knowledge is constructed socially and shared by society through media and other institutions (Mack, 2010: 9). In the context of the S4F FM programme, the focus of this study, learners may co-construct new Mathematics knowledge through interaction with teachers at school, family members at home and their peers in the community. This new Mathematical knowledge is constructed through each learner's personal experiences (Mack: 2010: 8). Amongst others, I was interested in understanding these experiences and performances as affected by the S4F FM programme. The research methodology that formed the basis of the empirical work in this study was not only consistent with adopted ontological and epistemological assumptions, but also considered the need to understand these experiences, and also to measure impact.

1.8 METHODOLOGICAL CONSIDERATIONS

Qualitative and quantitative research methodologies should not be considered as discretely separate methodological worldviews that cannot coexist in the same research endeavour. The two represent the opposite ends of the same continuum, with mixed methods in the middle (Creswell, 2009: 3). In fact, researchers have long ignored the dichotomous approach to research, and rather considered what works to answer their research questions. Most often a combination of both qualitative and quantitative methodology is utilised (Johnson & Onwuegbuzie, 2009: 22). Consequently, mixed methods are not dogmatically associated with any single paradigm. It is more similar to the pragmatism paradigm, which is influenced by what is practical or provides solutions to a research problem (Creswell, 2009: 10). Because of this common orientation to research problems, practicality and solutions by mixed methods and the pragmatism paradigm, many authors tend to locate mixed methods within this paradigm (Creswell, 2009: 10; Johnson & Onwuegbuzie, 2009: 16; Johnson, Onwuegbuzie & Turner, 2007: 120; Venkatesh & Brown, 2013: 37).

1.8.1 RESEARCH DESIGN

Research design is a master plan that is used for data generation, analysis and interpretation (Creswell, 2009: 3). In this research, I made use of sequential mixed methods (QUAL + QUAN + QUAL) because both data sets (qualitative and quantitative) were processed one after the other, in the order indicated. In this type of design, the research community uses qualitative research approaches to explore research questions that seek to understand how people interpret their world, construct knowledge and make meaning of their experiences (Merriam, 2009: 11). In addition, researchers use quantitative methodology to test hypotheses through some level of objective collection and statistical analysis of numerical data (Creswell, 2009: 4). Figure 1-5 diagrammatically shows how this research proceeded.

Specifically, in this study I used a hybrid approach of an explanatory and exploratory sequential design (Collins et al. 2012, pp.851–2). An explanatory sequential design according consists of first collecting quantitative data and then collecting qualitative data to help explain or elaborate on the quantitative results. The rationale for this design was that the quantitative data and results provide a general view of the research problem; more

analysis, specifically through qualitative data collection is needed to refine, extend or explain the general view gained through (Subedi 2016, pp.572–3). In the exploratory sequential design, on the other hand, involves the procedure of first gathering qualitative data to explore the phenomenon followed up by quantitative data to explain the relationships (Subedi 2016, pp.572–3). In the hybrid approach of this study, I started with qualitative data generation and analysis on the background on the S4F FM programme. Insights gained through this qualitative enquiry was followed up by analysis of learners' achievement marks, which was quantitative. The general view gained through the quantitative analysis was followed up by analysis of narratives from participants.

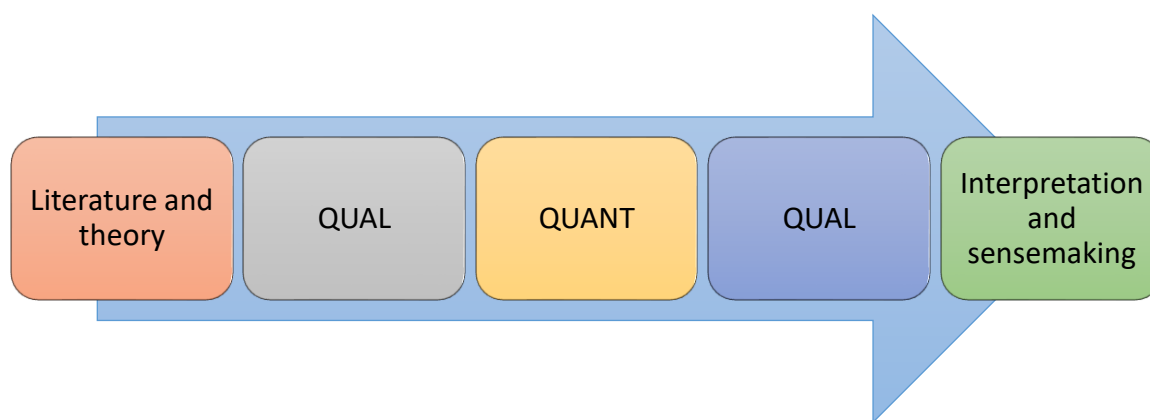


Figure 1 5: Sequential mixed methods design

I next provide a brief description of the QUAL and QUANT aspects of this research.

1.8.1.1 QUAL

Qualitative research is used to explore and understand the way in which individuals and groups, in their individual and collective capacities, interpret a social or human experience (Creswell, 2009: 5). In this research, I interpreted two sets of accounts to make sense of the meaning that participants make of firstly the background to the S4F FM programme, and secondly their interaction with the S4F FM programme. In the following sections, I describe my data sources, data generation and analysis thereof.

1.8.1.2 QUANT

The schools participating in the S4F FM programme were not randomly selected. There could therefore have been differences that predated selection, which could explain any differences in the Mathematics marks observed between participating and non-participating schools. To obviate such inherent deficit during the programme evaluation

stage, researchers often use quasi-experimental designs where the conventional experimental control of other factors or randomisation are not possible (Kim & Steiner, 2016: 395; White & Sabarwal, 2014: 2). Randomisation, according to Ravallion (2003: 2), is one strategy used in research to take care of extraneous factors, which could possibly affect the outcome, similar to the way that the variable of interest could. I used a quasi-experimental design to consider the influence that the S4F FM programme has had on learners' performance.

1.8.2 STEPS IN THE RESEARCH

In the section that follows, I briefly give an overview on how the study unfolded.

1.8.2.1 LITERATURE STUDY

I started by reviewing literature that addresses the perceptions that underlie families', teachers' and learners' practices towards learning in general and Mathematics education, in particular. The literature study was undertaken to understand the current body of knowledge related to the primary aim of this study. The literature study is aligned with the paradigm and theoretical propositions that are embraced in this study.

Reddy (2006) as cited in Austin and Webb (2011: 52) points to a national concern regarding negative attitudes towards Mathematics in South Africa. Meanwhile, Hoover-Dempsey et al. (2001: 204) argue for a positive interplay between the parent and child's positive attitudes, as families' positive attitudes towards homework has been associated with the development of children's positive attitudes towards learning (Hoover-Dempsey et al., 2001: 204). Families' experiences and attitudes towards mathematics have also been found to predict children's scores in Mathematics (Vandermaas-Peeler & Pittard, 2014).

The literature review in this study further explored these arguments and findings from other studies to fulfil the second objective of this study: To synthesise research findings on the attitudes and perceptions of family members, teachers and learners towards Mathematics education following their exposure to the S4F FM Programme.

1.8.2.2 FIRST QUALITATIVE STUDY-PART

I started by conducting interviews with purposively selected participants, in order to better understand the history of the S4F FM Programme. During the qualitative parts of this study,

I generated data through individual and group interviews. To understand the history of the S4F FM programme, I conducted individual interviews with people formerly and presently associated with the S4F FM programme at the UFS, and the sponsors of the programme. I triangulated that with information obtained through documents such as internet documents and reports. Merriam (2009: 140-149) highlights the advantages of using a variety of documents (reports, novels and newspapers) to obtain qualitative data that does not depend on the cooperation of the participants. Such documents are not usually produced for research, and are not affected by the presence of the researcher, which is typical of qualitative research. In concurrence, Creswell (2008: 231) considers documents as “*a good source for text (word) data for a qualitative study*”. The documents related to the S4F FM programme, together with information obtained from current and former UFS staff members who were and are part of the programme, and also the sponsors of the programme, enabled me to document the background purpose of the programme.

1.8.2.3 QUANTITATIVE STUDY-PART

I then obtained the Mathematics marks from the database of the Department of Basic Education for all 18 schools that are involved in the S4F FM programme, and all primary that were not part of the programme. Using the propensity score matching, two comparable groups were generated from the two groups of schools. One group represented the treatment schools (schools in the programme) and the other group represented the control group. The marks were used to quantitatively make an inference about the effect of the S4F FM programme on the Mathematics performance. In addition, the marks were used to analyse the performance of learners in the schools in Mathematics over time, since joining the S4F FM programme, and compare it to similar schools in the province that were not part of the programme.

1.8.2.4 SECOND QUALITATIVE STUDY-PART

Participants for this part of the research came from the OR Tambo Inland Education District in the Eastern Cape. Perry (2001: 312) posits that in qualitative research, there are no rules that prescribe the number of cases required to answer a particular question. Instead, the number of participants should increase for as long as new insights emerge, until “*data saturation*” is reached (Perry, 2001: 312). The participants for the study came from the school community that participated in the S4F FM programme according to Table 1-2

below. I conducted group and one-to-one interviews with participants for the second qualitative phase of the study, according to these categories:

- Group interviews with 36 learners from three different primary schools in three different sessions – 21 girls and 15 boys
- Group interviews with 13 teachers, each representing her school in one session – all females
- Group interviews with 24 family members from three different schools in three different sessions, immediately after each learner session
- One-to-one interviews with three female UFS S4F programme staff members in three different sessions.

Table 1-3: Numbers of family member individuals, teachers, learners and schools to which the S4F FM programme has been rolled out since 2013 in OR Tambo Inland Education District of the Eastern Cape

Year	Families	Teachers	Learners	Schools
2013	420	22	528	9
2014	480	22	561	9
2015	597	12	622	10
2016	683	12	695	10

According to the S4F FM programme coordinator in the OR Tambo Inland Education District, these schools are located within and outside of the OR Tambo urban centre. They therefore required a selection strategy representative of different contextual factors. I made use of Statistics South Africa's community survey of 2016 to further give insights into the socio-economic demographics of the communities surrounding the selected schools.

In order to understand the perceptions of the community, I conducted focus group interviews with families, teachers and learners. In the group interviews, mainly I made use of open-ended questions (Creswell, 2009: 181). These unstructured interviews are aimed at eliciting responses that demonstrate views and opinions (Creswell, 2009: 181) and experiences (Willis, 2012: 171) that participants may have on the subject under discussion. Group interviews, according to Creswell (2009: 181), are suitable in the case where the interviewees are people who have either been working together or people with a common purpose, such as teachers or learners, as is the case in this study. Group interviews

encourage discussion among the members of a group, which leads to a variety of responses. This gives the researcher insight into the issue being studied (Merriam, 2009: 94). These types of interviews are not without challenges, as they can be dominated by a single participant to the detriment of the potential responses that would be obtainable from other interviewees. Moreover, group interviews can bring about a “group think”, in effect suppressing alternative views from individuals within the group (Cohen et al., 2007: 393). I was aware of these challenges and did my best to control them.

1.8.3 DATA ANALYSIS

I commenced with the qualitative data analysis for this study during the data collection stages, as this is standard practice in qualitative research (Creswell, 2009: 184; Cohen et al., 2007: 183). While acknowledging that there are no set rules for analysing textual qualitative data, Cohen et al. (2007: 184) suggest a seven-step process of analysing qualitative data. First, the “*units of analysis*” are established, where similarities and differences are pointed out. This is akin to coding. I therefore classified data generated from the interviews into units, before seeking what the text means, whilst at the same time comparing it to constructs derived from the theoretical framework. This process is coding (Creswell, 2009: 186). I subjected the data generated from all the participants to the same process. For examining perceptions towards mathematics education from learners, for example, units of analysis or codes may involve the use of pointers. Pointers include such phrases as liking the subject or not; in favour or not of mathematics activities; belief in oneself as being successful in Mathematics; and considering whether Mathematics is valuable or not (Akay & Boz, 2010: 60). I followed the subsequent steps (Cohen et al., 2007: 184) during the data analysis process.

Regarding learner performance in Mathematics, I used descriptive statistics by working with mean scores and trends over time. I also used inferential statistics to determine the significance of possible differences in Mathematics performance between schools that are part of the S4F FM programme, and those that are not.

1.9 VALIDITY AND RELIABILITY

Validity and reliability were treated from the perspectives of both a qualitative and a quantitative research approach in this study in a manner that focused on what is practical.

The reason for this approach is that the present study is a mixed method one, which utilises both methodologies, and as such is premised on pragmatism paradigm. Irrespective of the methodology of research, validity and reliability refers to the integrity of the entire study. This includes how it is conceptualised and how data is collected, analysed and interpreted, and then finally reporting on the results (Merriam, 2009: 210).

To enhance the validity and reliability of this study, I used various methods of data collection, as suggested by Merriam (2010: 216). These methods include group interviews, one-to-one interviews and triangulation with quantitative data analysis. To complement the qualitative data, I obtained learner marks for Mathematics from the Education Department databases, with their permission, of course. Secondly, I pronounced on the biases that I as researcher bring to the study. I avoided ignoring unexpected, different or negative explanations (Creswell, 2009: 198). Lastly, I asked a colleague to critically review my interpretation and analysis of the accounts of the participants (Merriam, 2010: 217). All these measures should enhance the congruency between the research findings and the reality of the effect of the S4F FM programme in a rural school community.

Reliability in a research project is used differently in the quantitative and qualitative phases of the study. For the quantitative phase, reliability refers to the extent to which the same results would be obtained using the same methods of research (Willis, 2012: 271). For qualitative phase, reliability refers to the degree to which the results can be trusted or confirmed or transferred to a similar setting (Merriam, 2010: 228; Willis, 2012: 271). Onwuegbuzie and Johnson (2006: 48) acknowledge the complexity of the integration of the two methodologies, and recommend the term "*legitimation*" instead of validity. They pinpoint nine legitimation concerns that are specific to the mixed method. The majority of the legitimation concerns, as outlined by Onwuegbuzie and Johnson (2006: 57), are about issues of meta-inferences of "*substantive theory*" that emanates from the combination of qualitative and quantitative (Venkatesh & Brown, 2013: 23). I discuss those legitimation issues by Onwuegbuzie and Johnson (2006: 57) which I consider relevant to this study below.

- **Sample integration legitimation** is applicable in situations where the researcher seeks to generalise, based on the research sample. Sample integration, as Onwuegbuzie and Johnson (2006: 57) explain, is threatened if the same people that participate in the

qualitative part of the study do not also take part in the quantitative aspect. In this regard, I was less concerned about the extent to which there was participant continuity from the qualitative to quantitative aspects of the research, because external validity as implied by the applicability of the findings of this research in another context was not the intention (Merriam, 2009: 225).

- **Inside-outside legitimization** issues arise where there is a lack of clarity on the philosophical stance on which the researcher bases his/her research (Collins, Onwuegbuzie & Johnson, 2012: 858). The philosophical lens through which the activities of this study are viewed is pragmatism, which utilises the best of positivism and constructivism while avoiding the weaknesses of each (Onwuegbuzie & Johnson, 2006: 58).
- **Weakness minimisation legitimization**, according to Onwuegbuzie and Johnson (2006: 58), refers to the extent to which the researcher can design the study so that the weaknesses in one method are compensated for by another method. In the present study bias occurred when schools were selected to participate in the S4F FM programme. The purposeful and convenient sampling, during the qualitative phase of the study, compensated for this selection bias.
- **Paradigmatic mixing legitimization** occurs, as Collins et al. (2012: 56) explains, when the researcher lacks philosophical clarity, which potentially leads to a cascade of other threats to the validity of a study. The consequence of this deficit leads to the diminishing of the enquirer's ability to conceptualise a study rationally. This, in turn, could decrease his/her capacity to design the mixed research study adequately, leading to an adverse effect on the implementation of the mixed research study and its conclusions. I situate the current study within the ontological, epistemological and methodological philosophies in Chapter 2 (cf. 2.2.1).
- **Multiple validities legitimization** refers to the degree to which the researcher addresses validity issues that are specific to the qualitative, quantitative and mixed methods aspects of the study, which have implications for the conclusions drawn from a study (Collins et al., 2012: 857). The validity concerns that pertain to the qualitative and quantitative aspects of the study are addressed in Chapter 4 (cf. 4.4).

Also important to the validity and reliability of a study is its demarcation regarding what falls inside or outside of the scope of the study. This following section describes the scope of this study.

1.10 DEMARCATION OF THE STUDY

In this section, I describe the delineation of the study, regarding its uniqueness as a discipline as well as geographic specificity. I must restate the empirical objective of this study to help locate the discipline of this study. The objective is to understand the effect of the S4F FM programme on the perceptions of children's family members, teachers and the learners themselves towards mathematics. These perceptions are explored in the context of rural South Africa, focusing on the Eastern Cape Province. The study is therefore an inquiry into Mathematics education within a social context, and as such falls within the realms of Curriculum Studies. According to Pinar (2010: 53), curriculum studies is an inquiry into processes that deal with structured learning. One needs to exercise some caution not to confuse Curriculum Studies with curriculum and curriculum development. The latter two have an approach and policy aspects associated with them, respectively, while the former also delves into ontological philosophies of the curriculum discipline (Du Preez & Simmonds, 2014: 5).

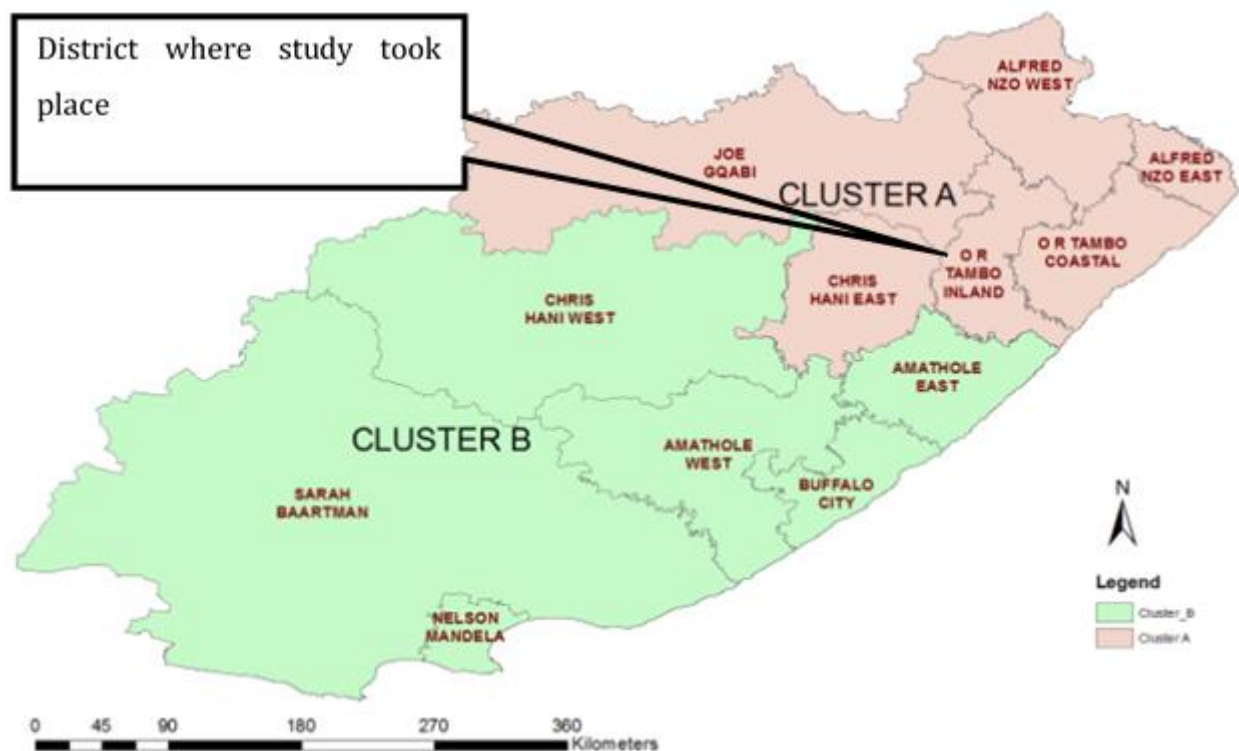


Figure 1-5: Map showing the education districts of the province of the Eastern Cape. Adapted from <https://www.google.co.za/search?q=education+schools+districts>

Geographically, the study area is the OR Tambo Inland Education District of the Eastern Cape province (cf. Figure 1-5). The province is administratively subdivided into three clusters of districts A, B and C. The OR Tambo Inland Education District is located in Cluster B in the north-eastern parts of the province. I next discuss the value of the study.

1.11 VALUE OF THE STUDY

The value of the present study is in the expansion of knowledge to the existing body of knowledge on specific forms of family involvement in Mathematics education in the primary school phase. The study also provides practical solutions to the approach and design of intervention programmes in Mathematics education. As such it will, in the first place be of value to the stakeholders in the S4F FM programme, namely the UFS, the various sponsors as well as the Department of Basic Education. As I have an outsider perspective, the findings are invaluable to the stakeholders to evaluate and review the programme. Secondly, the study is of value to the broader education community as learner performance in mathematics as well as parental involvement are both crucial issues that are grappled with here. Lastly, it contributed to what is known about the international FM project in a particular context, and this can lead to further studies in different contexts.

Although steps have been taken to enhance the reliability, validity and the value of the study highlighted, there still remains some limitations to the study that I must note.

1.12 LIMITATIONS

This study has limitations that go beyond those that are inherent in the methodology used. Creswell (2009: 179) lists the inherent limitations of interviews, for example, as the indirect nature of the information, inability to obtain information in the natural setting, bias stemming from the presence of the researcher, and an unequal ability of people to articulate their thoughts. This last limitation is particularly true for the study since learner's form part of the study. Consequently, the current study has the following limitations:

- The scope of the study is such that it was not able to establish the positive effects of exposure of the school community to the S4F FM programme, during the primary phase

of education, on the choice learners make between Mathematics and Mathematical Literacy later in the FET band.

- Each education district in the Eastern Cape has its own characteristic microecological identity, which implies that the findings of this research cannot be generalised to other districts.
- The initial selection of schools participating in the S4F FM programme was not an experiment, but rather an intervention, with inherent selection biases with limiting implications for robust statistical analysis.
- The quasi-experimental design for inferential statistics pivoted on finding confounding factors that predated the selection into the S4F FM programme in order to eliminate the initial selection bias. The potential to omit an important confounding fact and include less influential ones is always present, with a compromising effect on the analysis output.

These limitations, together with all the elements of the study outlined in the preceding sections, conclude this chapter. I now outline the layout of the entire study.

1.13 LAYOUT OF THE STUDY

This study comprises of six coherent and complementary chapters. All the chapters were distilled into answering the central question of the study: *What changes were brought about through an S4F FM programme in a rural school community in South Africa?* The layout of the chapters is as follows:

Chapter 1: Overview of the study: In this chapter the background, problem statement, rationale for the study, research questions, objectives and the theoretical framework/concepts on which the study is based are outlined. The research philosophy that guides the research methodology is explained under paradigms.

Chapter 2: The theoretical framework, guiding this study, is presented.

Chapter 3: Literature study: In this chapter the literature that addresses the attitudes and perceptions that underlie families', teachers' and learners' practices towards family involvement are reviewed.

Chapter 4: Description of the methodology for data generation, analysis and interpretation.

Chapter 5: Analysis and discussion on the background of FM in South Africa.

Chapter 6: Analysis and discussion of learner performance in Mathematics.

Chapter 7: Analysis and discussion on the perceptions towards Mathematics education.

Chapter 8: The conclusion to the study, with a synthesis of new insights through the integration of all of the above

1.14 CONCLUSION

The introduction to this chapter shows a failing Mathematics education system in the primary phase in South Africa. Linked to this failure is the high learner dropout rate, particularly in Grades 10 and 11. Also associated with poor Mathematics education is a lower uptake of Mathematics compared to Mathematical Literacy. Consequently, this failure in Mathematics education underlies the plethora of intervention strategies many institutions, including the Department of Education, have undertaken to help mitigate the worsening situation. My interest in this study is in an intervention that seeks to positively change attitudes towards Mathematics, which should manifest themselves in participation and performance in the subject. However, during the exploration of the literature on the theoretical framework, I began to gain further insights into the statement of the problem.

The theoretical framework that is derived from four models and theories provided me with the lens and guidance through which I approached both the literature study and the empirical work that is to follow. The four models and theories include the Hoover-Dempsey and Saunders model on parental involvement, Vygotsky's sociocultural theory, social constructivism, and Epstein's overlapping spheres of influence.

Through the lens of the derived theoretical framework, the research questions directed the study, which when answered would satisfy the objectives of this study. In the end, the study would satisfy the overall aim of this study: *to explore and describe the changes brought about through an S4F FM programme in a rural school community in South Africa.*

In the chapters that follow, the study unfolds in line with the research design explained earlier in this chapter.

CHAPTER 2: THEORETICAL PERSPECTIVE

2.1 INTRODUCTION

In this chapter, the theoretical concepts which I briefly introduced in Chapter 1 (cf. 1.6.5), and which guided this study, are explained in detail. They are also synthesised into a single model that serves as the theoretical framework for the research. To appreciate the rationale that informed the choice of the theoretical models for this study, one needs to first understand the nature of the Family Math programme (FM) within the context of the primary objective of this study. Secondly, the reader should comprehend the generic aims of the FM, which involve different components of the school community as role players.

The primary objective of this study is to explore and describe the changes brought about through FM in a rural school community in South Africa. At the onset, the originators of the FM were concerned with the marginalisation of vulnerable groups like women and children, especially in minority groups, resulting in these group's poor participation and performance in Mathematics (Kreinberg, 1989: 127) by these groups. Austin and Webb (2011: 53) list the aims of FM in South Africa as trying to redress the inequalities of the education system, and demystifying the myth that Mathematics is complicated and therefore meant for a select few. Another aim is to make the subject relevant to learners' everyday lives. These aims are achieved, according to the two authors, by providing opportunities to learners, teachers, children's family members (referred to as families hereafter) and community members to solve Mathematics problems through discussion, and the use of a hands-on, minds-on, process-oriented method of learning. A theoretical framework that would provide for school activities that promote the involvement of families and communities to children's education, and guide families' activities of engagement in their children's academic activities, would be suitable for this study. I enunciate the models that meet this criterion in the following section.

The Hoover-Dempsey and Sandler model (1997: 4) relates to the understanding of the psychological and social factors, which play a role in families' decision to participate in children's education. Secondly, I considered a complementary model, the overlapping spheres of influence model (Epstein & Sanders, 2006: 86), for the way it makes family involvement practical. Thirdly, to address the interaction of families and children in the

context of FM being about Mathematics education, I bring into focus theories that guide learning processes both inside and outside the classroom. Vygotsky's Sociocultural Theory and Constructivism guided aspects of this study that sought to understand the process of learning Mathematics. However, it is important to note that the term "constructivism" is used both as a paradigm and as a theory of learning (Liu & Matthews, 2005: 386). Given the dualistic use of the term, I draw the attention of the reader to the two ways I use it in this study. The first (cf. 2.2.2) is as a philosophical worldview or paradigmatic lens through which I approach aspects of this research, while the second (cf. 2.5.1) is as a theory of learning used in conjunction with Vygotsky's Sociocultural theory to provide a guide on learners' construction knowledge. Below I outline the paradigmatic and theoretical disposition that underpin this study.

2.2 PHILOSOPHICAL CONSIDERATION

Merriam (2009: 8) emphasises the importance of positioning a social research endeavour among other research forms. This positioning is necessary because philosophical worldviews, although hidden at times, influence the practicalities of research (Creswell, 2009: 5). Such positioning, according to Merriam (2009: 8), entails the researcher's declaratory statements about his/her beliefs regarding the nature of reality and knowledge. A set of assumptions about the nature of reality, ontology, nature of knowledge, epistemology, methodology, and strategies of gaining knowledge, constitute a paradigm (Scotland, 2012: 9). I therefore argumentatively discuss constructivism in this chapter. The aim is to position this study in a way that transcends the boundaries philosophical purists place around each of them (Johnson & Onwuegbuzie, 2009: 14), and to build towards mixed methods and pragmatism as an appropriate paradigm (Subedi 2016, p.571).

2.2.1 PRAGMATISM

The focus of pragmatic inquiry is on knowledge as an imperfect and dynamically revised product of experience (Biddle & Schafft, 2015: 323–324). What the researcher seeks to achieve with pragmatism dictates the methodology of research, rather than the other way round (Biddle & Schafft, 2015: 323–324). For this reason, pragmatism is considered as the most appropriate philosophical support for the use of more than one methodology in a single research project (Maarouf, 2019: 5–6). In other words, as Maarouf (2019: 5–6) points out, pragmatism is concerned about what works to understand the phenomenon

under investigation, and focuses on finding solutions for practical problems. The reader must bear in mind that pragmatism does not advance philosophical arguments, a weakness which the critics of this worldview emphasise (Maarouf, 2019: 5–6). The discussion below highlights how pragmatism transcends the divide from two opposite extremes, namely post-positivism and constructivism.

- The ontological assumptions of positivism are that an objective reality exists in our world, waiting to be discovered, which is independent of the researcher and the researched (Merriam, 2009: 8). The truth, as positivists see it, is generalisable independently of time, place, and context, and generally summed up as cause and effect (Guba, 1990: 20). Epistemologically speaking, positivism assumes that knowledge is absolute and exists in objective reality (Scotland, 2012: 10). Post-positivists (Kirby, 2013: 97), influenced by the thinking of Karl Popper, do not align themselves with absolute truths, but rather claim that an approximation of the truth can be established with a certain level of probability. The researcher eliminates biases, values, and confounding factors during an endeavour to uncover knowledge about what reality is and how it works (Guba, 1990: 20). The researcher, while attempting to discover this knowledge, takes an impartial stance (Cohen et al., 2007: 11). In this regard, Guba (1990: 26) points out that subjectivity, as one of the contradictions between (post)positivist and constructivist epistemologies, is the only way that an enquirer can understand the meaning of the constructions people possess. It therefore requires methodologies that allow for that subjective interaction between the researcher and the researched.
- Methodologically, positivists and post-positivists advance propositions which they empirically work to confirm (in the case of positivism) or disconfirm/refute (in the case of post-positivism), through measurement and experimentation with firm control of the confounding variables (Guba, 1990: 20). Both of these approaches are reductionist, because the intention is to reduce the thoughts into small and discrete beliefs that are then subjected to empirical tests (Creswell, 2009: 7).
- In contrast, constructivist ontology assumes that subjective reality is that which people understand, based on their life and work experiences (Creswell, 2009: 8). As a result of lived experiences, these vary from one person or group to another, leading to a multiplicity of meanings. In effect, (post)positivism therefore differs from

constructivism in that the former is premised on a certain level of objectivity, theory verification of refuting, and the determination of a cause and effect relationship. The latter focuses on subjectivity, theory generation, and understanding. Empirical experimentation and measurement, as opposed to social and historical construction, constitute further epistemological differences between (post)positivism and constructivism, respectively (Creswell, 2009: 6). Procedurally, constructivists proceed to uncover the participants' meanings in their diversity (Cohen et al., 2007: 187). In other words, as Johnson and Onwuegbuzie (2009: 18) state, theory generation, induction, and the inquirer as the primary instrument of measurement, characterise constructivist methodology.

- Johnson and Onwuegbuzie (2009: 14) suggest that purists on each end of the spectrum believe that the two philosophies are irreconcilable. Positivist purists believe that social observations should be viewed and pursued as tangible units in the same way realists treat physical phenomena (Johnson & Onwuegbuzie, 2009: 14). As such, in educational research such as the current study, the researcher should remain emotionally detached from the researched, exclude his/her biases, and merely proceed to either accept or reject the hypothesis.
- However, Guba, whom Johnson and Onwuegbuzie (2009: 14) considered a constructivist purist, concedes that no paradigm can be dismissed out of hand because, at the final analysis, no paradigms are value-free (Guba, 1990: 23). Guba (1990: 23) argues that activities of enquiry, such as selecting a problem to research, choosing a paradigm lens for that study, construction of instruments for measurement, analysis, interpretation, and conclusions are all human constructs, irrespective of the philosophy of research. As such, these social constructs reflect human values.
- Consequently, Johnson and Onwuegbuzie (2009: 116) assert that it is useful to examine education research questions from multiple perspectives in order to harness their complementary nature and benefit from the strength of each. In any case, the dividing lines between methodological positions are blurry, and the practice of utilising both quantitative and qualitative research has been in place for some time (Johnson et al., 2007: 117). The practice has been called different names like "*blended research, integrative research, multimethod research, multiple methods, ethnographic residual analysis, and mixed research*" (Johnson et al., 2015: 118). The strategy is now called

mixed methods (Creswell, 2009: 66; Collins et al., 2006: 69). The mixed method is discussed in Chapter 4.

In summary, pragmatism refers to what is practical and what works of the philosophies outlined, it guided the types of questions I asked, the manner in which participants were to understand the questions, what data was collected, and the procedure for interpretation of research results to develop answers to the research questions (Bergman, 2010: 172; Cohen et al., 2007: 172). As such, I use the pragmatic point of departure as unifying structure, which contains the theoretical framework, beliefs, assumptions, principles and values, that form the basis for making sense of the problem statement for this study (Bergman, 2010: 172). Mack (2010: 5) points out that the ontological and epistemological positions from the philosophical worldview lead to the researcher's theoretical perspective for a specific research effort. I therefore proceeded to discuss the theoretical perspective of the study below.

2.3 THEORETICAL PERSPECTIVE

In social science research, as in this study, the theoretical perspective serves as a directing lens to study research questions (Creswell, 2009: 235) empirically. Rocco and Plakhotnik (2009: 7) make a distinction between two concepts, theoretical and conceptual framework, that are often used interchangeably (Imenda, 2017: 186). A conceptual framework situates the study within a body of the relevant knowledge base, which grounds the importance of the problem statement and research questions. A theoretical framework, on the other hand, is used when investigating a specific theory (Rocco & Plakhotnik, 2009: 7). That is, a conceptual framework is appropriate when the researcher believes that the research question cannot be answered when only one theory, or concepts derived from a single theory, is used (Imenda, 2017: 189). Still, as I principally use the theories complementary, I will refer to it as a theoretical framework or simply a framework. Consequently, the discussion below, on theoretical perspective, builds towards a theoretical framework for the study.

In this study, a framework derived from four different models and theories guided the study in its entirety (cf. Figure 1-4). The models include the Hoover-Dempsey and Sandler model (Hoover-Dempsey & Sandler, 1997: 4), Vygotsky's Sociocultural theory (Jaramillo, 1996),

constructivism (Fosnot & Perry, 1996: 25) and Epstein's overlapping spheres of influence (Hornby & Lafaale, 2011: 39)

2.3.1 HOOVER-DEMPSEY AND SANDLER MODEL

In this study, the Hoover-Dempsey and Sandler Model is used to understand family members' motivation for involvement in children's education at home. However, it is important that the family members' involvement at home is explained. The all-encompassing concept of parental involvement with implicit reference to parents' efforts to be actively involved in their children's education (Suleyman, 2012: 175) is further teased out into two forms of involvement, namely home- and schools-based (Kim & Hill, 2015: 920 & Green, Walker, Hoover-Dempsey, & Sandler, 2007: 534). This study is interested in home-based family involvement. Home-based involvement, according to Kim and Hill (2015: 920), includes such activities as helping with homework, visits to public educational places like museum, conversations with children about family expectations and goals regarding children's education, and creating a conducive environment at home for learning to take place. Green et al. (2007: 534) describe home-based parental involvement in more general terms as the interaction between family members and their children outside of the school.

I have chosen this model for this study mainly for its wide-ranging nature in dealing with factors that influence the decision-making of getting involved (Anderson & Minke, 2007: 312). The fact that the model is supported by both qualitative and quantitative research studies (Anderson & Minke, 2007: 312; Green et al., 2007: 535; Hoover-Dempsey et al., 2001: 201; Lavenda, 2011: 529) further motivated its choice. The original model, Figure 1-1, was put forward in 1995 (Hoover-Dempsey & Sandler, 1995: 17) and revised in 1997 (Hoover-Dempsey & Sandler, 1997: 3).

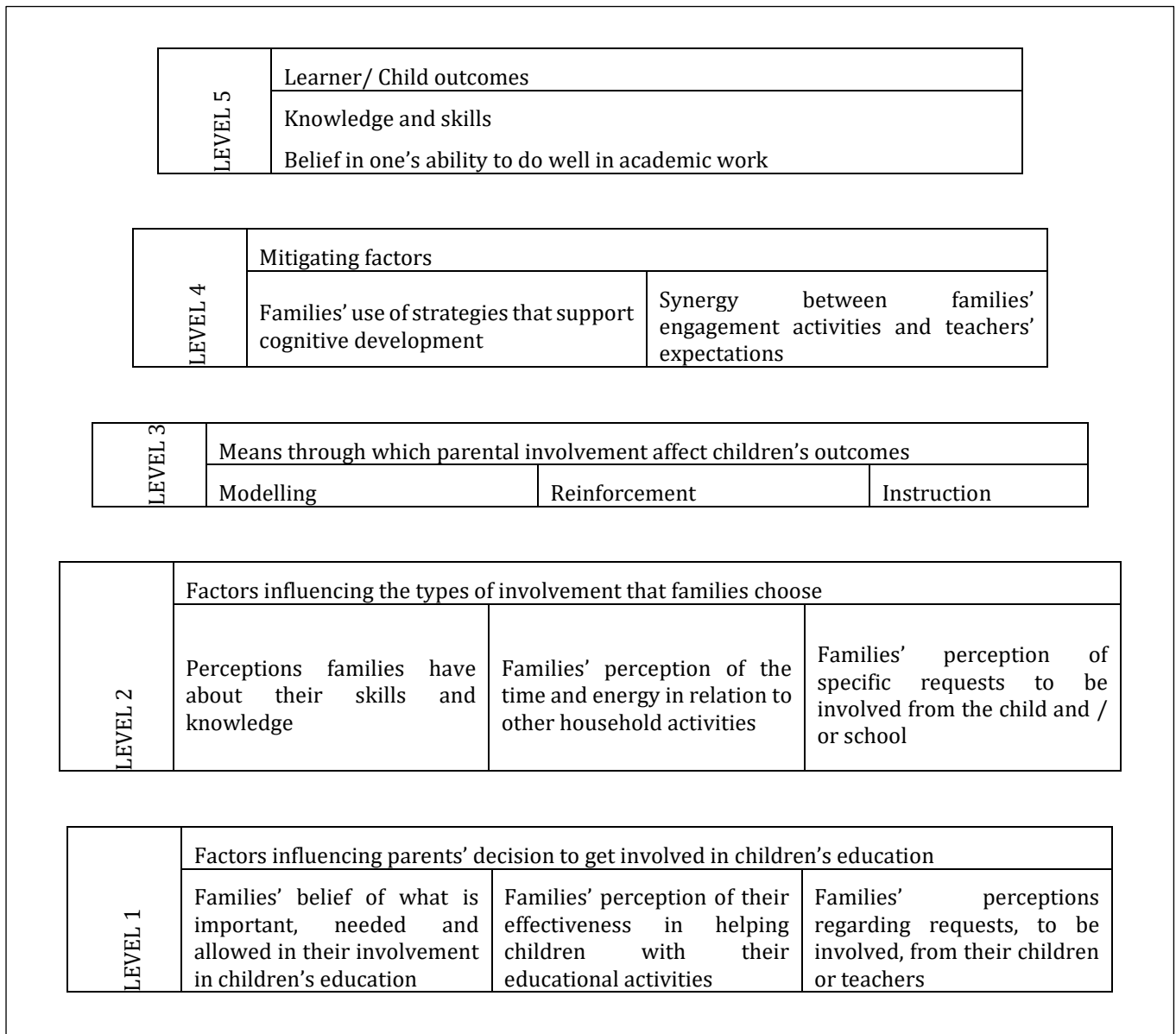


Figure 2-1: The Hoover-Dempsey and Sandler model (Hoover-Dempsey & Sandler, 1997)

The Hoover-Dempsey and Sandler Model (Hoover-Dempsey & Sandler, 1997: 4) on the motivation for parental involvement is a five-level representation of families' activities of involvement. The levels range from the decision to get involved, at level one, to the outcomes of involvement at level five. The factors that are involved in the decision to get involved, according to Hoover-Dempsey and Sandler (1997: 3), include:

- Families' role construction, which entails the parents' beliefs about their role in their children's education. Empirical evidence suggests that role construction is the leading predictor of home-based parental involvement (Lavenda, 2011: 928)

- Parents' sense of self-efficacy involves the degree to which families believe that their involvement can yield the desired educational outcomes
- Resources at the disposal of the parents at home
- Specific invitations from children, teachers or both focus on perceptions about whether their involvement is required or not

The next step that follows the decision to become involved in the child's education (Hoover-Dempsey & Sandler, 1997: 3) are the types of involvement the parent chooses to engage in. The Hoover-Dempsey and Sandler model places the factors that influence the type of involvement in level two. These factors are considered as contextual (Green et al., 2007: 535; Walker, Wilkins, Dallaire, Sandler & Hoover-Dempsey, 2005: 87; Hoover-Dempsey & Sandler, 1997: 3). They include families' perceptions of their competencies and knowledge, families' perception of the time and energy regarding other household activities, and families' perception of specific requests to be involved from the child and / or the school (Hoover-Dempsey & Sandler, 1997: 4).

With regards to the first factor, families are likely to engage in the educational activities of the child in areas where they perceived themselves to be competent (Green et al., 2007). Perception about these competencies and knowledge, according to Green et al. (2007: 534), should not be confused with the families' self-efficacy mentioned in level one. The two are both practically and theoretically distinct in that individuals with the same competencies and knowledge may perform differently, depending on their perceived self-efficacies (Green et al., 2007: 534).

The second factor that influences involvement is the families' perception of the time and energy needed for their involvement, against other household activities and families' work demand (Green et al., 2007: 535). In families with a larger number of children, and in situations where children are from extended families, parental involvement tends to be lower (Anderson et al., 2007: 312; Green et al., 2007: 535; Walker et al., 2005: 87).

Families' perceptions of the request from others to become involved constitute the last of the factors influencing the type of involvement. Anderson et al. (2007: 319) report that there is an interplay between these invitations and role construction mentioned in level one of the model. The interplay between the two is such that families' role construction

determines their involvement behaviour according to invitations from others to become involved (Anderson et al., 2007: 319). These invitations generally come from the school, from a specific teacher or directly from the child (Green et al., 2007: 536). Perceptions of whether the parent feels welcomed by the staff at school influences the type of involvement that a parent may engage in. How the parent perceives the request to become involved by a specific teacher, coupled with a specific request from the child, also influences the type of involvement. Lastly, the perceptions of invitation from the child influence the parent at two levels, first, whether or not to become involved, and then type of involvement (Walker et al., 2005: 96).

In summary, the Hoover-Dempsey and Sandler model (1997: 3) model advances three bases for families' motivation to become involved in their children's education. The first is the beliefs that families have about their role and efficacy when assisting the child. The second is perceptions regarding general invitations by the school and specific invitations by the teacher and the child. The last is the families' specific contexts, which include competencies and knowledge for involvement, and the time and energy demands required to be invested in such involvement.

The overview of the Hoover-Dempsey and Sandler model (1997: 3) lays the basis for understanding the factors that facilitate or hinder family involvement in their children's education. The psychological and socioeconomic factors advanced by the model should be able to equip an involvement practitioner with the necessary strategies to mitigate against the potential hindrances to involvement. The next model I consider deals with the practical strategies aimed at encouraging family involvement in children's education. I make use of Epstein's model of overlapping spheres of influence (Epstein & Sanders, 2006: 86) to proceed from where the Hoover-Dempsey and Sandler model (1997: 3) leaves off. The focus here is to provide practical involvement strategies.

2.3.2 OVERLAPPING SPHERES OF INFLUENCE

The model of overlapping spheres of influence has been used to explain how schools, families and community collaborate to support children's education (Epstein & Sanders, 2006: 86). The model posits that learning is enhanced when school, home, and community work together to improve education provisioning for children (Epstein & Sanders, 2006: 87). The school, home, and community represent the three spheres of influence, which have

a mutual interest in children's academic success (Sanders & Epstein 1998: 2). The more the spheres overlap, the higher the opportunity for academic success. Conversely, the more separate they are, the less the likelihood of academic achievement (Epstein, 2009: 81). Sheldon, Epstein and Galindo (2010: 31) argue that the overlap of the three spheres is a function of three belief systems espoused by the school, family and community. First is the degree to which families and schools believe that together they are part of the same shared community, with congruent aspirations about the education of the children. Second is the extent to which both institutions appreciate the importance of support for education. Lastly is the scope of cooperation that exists in the work of assisting children in learning and succeeding in their education.

The overlap or lack thereof, depends on the frequency and quality of communication from the side of the school to engage families in their children's education (Epstein, 2009: 82). Patel and Stevens (2010: 117), on the other hand, assert that the three spheres of influence are also pulled apart when there are very few or no shared goals amongst individual family members within the community. The two authors reason that individual family members' practices, developmental features, histories and policies determine the extent to which individual family members harbour common goals about their children's education. Whatever the cause of the separation of the spheres, the consequences are that the children get conflicting messages from the school, home, and community. This leads to confusion and lessened opportunities for optimal learning (Patel & Stevens, 2010: 117; Epstein, 2009: 82).

Epstein (2009: 81) apportions a greater responsibility of continuity amongst the three spheres on the schools' partnership programmes. Concisely, the more often schools engage in quality communications with family members, the more likely it is that the three spheres will act together. To help schools manage their partnerships with families and community, Epstein proposes a model of six types of involvement (Epstein, 2009: 85; Sheldon & Epstein, 2001: 197). Epstein (2016: 43) developed these types of involvement from the experience of years of working in the arena of family involvement in the education of their children. The involvement types include parenting, communicating, volunteering, learning at home, decision-making, and collaborating with the community. Each of these has a variety of activities, challenges and opportunities for learners if implemented (Epstein & Sanders, 2006: 88). Each school, therefore, is required to implement any one or more of the

involvement types, which is best suited for the contextual circumstances of the community where the school is located. It is worth mentioning, though, that Sheldon et al. (2010: 43) reported on studies which suggest that even in schools where this have been implemented, there is hardly any engagement in activities focused on enhancing Mathematics education. While these authors do not suggest possible causes for this observation, I contend that with concerted efforts to empower families and teachers on family involvement, as is the case with Family Math by the UFS, a different outcome is possible. I expand on each of the six involvement types below, about the activities involved and challenges associated with each, starting with parenting.

2.3.2.1 PARENTING

In this type, families engage in activities to establish home environments to support children as learners, and assist families in understanding child development. Other activities are directed at parent education and training for families to raise awareness about social wellness issues like health and nutrition. Home visits, particularly during the transition phases from foundation to intermediate, senior, and further education and training phases, also form part of a partnership programme to raise the level of parenting (Epstein, 1996: 46). As in the other five types of involvement, the model envisages some inherent challenges that may hinder its effectiveness.

The challenges include the need to ensure that the information intended for families reaches all of them, not only those who attend meetings or workshops. The second challenge is in creating a rapport with families so that they can share culture, values as well as their children's strengths, weakness, and talents. The last challenge is that the information flow from and to families is unambiguously intended for enhancing the children's learning process (Epstein, 1996: 46).

2.3.2.2 COMMUNICATING

With communicating, schools should design useful forms of school-to-home and home-to-school communication about school programs and children's progress. To achieve this interconnectivity, schools need to arrange a parent conference at least once a year, besides the parent, child, and teacher conference that should take place with the issuing of report cards. Translators should be available to assist families who do not understand the language of teaching and learning. Schools should also periodically prepare learner

portfolios for perusal and comment by families. At regular intervals, schools need to prepare and send memoranda, newsletters and cell phone messages to families, which at appropriate times must include the curriculum offerings of the school for each grade (Epstein, 1996: 46). These activities seem to add to a challenge of paperwork and additional preparation to communicate with families.

As a whole, communicating presents a challenge, as schools need to have live systems for the evaluation of all forms of communication to families, and also for incoming communication from families (Epstein, 1996: 46). Due consideration should also be given to families who might not be conversant with the language of teaching and learning at the school, especially during contact conference sessions. The utilisation of volunteers from the community can help the school in communicating with families.

2.3.2.3 VOLUNTEERING

Regarding volunteering, schools recruit and organise parental help and support from willing and capable community members. For example, families may be recruited to aid in school patrols to enhance safety at the school. However, the scope of volunteer recruitment should be wide enough that the help is dedicated to different components of the school community. At least once a year the school should embark on a campaign to identify expertise, time, and suitable venues through the use of mini surveys. Times and venues might pose a challenge of coordination between volunteers.

Other challenges may include the perception of some community members that they are not appreciated at school because they have not been recruited to volunteer. Finding a match between the needs of learners, teachers or families on the one hand, and the available volunteer talents on the other, can also be difficult.

2.3.2.4 LEARNING AT HOME

Schools provide information and ideas to families about how to help learners at home with homework and other curriculum-related activities, decisions, and planning. Skilling families with strategies on how to monitor progress, encourage children, and assist them with their homework are also relevant here. Teachers should also regularly give homework to children that would require discussion with family members at home.

To coordinate activities with individual teachers in order to design homework activities that will require family participation, may be difficult in the intermediate and senior phases of primary education. The difficulty lies in the fact that one learner is with more than one teacher during the day. If teachers have not been trained in this during their teacher training years, or through in-service training, they find it difficult to implement (Epstein, 1996: 46))

2.3.2.5 DECISION-MAKING

Schools should include families in school decisions by developing parent leaders and representatives through School Governing Bodies (SGBs) or other parent organisations, advisory councils, or committees (e.g., School Safety Committee) for parent leadership and participation. The strategic position of district-level bodies such as District Based Support Teams (DBST) and other temporary district task teams should also be harnessed in a way that improves decision making at the school. Challenging as it might be, schools should also to do more to nurture collaboration between families and SGBs and enhance inclusiveness among learners, families, and communities.

To include learners in decision making alongside their families in an intergenerational mix may prove elusive. It might be a challenge, in a socioeconomically diverse community to elect parent-school representatives with a reasonably broad appeal to the majority of families.

2.3.2.6 COLLABORATING WITH COMMUNITY

Resources and services from the community to strengthen school programs, family practices, and student learning should be identified, integrated and developed by, amongst others, providing information for learners and families on community health, cultural, recreational and social support, and other programs or services (Epstein, 1996: 46). The school needs to position itself to be of service to the community by becoming the centre of information dissemination. As such, the school should distribute information about community activities like cultural events, recreational occasions and social and governance gatherings. The school can also utilise and collaborate with the alumni on issues of improving the quality of learning, both at school and at home. These activities of collaboration with the community often pose challenges that the proponents of the model foresaw.

One challenge is aligning community activities with the goals of the school as far as teaching, learning and assessment are concerned. Further, the school may not be in a position to mediate in turf contestations amongst interest groups within the community. Collaborating with the community, like all the other types of involvement, can be fraught with challenges.

The overview of these types of involvement indicates that they are practical and implementable, despite the challenges associated with them. Epstein (1996: 46) does not provide silver bullet solutions for the challenges envisaged in the model. However, the author urges that solutions to the challenges be found for the benefits of each to be realised. The benefits might not necessarily be improved learner marks, but hopefully improved attitudes towards learning (Epstein, 1996: 46). In the context of the present study, this model provides the lens through which schools' attempts to involve families in the Mathematics education of their children is viewed. That is, it would be interesting to understand, from the viewpoint of the learners and teachers and family members, how close or separate the three spheres of influence are, as a result of the S4F FM programme. I am further interested in understanding the activities of family engagement, now that the factors and strategies that play a role in getting the families involved in the first place are understood. I use two theories of learning to unravel the actual learning process that emerges out of the engagements, both at home and in the classroom. The theories are Vygotsky's Sociocultural Theory and social constructivism.

2.3.3 VYGOTSKY'S SOCIOCULTURAL THEORY

Vygotsky's Sociocultural theory is an educational theory that serves the purpose of explaining the human phenomenon of learning and providing a conceptual framework for clarifying how and why we learn (Jaramillo, 1996). This theory applies to research on parental involvement and academic achievement (Marshall & Jackman, 2015: .85). The sociocultural theory is used in this study to to understand the process of learning Mathematics in a social setting primarily at home and in the classroom. How learning takes place, according to Vygotsky (1978) as cited in Louis (2009: 20) is explained in this theoretical concept.

Vygotsky (1978) as cited in Louis (2009: 20) posits that cognitive development takes place through culture, language and social interaction. The interplay amongst these three elements is such that social interaction is facilitated by language, while culture nurtures

cognitive development during social interaction. In other words, learning takes place as two or more people converse (social interaction) in a language understandable to both or all of them, within a given cultural setting. Further, according to Vygotsky (as cited in Louis, 2009: 20), there are three processes through which cognitive development takes place, and social interaction is a prerequisite for all of them. The three processes are the Zone of Proximal Development, Scaffolding, and Psychological Tools. In the section below the first two processes are explained, as they relate to the present study.

2.3.3.1 THE ZONE OF PROXIMAL DEVELOPMENT

The Zone of Proximal Development (ZPD) is defined differently by different authors. Wang and Bruce (2010: 298) and Pinxten (2016: 192) describe it as a distance between actual development, governed by independent problem solving, and potential cognitive growth that is achievable under the guidance of a more proficient adult or peer. Salonen (2013: 632), on the other hand, defines the ZPD as the difference between a child's actual development level and the potential development under guidance. This author goes further to add that, in essence, this is the interaction between the child's everyday and academic concepts. It is, however, a description of ZPD given by Louis (2009: 20) that brings more clarity to the concept. This author describes it as the range of difficulty of tasks that are too hard for the learner to complete without assistance from an adult person. Cognitive development will only occur when the learning person is confronted with tasks that fall within this range. Tackling a task that is either too easy or difficult, that is, a task that falls outside the range of ZPD, will not result in cognitive development.

2.3.3.2 SCAFFOLDING

Scaffolding, the second concept in the sociocultural theory, describes the nature of assistance provided by a more knowledgeable person (Louis, 2009: 20). With scaffolding, the learner accrues the most significant benefit in cognitive development from the assistance of a more knowledgeable person if the support is high at first and should be scaled down as skills and competency levels improve. The timing and appropriateness of the degree of assistance become essential when scaffolding is applied (Pishghadam & Naji, 2011: 73). Scaffolding should be applied within the learner's ZPD (Louis, 2009: 20; Pishghadam & Naji, 2011: 74). In other words, the task that a learner tackles, on which he/she needs scaffolding, must be of such difficulty that the learner will not be able to complete it alone, but with the assistance of a more knowledgeable person. Eventually the

ZPD is extended, or a new one is created (Engin, 2014: 27). González-Calero, Arnau, Puig and Arevalillo-Herráez (2015: 1191) caution against the inappropriate utilisation of scaffolding because little or no learning takes place under such circumstances. It is therefore essential to understand the exact behaviours and activities that underpin the process of scaffolding. To this end, Anghileri (2006: 34), and Fernández-Cárdenas, Wegerif and Mercer(2001: 46) list six behaviours that a tutor should engage in during scaffolding.

The first is focusing the learners' attention and interests in the requirements of the learning task to be tackled. In a manner akin to social constructivism, the tutor groups learners to foster a discussion and engages them in an interaction that leads to a shared understanding of the problem. The second is simplifying the task to a level that the learners can manage, with the view of feedback and correction in mind. The different tasks or steps required to solve the problem are given to different groups, to reduce the complexity of the problem. The third is motivating, keeping in focus and guiding the activities of the learners towards the desired goal. This motivation, amongst others, is achieved through encouraging conversations amongst group members. Next, the tutor should highlight essential aspects of the tasks for the learners by affirming and pointing out discrepancies. It is important that the tutor does, and is readily available to, point out these important aspects. If not, it may happen that the wrong pointers are highlighted. The fifth is that the tutor should respond to the learners' emotional state by controlling frustration and fear of failure. Individual frustration and fear of failure are reduced in the group and are instead shared. Lastly, the tutor should demonstrate a general solution to the task. Learners should be encouraged to talk about how, in general, problems similar to the one they are facing could be solved. This demonstration leads to a shared understanding of the solution to the problem.

In general, these behaviours and activities suggest that the interactions are between a more competent or knowledgeable person (teacher, peer or parent) and a learner, as has been the tradition since the advent of the concept of scaffolding (Sherin, Reiser & Edelson, 2004: 387). However, scaffolding has been noted even in symmetrical situations. Fernández-Cárdenas, Wegerif & Mercer (2001: 69), for example, found that children who are at the same level of understanding and reasoning, can mutually support each other's cognitive development through discussion. These authors have termed this phenomenon as symmetrical scaffolding to distinguish it from the traditional scaffolding between a more skilled person and a learner. Mutual scaffolding between learners has also been reported in

the development of language skills (DeGuerrero & Villamil, 2016: 54). Another form of scaffolding which is of interest to this study is the one that takes place between a child and a parent or family member. Interest in parent scaffolding arises out of the fact that one of the primary aims of the S4F FM programme is to empower family members to assist their children with Mathematics learning at home.

Empirical evidence suggests that parent scaffolding is positively correlated with ten-year-old children's academic achievement in Mathematics, both in immediate and extended terms (Mattanah, Pratt, Cowan & Cowan, 2005: 101). In concurrence, Vandermaas-Peeler and Pittard (2014: 501) report that parent scaffolding behaviours are positively related to the children's development of numeracy skills in the foundation phases of education. The positive association between improved children's Mathematical skills and parent scaffolding seem to emanate from a helping family member's Mathematical knowledge and self-concept (Dumont, Trautwein, Nagy & Nagengast, 2014: 146). In contrast, Epstein and Van Voorhis (2001) as cited in Dumont et al. (2012: 163) found that socioeconomic background does not predict the frequency of family members' involvement with Mathematics homework. Mattanah et al. (2005: 101) further suggestively attribute the observed positive association between parents' scaffolding behaviours regarding Mathematical learning to the enhancement of the child's motivation. The families' scaffolding behaviours, therefore, need to be understood in some detail. In the section below parents' scaffolding behaviours are explained in the context of learning artefacts, since learning artefacts form an integral part of the S4F FM programme of the present study.

The exact details of the activities of the parent when scaffolding a child are described in Wood, Petkovski, De Pasquale, Gottardo, Evans & Savage (2016: 5). These activities involve physical, verbal, emotional-verbal and emotional-physical support given to a child. Sherin et al. (2004: 388) define learning artefacts as objects that have been designed or adapted to support learning. Learning artefacts include cultural tools such as charts, puzzles and measuring apparatus (Anghileri, 2006: 40). Technological tools such as calculators and computer software are also considered to be learning artefacts (Sherin et al., 2004: 388). Parent scaffolding using these artefacts, as described by Wood et al. (2016: 5), include holding the artefact for the child and pointing out some important features that may be necessary for completing the task. Verbal support is another form of parent scaffolding behaviour where the parent vocalises instructions and / or the steps required to complete

the task. The third parent scaffolding behaviour using learning artefacts is emotional-verbal, where the parent vocalises sounds of praise, encouragement and excitement. Lastly is the emotional-physical support that a parent gives to a child, which includes physical actions such as the clapping of hands or patting the child on the back.

Overall, Vygotsky's Sociocultural theory places social interaction at the centre of the learning process. Social interaction, as defined, occurs in the classroom, at home and in the community, and by extension, learning takes place in these situations too. Epstein's model of overlapping spheres of influence (Epstein & Sanders, 2006: 86), which encompass the school, home and community, are also foci of learning. These should not be in discord, as it may confuse the child. Further, the concepts of the Zone of Proximal Development and Scaffolding provide guidance on how social interaction should proceed if optimal learning is to be realised. Another theory, which is an extension of Vygotsky's Sociocultural theory, is social constructivism (Liu & Matthews, 2005: 388). It goes further to explain how new knowledge is acquired in the context of pre-existing knowledge. In the next section I briefly discuss social constructivism under the broader learning theory of constructivism.

2.3.4 CONSTRUCTIVISM

Social constructivism assumes that individuals search for understanding of the environment in which they live or work (Creswell, 2009: 8). Individuals develop experiences based on the interaction with their environment, leading to different interpretations and meanings. The different interpretations and meanings are socially shared through person-to-person interaction. Historical and cultural contexts of community service act as a springboard on which individuals make sense of their environment (Creswell, 2009: 8).

Constructivism, as a theory of learning, focuses on cognitive development and understanding, rather than characterising stages of development and maturation as espoused by behaviourism and maturationism theories (Fosnot & Perry, 2005: 11). There are various forms of constructivism found in the literature (Fosnot & Perry, 2005: 11), and there are contestations among them. Von Glasersfeld (1995: 191), a radical constructivist, rejects the idea of negotiated meaning and holds that each learner has his/her knowledge or preconceptions that he/she brings into the learning process. The role of the teacher, according to radical constructivism, is to assist the learner in creating this knowledge

(Pinar, 2010: 142). Radical constructivism, therefore, believes that the development of knowledge is an individual endeavour rather than the co-construction of knowledge as envisioned by social constructivism. Varied as they are, one theme connects the various versions of constructivism, and that is that new knowledge is built from pre-existing knowledge (Dennick, 2016: 200). Dennick (2016: 202), arguing in favour of social constructivism, points out that by the time a child goes to school, he/she has some experience about light, the physical world (water, soil, temperature, light) the natural world (plants, animals) and heat. Therefore, teachers should make an effort to understand the learners' point of view through interaction with them.

2.4 THE DERIVED THEORETICAL FRAMEWORK

The derived theoretical framework for the present study is based on the models by Hoover-Dempsey and Sandler (1997: 3) and Epstein and Sanders (2006: 86), as well as Vygotsky's Sociocultural theory (1978) as cited in Louis (2009: 20), and also social constructivism theories. This synthesised and integrated framework begins with the unravelling of the thought processes, and factors influencing them, that a family member engages in before involvement in the education of the child. The framework goes on to explain the importance of synergy among the learning environments that surround a child. Of these environments, the theory places the school at the centre, for creating a collaborative atmosphere amongst the school itself, family and community, which collectively constitute the child's learning environments. The school plays the role of synergising the learning environments through categorised involvement activities targeted towards both the family members and learners.

The implications for the S4F FM programme are that the training of teachers needs to take into account the personal context, and psychological and socioeconomic factors of families in the community where the school is located. Doing so may help provide the school with the basis on which to construct involvement activities, and make family involvement an ongoing school-wide project. In an attempt to assist in the sustainability of involvement endeavours, the framework advances some potential challenges for each type and encourages schools to expect and deal with them whenever they arise, thus diminishing the chances for despondency. However, improved learner attitudes and perceptions towards Mathematics learning, leading to better marks, can also play a significant role in the

sustainability of involvement activities by the school, as these provide positive feedback to practitioners. Learner marks also depend on the frequency and quality of learning that takes place as a result of involvement activities, and for that, the learning part of the derived theory takes over.

The derived framework emphasises the importance of social interaction in the learning process. Conversations form an integral part of social interaction, and take place in the classroom, at home as well as in the community. All three of these are therefore considered to be learning environments. When training teachers in the S4F FM programme for family involvement, the understanding of the structure of interactions regarding the Zone of Proximal Development and Scaffolding needs to be considered. Another aspect that needs to be taken note of during training, is the appreciation of the knowledge the child brings into the learning process. This should be tactfully nudged further by a more skilful other (fellow learner, teacher, family or community member). Figure 2 below diagrammatically sums up the preceding discussion.

As shown in the figure below, the derived theoretical framework places the school in the centre of the family involvement concept. The centrality of the school stems from the fact that it is strategically placed, both academically and socially, to facilitate family involvement and learners' cognitive development, which again impacts on learners' attitudes, perceptions, and performance. The S4F FM programme, through the school, theoretically influences family involvement and learners' cognitive development.

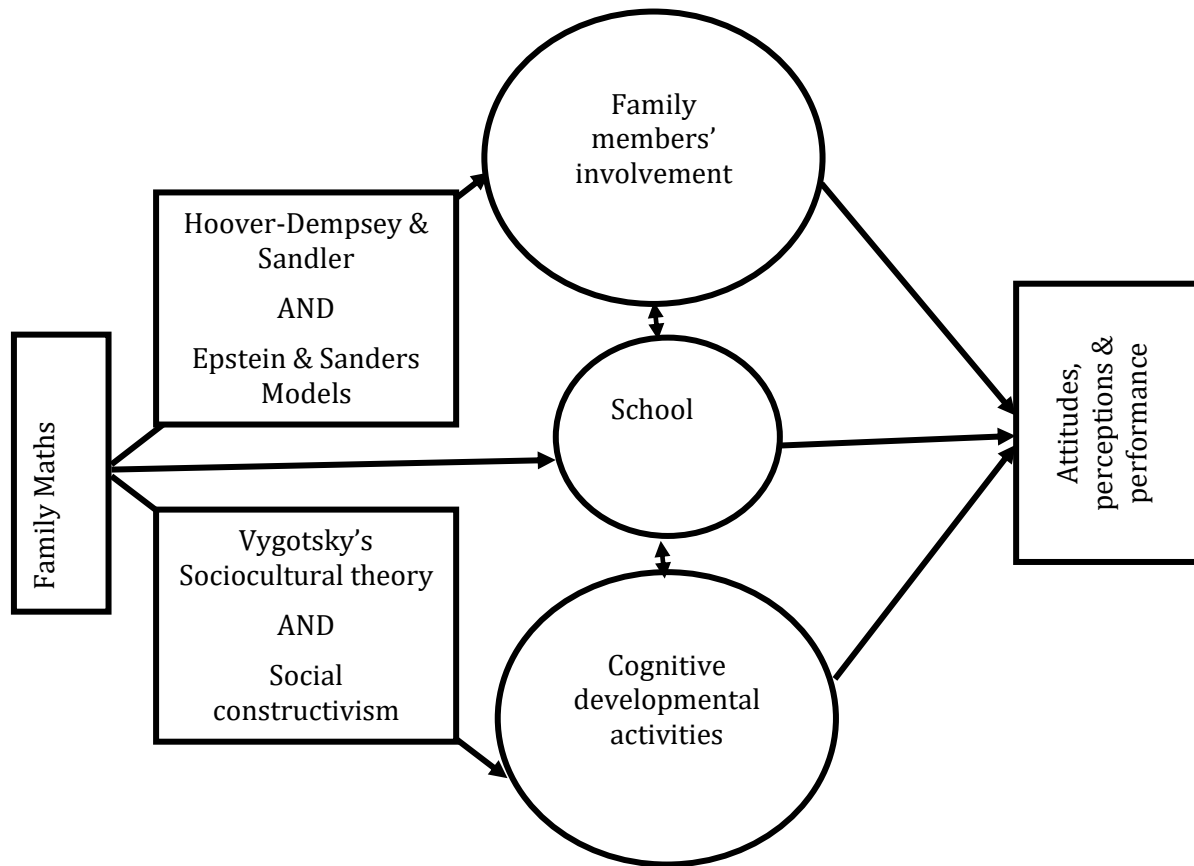


Figure 2-2: The theoretical framework for the study derived from three different theories

Family involvement and the resultant cognitive development ultimately leads to the outcomes that constitute the goals of the S4F FM programme. These outcomes are improved attitudes, perceptions and performance in Mathematics. The empirical work of the present study, therefore, be guided by this derived theoretical framework in terms of data generation, analysis and interpretation. The framing of the research question to participants, the analysis of the transcripts and the interpretation of the multiple perspectives from narratives of lived experiences on family involvement are undertaken informed by the synthesised Hoover-Dempsey, Sandler and Epstein and Sanders models. On the other hand, the elements of research for this study that relate to cognitive developmental activities leading to changes in learners' scholastic achievement are pursued through an integration of Vygotsky's Sociocultural theory and Social constructivism. The above discussion on the theoretical framework also guides the literature study for the study, as is explored in the next chapter.

CHAPTER 3: LITERATURE STUDY

3.1 INTRODUCTION

The overall aim of this study is to *explore and describe the changes brought about by an S4F FM programme in a rural school community in South Africa*. Family Math is one of the programmes of the Science-for-the-Future (S4F) entity at the University of the Free State (UFS). To achieve this aim, I posed three questions to drive the empirical aspect of this research (cf. 1.5). The first question is: what is the background and nature of the S4F FM programme offered by the University of the Free State? Second, what was the effect of the S4F FM programme on the performance of learners in the OR Tambo Inland School District in the Eastern Cape? Lastly, what was the effect of the S4F FM programme on the perceptions of children's family members, teachers and the learners towards mathematics?

To lay the basis for the empirical work and set a reference point for the analysis and interpretation of the results (Rocco & Plakhotnik, 2009: 4), I therefore explored the body of existing knowledge as it relates to each of the three research questions. In a broader sense, the purpose of this literature review is to enable me, the researcher, to relate the results of my empirical work to other studies on the subject in question (Creswell, 2009: 25). Creaven, Madajewicz, Pendyala, Takita, Mittelman, Huben, Henderson and Cushman (2018: 27), who dedicated an entire book to the subject of literature review, lists the purpose of this section in a scholarly work in the following way:

- *distinguishing what has been done from what needs to be done;*
- *discovering important variables relevant to the topic;*
- *synthesising and gaining a new perspective;*
- *identifying relationships between ideas and practice;*
- *establishing the context of the topic or problem;*
- *rationalising the significance of the problem;*
- *enhancing and acquiring the subject vocabulary;*
- *understanding the structure of the subject;*
- *relating ideas and theory to applications;*
- *identifying the main methodologies and research techniques that have been used; and*

- *placing the research in a historical context to show familiarity with state-of-the-art developments. (Creaven et al., 2018: 27)*

Regarding the pertinent issues raised in the list above, and over and above exploring literature related to the empirical research question, I started by clarifying my position regarding the interchangeable use of two concepts, namely family involvement and parental involvement. However, it is necessary to situate the present study within the programme evaluation practices, before delving into this family – parent dichotomy.

3.2 PROGRAMME EVALUATION

Education programmes of the 21st must constantly improve to build a robust dynamic future for the role players (Ahmady, Lakeh, Esmailpoor, Arab, & Yaghmaei, 2014, p. 5). This argument is also true for the S4F FM programme. Therefore, the S4F FM programme is evaluated, in this study, to understand how the programme works and how role player's affective beings are affected and how successful it is an interventions (Hassan, 2013, p. 34). Hereunder I situate the evaluation within the current models of programme evaluation.

3.2.1 THE LOGIC PROGRAMME EVALUATION MODEL

At their inception, as the Kirkpatrick's, programme evaluation models were linear based where they focused on a linear relationship between the elements of the programme and the outcomes (Ahmady et al., 2014, pp. 6–7). Over time new models that incorporate the situation in which the programme is taking place in addition to the inputs, outputs and outcomes have come to the fore (Roghayeh Gandomkar, 2018, p. 94). The logic model, which I consider suitable in the present is one such modern models the depart from the traditional evaluation endeavour. The pillars of the logic model, as Srečo Zakrajšek (2016, p. 112) outlines, are in agreement with the key intentions of the present study and include:-

- an analysis of the conceptual core of the programme
- its design
- factors affecting its implementation,
- its outcomes

3.3 FAMILY INVOLVEMENT

The more inclusive family rather than parental involvement approach is preferred in this study. This approach is motivated by the fact that almost 25% of all African children in South Africa live with one parent only, while a further 44% of African children live with their mothers but without their fathers (Hall & Sambu, 2016: 107). Despite these living arrangements, the majority of literature uses the concept of parental, rather than family involvement when dealing with children learning at home (Anderson & Minke, 2007: 311; Cunha, Rosário, Macedo, Nunes, Fuentes, Pinto & Suárez, 2015: 159; Wamala, Kizito & Jjemba, 2013: 113; Ireson & Rushforth, 2014: 14). This approach may be construed to presuppose that all children come from intact families, which is not entirely correct, since even intact families do, from time to time, experience disruptions like divorce or separation (Astone & McLanahan, 1991: 318). Contrary to the assumption of intact families, Meier (2012: 903), reports that children accrue education benefits not only from their interaction with immediate family members, but also from their siblings, cousins and grandparents. The interaction amongst family members has also been reported to be educationally beneficial to the child (Meier, 2012: 903). There are a number of other social and economic factors that threaten intact family structure units, such as teenage pregnancy.

3.3.1 TEENAGE PREGNANCY AND PARENTING

South Africa, according to the Human Sciences Research Council, experiences unacceptably high levels of teenage pregnancy (Panday, Makiwane, Ranchod & Letsoalo, 2009: 6). This has severe social consequences for parenting young children (Jewkes, Morrell & Christofides, 2009: 680). One of the social consequences of teenage pregnancy is that young mothers are less likely to raise their children themselves (Panday et al., 2009: 27). In the African culture, these children are usually raised by their maternal grandmothers as their own youngest children (Jewkes et al., 2009: 680). The province of the Eastern Cape is no exception to these observations. For example, while South Africa has experienced declining teenage pregnancy numbers between the 2011 national census and the 2016 community survey, there was an increase from 5,0 to 5,3 between these two surveys in the Eastern Cape province (StatsSa, 2016: 47). Incidentally, the Eastern Cape province recorded the highest number of pregnancies in the 15 – 19 age group during the same period (StatsSa, 2016: 47). I therefore propose that a researcher should not ignore the grandparents who

raise children as their own as a result of premarital childbearing. The other reality that needs to be considered in child rearing is that of internal migration.

3.3.2 TEMPORARY MIGRATION

Temporary migration is another factor that affects the family structure and parenting of school children since it affects young and labour-able adults (Collinson, 2010: 5). This form of migration occurs when a family member is away from the household for most of the time, but keeps links with and remains a member of the basis household (Collinson, 2010: 5). The phenomenon of temporary migration is not confined to South Africa, as Cortes (2015: 62), for example, reports that about 10% of people in the Philippines are temporary migrants. It is rife in Sub-Saharan Africa, and seems to become more feminised as more women are seeking or accepting employment opportunities away from home, leaving children behind in the care of other family members (Adepoju, 2000: 385). In South Africa, according to StatsSA, the Eastern Cape province experienced the highest emigration numbers of just below two million, in both the 2011 National census and the 2016 Community Survey (StatsSa, 2016: 29). The Western Cape and Gauteng provinces, on the other hand, comparatively experienced the highest number of immigrations in the same census and community survey. One can therefore infer that young and able adults, some of whom are female, leave the Eastern Cape province for other provinces such as the Western Cape and Gauteng. In the process, they leave their children behind in the care of other people. These facts about temporary migration further enhance my bias towards family rather than parental involvement in children's education. Deaths in the family may also affect child rearing, particularly under pandemic scourges like HIV and AIDS.

3.3.3 HIV AND AIDS AND PARENTING

The 2012 South African National HIV Survey shows that just over 3 million children in South Africa have been orphaned, mostly as a result of HIV (Shisana, Rehle, Simbayi, Zuma, Jooste, Zungu, Labadarios & Onoya, 2012: 04). These findings are in agreement with the previous survey of 2008, and focus on the 0 - 18-year-old age group (Shisana et al., 2012: 104). The impact of HIV and AIDS on family structure is not limited to orphanhood, as studies in other countries in Southern Africa indicate that the risk of marriage dissolution in families where one or both partners are HIV positive is higher than otherwise (Hosegood, 2009: 14). In addition, remarriage by widows and widowers end up in social and residential

arrangements that can no longer be referred to as intact (Hosegood, 2009: 14). As South Africa harbours the highest number of people living with HIV and AIDS in the world (Hemelaar, Gouws & Ghys, 2006: 179), the impact of the HIV pandemic on family structure cannot be ignored.

Based on the preceding discussion, I contend that family rather than parental involvement is more appropriate. The discussion highlights factors such as grandparents taking over the roles of parents as a result of teenage pregnancy, single parenting emanating from temporary migration, and orphanhood as a result of HIV and AIDS in South Africa and the world over. As a result, throughout this literature review and subsequent chapters of the study, I use the concept of family involvement over parental involvement even when referring to the literature on parental involvement, since families and parents are not mutually exclusive. I apply the concept of family involvement in the following discussion on the background of Family Maths.

3.4 BACKGROUND TO FAMILY MATH

3.4.1 *INTERNATIONAL ORIGINS OF FM*

Here below I recount the beginnings of Family Math, as Kreinberg (1989: 127) reports about it. Nancy Kreinberg was the co-founder of both the EQUALS and Family Math programmes and later became the director of EQUALS at the Lawrence Hall of Science at the University of California, Berkeley. EQUALS is a teacher development programme that was designed to help teachers address the issues of equity in Mathematics, as these adversely affected female students and learners from minority groups (Merttens & Vass, 1993: 232; Aldrich, 1980: 261).

The women's movement in the 1970s in the United States managed to put to public focus many issues that affected women, including the fact that Mathematics education discriminated against females (Anderson & Thompson, 2001: 6; Aldrich, 1980: 12). To this end, Chipman, Brush & Wilson (1985: 2) demonstrated huge disparities in male and female students through the meticulous analysis of data on women's participation and achievement in Mathematics. The discrimination manifested itself in three ways: attitude, performance and participation. The discriminatory attitudes against females included teachers' and parents' gender stereotyping that female learners are less capable in

Mathematics, or that Mathematic- based careers are not for women (Anderson & Thompson, 2001: 6). The available data at the time indicated that female learners performed poorly in the subject when compared to their male counterparts (Chipman et al., 1985: 22). The combination of stereotypical attitudes and performance led to fewer females choosing Mathematics as an elective in high school, leading to reduced participation in the subject by female learners (Kreinberg, 1989: 127).

In response to the gender discrimination in Mathematics education raised by the women's movement, a few people, including Nancy Kreinberg (1989: 127) at University of California, Berkeley, started a teacher development programme called EQUALS in 1977 (Anderson & Thompson, 2001: 6). Through this 30-hour long programme, the university strived to empower teachers to be aware and sensitive of the issue of gender equity in Mathematics education in the USA. In a broad sense, the proponents of this teacher development programme designed it to achieve three objectives, namely to firstly build capacity for competence and confidence amongst female learners. Secondly, it aimed to raise the interest of female learners in Mathematics-based careers (Aldrich, 1980: 4). The third aim was to increase support from parents and fellow teachers for female learners to participate in Mathematics (Kreinberg, 1989: 127). The EQUALS programme quickly spread across USA and to other countries, arousing interest from researchers who conducted evaluation studies on it. Four years after initiating EQUALS, Nancy Kreinberg (1989: 127) and her fellow protagonists began to receive feedback from teachers, requesting information on empowerment strategies to involve parents in the Mathematics education of their children. This gave rise to the initiation of the Family Math programme in 1981. These two programmes, EQUALS and Family Math, would later form the backbone of the partnership between the University of the Free State and the Edinboro University of Pennsylvania (EUP) (UFS 2014a).

3.4.1.1 EQUALS

EQUALS, the in-service teacher development programme, endeavoured to overcome the obstacles to female learners' competence and participation in Mathematics (Aldrich, 1980: 215). Some of the barriers included an unfriendly male-dominated Mathematics classroom, confidence deficiency in their ability to cope with the subject, and negative attitude towards the subject (Anderson & Thompson, 2001: 8). To this end, the programme focussed on encouragement, awareness and competence amongst female learners. Teachers were

encouraged to invite local role models to demonstrate that it is possible to succeed in the subject, and to motivate female learners to take up Mathematics in high school as an elective subject. The EQUALS programme made use of activities that included engagement with real-time statistics to raise awareness of participation and competence amongst female learners. Other key features of the activities of EQUALS included a creative and interesting problem-solving focus and the use of manipulatives (Kreinberg, 1989: 129). These materials are also useful in the learner-parent activities of Family Math.

3.4.1.2 FAMILY MATH

Amongst others, the feedback from the evaluation studies indicated that teachers need to be empowered to interact with parents, so that they can become involved in the Mathematics education of their children (Anderson & Thompson, 2001: 9). The need for increased parental involvement was more prominent in communities from low socioeconomic areas than in other communities. This included African, Native American and Latino communities. The proponent of the EQUALS programme at University of California responded to the need for parental involvement by establishing the Family Math programme in 1981. Almost two decades later, the programme landed at the UFS in South Africa and are currently run under the umbrella of Science for the Future (S4F)(SANRAL, 2017: 63).

3.4.2 FM IN SOUTH AFRICA

A search of Family Math revealed that there are two universities and one Non-Governmental Organisation (NGO) running the programme in South Africa. The universities are the Nelson Mandela Metropolitan University and the University of the Free State, while the NGO is the Cooperative Organisation for the Upgrading of Numeracy Training (COUNT), based in Gauteng. Below I briefly discuss the background and results of the programme as run by each institution.

The origins of the Nelson Mandela Metropolitan University (NMU) Family Math programme point towards direct inspiration by the University of California at Berkeley teacher development programme called EQUALS, which was started in 1977 (Webb & Austin, 2009: 28; UFS, 2014). EQUALS in the USA, gave rise to Family Math as one of its programmes in 1981 (Kreinberg, 1989: 134). The Family Math programme spread within the USA and to

other countries (Merttens & Vass, 1993: 233), primarily because of its pliability (Kurz, 2011: 227). The programme can be adapted to suit local contexts wherever it is adopted (Kurz, 2011: 227). I contend that the wide positive reception of the programme has contributed to its sustainability (Jaramillo, 1993: 84; Sadler, 1998: 78; Jacobbe et al., 2012: 1176).

3.4.3 EVALUATION OF FAMILY MATH

The programme has been evaluated in a number of ways. Jaramillo (1993: 84), for example, evaluated the programme for its impact on teachers' and families' beliefs about Mathematics and Science teaching. The finding was that the programme improved these stakeholders' attitudes towards Mathematics education, thereby affirming the congruency amongst the three spheres of influence (Jaramillo, 1993: 84). Sadler (1998: 78), again, studied the relationship between the programme and learners' performance in Mathematics amongst intermediate and senior grades learners of marginalised minorities. It was found that these groups accrued no benefit. The author suggested that there were too few workshop sessions (five sessions of four hours each) to make an impact. Lastly, Jacobbe, et al. (2012: 1176) evaluated the effect of the Family Math workshops on the perceptions of entrant teachers into the teaching profession and one year later. The authors found that the new educators had a significant positive perception of the value of parental involvement. They concluded that the programme has a long-term effect on teachers' perceptions of parental involvement. Aside from some negative findings, the Family Math programme has inspired the formation of similar programmes around the globe (Kurz, 2011: 227), including the equally much evaluated NMMU version.

The NMMU version of Family Math started in 1996, and the nomenclature "Family Maths" as opposed to "Family Math" distinguishes it from its precursor at the University of California, from which it was adapted (Webb & Austin, 2009: 25). Despite this semantic difference, the primary aims of the original programme were retained and still inform the activities of the programme at NMMU (Austin & Webb, 2011: 52). Like its precursor at the University of California, the NMMU Family Maths programme has been evaluated for its impact.

The evaluation of the NMMU version centred around two issues, namely the programme's effect on the beliefs of teachers, learners and families, as well as its efficacy in preparing

facilitators for inquiry-based techniques of learning (Austin & Webb, 2011: 53). These evaluations include published research articles (Austin & Webb, 2011: 52–63; Webb & Austin, 2009: 27–44). One Master's (Austin, 2007) and PhD (Govender, 2007) thesis, as well research papers presented at international conferences (Webb & Austin, 2003: 579–583) also form part of the evaluations. The findings were mainly that families and learners had positive perceptions of the programme of Family Maths (Govender, 2007: 169). This was even more so for families exposed to an enquiry-based method of learning (Webb & Austin, 2003b: 582). Facilitators of the programme also, over time, incrementally became more skilful in working with families (Austin, 2007: 98). There is, however, little evidence from the evaluations of the NMMU Family Maths of the effect of the programme on the academic performance of learners. Some work on the effect of the programme on the academic performance of learners was done on the COUNT version of Family Maths.

It must be kept in mind that while COUNT runs independent programmes on Family Maths, it also partners with institutions like the University of South Africa (UNISA) (Glover & Smith, 2016: 37). COUNT Family Maths, even though it is currently based in Johannesburg, started in the Eastern Cape in the Uitenhage and Port Elizabeth area, almost a decade earlier than the NMMU version. It currently operates across at least five provinces in South Africa (Glover & Smith, 2016: 7). The genesis of COUNT appears unrelated to any university in the United States (Glover & Smith, 2016: 7), although inspired by the work of EQUALS at the University of California. The South African Institute for Distance Education (SAIDE) independently instituted an evaluation of the COUNT Family Maths programme in 2006 (Roberts, 2006). The quantitative evaluation was intended to establish whether there was an improvement in the Mathematics performance of learners from schools involved in the Family Math programme. The outcome of the evaluation was that the Family Maths programme had helped improve learners' understanding on Mathematics in Grade 2 and to a lesser extent in Grade 5 too (Roberts, 2006: 18). Besides this evaluation, there is no evidence of an evaluation that investigated the perceptions of role players in the Family Maths programme as rolled out by COUNT.

The observation on the evaluation of the COUNT programme is in contrast to the Family Maths programme as run by NMMU, which has been extensively evaluated. The UFS version, on the other hand, has not been formally evaluated in terms of either academic performance or perceptions. The present study hopes to address this pragmatic gap in empirical work.

In the following section, I discuss the perceptions, from literature, of family members, teachers and learners.

3.5 PERCEPTIONS

People's perceptions of reality are socially constructed (Dennick, 2016: 203), and different people interpret reality differently, leading to different perceptions (Mack, 2010: 7). I therefore contend that the school community members may continually be developing and adapting their perceptions about Mathematics education as a result of their interaction with the FM programme. Perceptions, in turn, may influence how Mathematics is learned, because self-confidence, together with engagement during lessons, is known to significantly influence performance in the subject (Mutodi & Ngirande, 2014: 434). In this regard, I first synthesised the literature on the family members' perceptions regarding the motivation to become involved. I also delved deeper into the literature on perceptions of learners about education in general, and Mathematics education in particular. Lastly, I synthesised the literature on the perceptions of teachers about their engagement with family members. However, it is imperative that I define the term "perception" before any discussion about the concept takes place.

3.5.1 DEFINITION OF PERCEPTION

The definitions of the concept of perception varies from simple to complex, and are also discipline-based. For example, the Oxford Dictionary (2019) defines perception only as "*how something is regarded, understood, or interpreted.*" The Cambridge Dictionary (2019), on the other hand, adds an effective dimension to the definition, as "*a belief or opinion, often held by many people and based on how things seem.*" Ward, Grinstein and Keim (2015: 73), from a psychological viewpoint, define perception as "*the process of recognizing (being aware of), organizing (gathering and storing), and interpreting (binding to knowledge) sensory information.*" This last definition places perception within the realms of receipt, processing and storage of information. Storing in memory, on the other hand, is known to be a part of the cognitive process (Kret & De Gelder, 2016: 282), thus suggesting that perception and cognition are closely intertwined.

3.5.2 *PERCEPTION AND COGNITION*

Barsalou (1999: 577) argues that researchers should consider cognition and perception as inseparable, because cognition is intrinsically perceptual. Perception and cognition also share systems at neural and cognitive levels (Barsalou, 1999: 557). In this regard, Leder, Pehkonen & Törner (2006: 57) assert that understanding the modalities of Mathematics learning is dependent on the exploration of learners' affective aspects such as moods, attitudes, feelings, beliefs and perceptions. I will, however, first discuss the perceptions of family members.

3.5.3 *FAMILY MEMBERS' PERCEPTIONS*

Three psychological factors influence families' decision to become involved in their children's education (Hoover-Dempsey & Sandler, 1997: 8). The first of these is the belief of what they need to do about their children's education, in other words role construction. The second is the belief that getting involved in their children's education will help to improve their educational outcomes. This basically refers to self-efficacy. The last factor is families' perceptions of the request for involvement with their children, and other general opportunities. These factors form the basis of other subsequent activities related to engagement activities and eventual learning outcomes.

In their revision of the original model by Hoover-Dempsey & Sandler (1997: 8), Walker et al. (2005: 87) rearrange these psychological factors. They, collectively combine role-construction and sense of efficacy into one factor, namely motivational beliefs. Parental perceptions of requests to become involved, either from their children, the teachers or the school, constitute a second factor that influences parents' decision to become involved. The most significant addition, more than just the reorganisation of the original factors that Walker et al. (2005: 87) introduced into the original model, is the parents' perceived life context. The perception of life context includes families' perceived availability of time and energy, as well as the perception of the possession of the required skills and knowledge for involvement. In their quantitative research using this model, Dumont et al. (2012: 64) refer to these life context factors as social variables. They found that these have a stronger influence on the decision to become involved when compared to a family's socioeconomic background.

In contrast, Green et al. (2007: 540) found that families' self-efficacy strongly influenced the decision to become involved with home-based involvement. Gonida and Cortina (2014: 378) add to this by highlighting that a child's poor academic performance often elicits an invasive form of parental involvement. These invasive practices include monitoring the completion of homework. It is clear, however, that irrespective of the strength of a factor in predicting the parental involvement, perceptions are central to the decision to become involved. These perceptions can either be grouped under beliefs on role construction, self-efficacy or invitations for involvement and personal life context, as identified by Hoover-Dempsey and Sandler (1997: 8) and Walker et al. (2005: 87). Next, I discuss families' beliefs about involvement, starting with role construction.

3.5.3.1 ROLE CONSTRUCTION

Various descriptions of role construction appear in literature, the majority of which refer to what parent needs to do regarding their children's education (Anderson & Minke, 2007: 312; Green et al., 2007: 532; Hoover-Dempsey et al., 2001: 201). Even though the common theme in the description of role construction relates to what a family member should do, various authors use different words to refer to the construct that underlies the question. Anderson and Minke (2007: 312) refer to "*ideas about what the family member should do.*" Conversely, Hoover-Dempsey et al. (2001: 201) mention the words "*expectations and beliefs about what the family member should do.*" Lastly, Green et al. (2007: 532) use "*beliefs about what a family member should do.*"

Hoover et al. (2005: 107) add a different definition for role construction. They describe the concept as the simultaneous existence of a sense of personal or collective responsibility, on the one hand, and beliefs about whether a family member should be engaged in supporting the child's academic endeavours, on the other (Hoover et al., 2005: 107). One glaring difference between the two descriptions is that the former refers to beliefs about what needs to be done, while the latter refers to whether or not a family member should become involved.

Multiple factors such as socioeconomic, traditions and cultural background are known to influence the family's role construction. Dumont et al. (2012: 64), for example, found that families in the USA without an immigrant background have a higher role construction when compared to that of immigrants. Immigration is closely intertwined with socioeconomic

background in that country. This implies that families from low socioeconomic backgrounds tend to have less favourable role construction (Gonzalez, Borders, Hines, Villalba, & Henderson, 2005: 187). The traditions and culture of the parents' community are also known to affect families' role construction, as some communities hold the belief that nurturing teaching and learning is the role of teachers and not of parents (Gonzalez et al., 2005: 187). Despite the associations between families' role construction and the mentioned factors, role construction has been found to carry less weight in the decision to become involved when compared to other constructs like self-efficacy and invitations (Anderson & Minke, 2007: 319).

3.5.3.2 SELF-EFFICACY

In general terms, self-efficacy and beliefs are also defined by one's perceptions about one's own abilities (Pajares, 1996: 544; Akay & Boz, 2010: 60) and expected outcomes of activities (Walker et al., 2005: 93).

Regarding family involvement in children's education, perceptions about parents' engagement with their own children's educational activities constitute self-efficacy beliefs (Anderson & Minke, 2007: 312). In research, perceptions about one's abilities are best probed by asking the participants to state their confidence in accomplishing specific tasks (Walker et al., 2005: 93; Pajares, 1996: 544). Families with high self-efficacy for school-based involvement believe that they will be able to cope with the tasks required of them (Gonzalez et al., 2005: 187) at home. Research has also found that families who harbour positive outcomes for their involvement are more likely to take up a variety of activities related to their children's education (Walker et al., 2005: 94). Family members' perceptions and responses to invitations they receive from schools to become involved, needs some interrogation.

3.5.3.3 INVITATIONS

Parents' perceptions of invitations from the school, teachers and learners to become involved in children's education are considered to be one of the most vital factors influencing involvement (Hoover et al., 2005: 110). Such invitations can be general or specific (Anderson & Minke, 2007: 312). They are general if they emanate from the perceived welcoming climate of the school or children's' enthusiastic talk about their

schoolwork, and specific if there is a direct request for involvement (Hoover et al., 2005: 110).

Research on families' perceptions of specific invitations vary, and depends on life contexts. Connors and Epstein (1994: 19) report that the majority of families positively perceive such invitations from high schools in the USA.

In contrast, Mbokodi (2008: 80) found that families from poor socioeconomic backgrounds in the Port Elizabeth area of South Africa did not respond to specific invitations for involvement from the school, even if the school changed meeting times. Families in Mbokodi's research reported that their children did not relate invitation messages from the school to their parents. In her model of the overlapping spheres of involvement, Epstein (2010: 86) mentions such school-to-home communication breakdowns and proposes that schools needs to review their communication channels from time to time.

In summary, families' psychological considerations relate to their role should be when becoming involved in their children's education. A second aspect is whether such involvement will help their children. The third aspect playing a role in families' decision to become involved are the perceptions they hold regarding general and specific invitations from the school and their children. All of these considerations take place within each parent's life context of time and energy, which are affected by factors such as socioeconomic, cultural and traditional circumstances.

In addition to the perceptual considerations influencing the decision to become involved, I attempt to understand how families perceive the value of education, as this may discourage or encourage learners' dropout rates (Motala, Dieltiens, Carrim, Kgobe, Moyo & Rembe, 2007: 108). I also need to understand families' perceptions of what Mathematics teaching entails that might affect, firstly, the type of feedback they provide to teachers about their children's comprehension of mathematical concepts (Muir, 2012: 31), and secondly, parents' engagement activities (Hoover-Dempsey et al., 2005: 114). Further, as guided by the derived theoretical framework for this study, the empirical work for this study needs to unearth the scaffolding behaviours that families engage in with their children at home. These scaffolding behaviours, according to Cunha et al. (2015: 160) can either promote a child's independent learning, regulate the amount of knowledge the child can master, or

emphasise the importance of homework and getting it done on time. Consequently, the actual questions for the instruments of this study encompass the aspects of parental involvement highlighted in the preceding discussion. Hereunder I discuss learner perceptions.

3.5.4 LEARNERS' PERCEPTIONS

Learner perceptions about Mathematics education are influenced by multiple factors, including the school-to-home synergy, as Epstein's model of overlapping spheres of influence suggests (Epstein, 2009: 81). In effect, a functional school-home partnership promotes positive perceptions on the part of children about Mathematics education at home. This leads to improved performance in the subject at school (Sadler, 1998: 1). Van Voorhis, Maier, Epstein & Lloyd (2013: 27) suggest that these learner perceptions are also influenced by tutoring programmes targeting family members and productive school and home communication. The parent-child learning engagement activities that ensue, following the tutoring programmes and positive communications, are perceived differently by the child and parent, Dumont et al. (2012: 64). It is therefore essential to understand learners' perceptions of Mathematics education independently of those of their family members.

Positive learner perceptions, according to LaRocque et al. (2011: 117), are also associated with increased family involvement in children's education. Further, several studies have found that learners' perceptions of their ability in Mathematics are one of the critical constructs that contributes to achievement in the subject (Dumont et al., 2012: 61; Wang, Osterlind & Bergin, 2012; 1216; Knollmann & Wild, 2007: 65). These findings, therefore, informed and guided the construction of research questions for the current study.

In the current study, I therefore sought to understand learners' perceptions of their families' involvement in the learning activities at home, and the synergy between the school and home and learners' ability in Mathematics. It is essential to understand these perceptions, because their effect determines the effectiveness of the efforts to improve Mathematics learning (Dumont et al., 2012: 57). Questions in this study seeking to understand learners' perceptions of Mathematics education, as impacted upon by the Family Math programme, were adapted from the works of Untersuchung (2012: 194) and

Dumont et al. (2012: 65). In the section below, I discuss teachers' perceptions of family involvement in the Mathematics education of their children.

3.5.5 TEACHER PERCEPTIONS

In Chapter two of the present study, the theoretical framework, I described the critical role of schools in nurturing family involvement in children's education using the theory of overlapping spheres of influence (Epstein & Sanders, 2006: 86) (cf. 2.3.2). The perceptions by one group of the other – teachers and parents - influence the extent to which the two can create a continuous learning environment from school to home (Sheldon et al., 2010,: 31). In this section, I therefore explore the literature on teachers' perceptions of family involvement in children's education. While the focus is on the South African context, I predicate the discussion on experiences from various parts of the world, with different experiences in learner performance in Mathematics. I begin by highlighting the importance of teacher perceptions.

Teacher perceptions are critical due to the authority that they have over the learners. They take crucial decisions regarding teaching, learning and assessment of all subjects, including Mathematics (Rice, Barth, Guadagno, Smith & Asert, 2013: 1030). Consequently, according to these authors, teachers' perceptions tend to influence over learners' perceptions about Mathematics education, and ultimately on the academic achievement in the subject. Patel and Stevens (2010,: 130), for example, studied the effect of the relationship between the teachers' and parents' perceptions of children's academic ability on family involvement. The two authors found that the more incongruent these perceptions, the higher the likelihood of family disengagement with Mathematics education of the children. How teachers perceive their communication to family members is also essential, as studies have shown that at times family members do receive them. Often, though, parents do not interpret these in the way the teachers intended (Anderson & Minke, 2007: 321). Several other studies, from countries with a wide range of academic performance in Mathematics in the internationally standardised assessments, reflect on parental involvement, as perceived by teachers.

Chung (2009: 253) studied the teacher perceptions of the factors which make South Korea achieve comparatively high scores in international Mathematics assessments. This author found that families' high expectation for their children's performance in the subject was

believed to have a major contributory effect on that country's performance. Teachers' perceptions of parental support and involvement from two countries, Taiwan and Saudi Arabia, on the opposite ends of performance in TIMMS assessments, were studied, and found to be unsatisfactory (Dodeen, Abdelfattah, Shumrani & Hilal, 2012: 75). Interestingly, another independent study in Taiwan, which performs well in TIMSS, found that teachers perceive families as non-cooperative, and that teacher-parent interactions are initiated by learner performance in Mathematics (Wu, 2015: 315). The teacher therefore tends to be the one who contacts the parent to initiate an interaction when the learner is not doing well in the subject, while parent becomes the initiator when the opposite is true. Similar results of teachers' perception of the non-involvement of families were found in rural South Africa (Mudzielwana, 2014: 26). Mbokodi (2008: 287) concurs with this, through a study done in the Port Elizabeth area of the Eastern Cape, South Africa. He attributes the perceived lack of parental involvement on families' perception that teachers are self-sufficient.

The research findings reported here also need to be interpreted carefully, as factors such as the personal life contexts of parents, as well as the community's background, may play a role. For example, Aslan (2016: 144) like others in Taiwan, Saudi Arabia, Botswana and South Africa, found in Turkey that teachers espoused negative perceptions about parental involvement. These perceptions were created out of unsavoury meetings between the two groups. Mothers from low socioeconomic backgrounds constituted the majority of families who attended teacher-family meetings. Similar observations were made in a Southern African country, Botswana, where families' support for education was negatively perceived by teachers (Pansiri & Bulawa, 2013: 75). These findings from Botswana related to parental support in the form of visits to the school, volunteering to teach children, encouraging learners to learn at home, and assisting children with homework. Pansiri and Bulawa (2013: 75) also reported that there were degrees of negative perceptions between rural and urban settings.

The preceding discussion seems to show that research findings are consistent, at least at a global level and despite the specific context, that teachers perceive families as not being involved. LaRocque et al. (2011: 118), in concurrence, point out that teachers from various backgrounds perceive families as not being involved in their children's education. Even in cases where learners' academic performance, especially in Mathematics, is relatively good,

teachers' perceptions of parental contributions is that of emotional expectations of performance, as found in South Korea (Chung, 2009: 253).

Regarding the Family Math intervention, teachers' perceptions of family involvement, resulting from their exposure to Family Math activities, have been studied both abroad (Jacobbe et al., 2012: 1176) and in South Africa (Austin & Webb, 2011: 61). In either context, studies are consistent with the finding that teacher participation in Family Math activities, as facilitators, tend to improve their perception of the usefulness of the programme (Freiberg, 2004: 38). These studies also make an observation that teachers' perceptions of family involvement regresses with time, which is valid for both in-service and pre-service teachers.

In summary, the literature demonstrates that teachers' perceptions of family involvement in children's Mathematics education are generally negative. There seems to be no distinction, regarding negative teacher perceptions, between education systems with successful or failing Mathematics education systems. The literature considers that contextual factors of families, such as socioeconomic status, also influence families' beliefs about schools and teachers. This, again, reciprocally elicits negative teacher perceptions of family involvement. The Family Math programme, according to literature, seems to break the cyclic nature of mutual negative perceptions between teachers and families, by improving teachers' perceptions regarding family involvement. However, the S4F FM programme can only be beneficial if the learners' academic performance also improves, and I explore this fact in the next section.

3.6 LEARNERS' ACADEMIC PERFORMANCE IN MATHEMATICS

Internationally, regionally and locally standardised assessments of Mathematics demonstrate the failure of the education system to provide learners with the required knowledge and skills to cope with the cognitive demands of the subject. In this section, I briefly explore the literature to contextualise the systemic failures of Mathematics education in the country. I start by highlighting barriers experienced in Early Childhood Development (ECD). I begin with the challenges of quality of teaching in early childhood and in primary schools, then focus on the language of teaching and learning, and finally some confounding factors.

3.6.1 QUALITY OF TEACHING

The challenge of inadequate preparation of learners to cope in Mathematics learning begins at ECD level with consequences that manifest themselves in the later grades. Feza (2014: 898) studied the professional practices of ECD practitioners in laying the foundation for Mathematics learning. She found some systemic barriers, particularly in previously disadvantaged communities, which might explain learners' poor Mathematics performance in the primary phase. These include practitioners who are poorly qualified to stimulate Mathematics learning at ECD. A second factor is that the average ratio of practitioner to child is high when compared to other countries that perform well in TIMMs, such as Russia and Lithuania. There is little or no opportunity for individual attention. Thirdly, there is limited use of manipulatives like worksheets, when compared to ECD centres in the more affluent areas of South Africa. The cumulative effect of these hindrances is learning deficits that manifest themselves in later grades, such as a deficit of 18 months in Grade 3 learners (Spaull 2013b, p.6).

The poor quality of teaching in the intermediate and senior phases of education compound the effect of learning deficits brought forward from the ECD years. Heyd-Metzuyanim & Graven (2016: 351) identify shallow presentation of Mathematical concepts with limited focus and feedback to individual learners, especially in schools from previously disadvantaged backgrounds. The authors further note the insufficient cognitive demand in lesson presentation, predominated by hard and abstract mathematical concepts presented in learners' second language. The deficits accumulate for each grade, making remediation difficult (Spaull, 2013b; 6) and leading to dropping out of school during the senior phase and early Further Education and Training (FET) years (Spaull, 2015: 36). The transition from one language of teaching and learning to another between Grades 3 and 4 further compounds the quality of teaching.

3.6.2 EFFECT OF CHANGE OF LANGUAGE OF TEACHING AND LEARNING

The transition from the foundation to intermediate phase, with the associated language policy, also seems to further impede Mathematics education in primary schooling. Nomlomo & Vuzo (2014: 79) studied the effect of switching between home language and language of teaching and learning in South Africa and Tanzania. The two authors found that, both teachers and learners manage the transition to the reaching language ineffectively.

This is irrespective of the number of years of teaching and learning in the home language - four and seven years of schooling in South Africa and Tanzania, respectively. The incompetent management of the language transition leads to linguistic, cognitive and affective deficiencies, with resultant poor learner performance. Further clarification of the complex nature of language use comes from Reddy et al. (2015: 12). They analysed South Africa's performance in TIMMS 2015 and factors affecting that performance. They found a positive association between the frequency of the use of the language of TIMMS assessment at home and performance in Mathematics amongst Grade 6 learners. In fact, learner performance in Mathematics and Science in TIMMS assessments shows that countries where learners frequently speak the LoLT at home, perform better than those who never do (Reddy et al., 2012: 7). This suggests that learners tend to perform better if they are assessed in their home language, which is not the case in many classrooms in previously disadvantaged communities (Feza, 2014: 898).

In summary, literature seems to suggest that the widely reported poor learner performance in Mathematics in South Africa has multiple sources. These include teachers' readiness to teach, with regards to their training and practices in the classroom. Policy issues, especially regarding the switch from home to LoTL during the transition from foundation to intermediate phase, have also been highlighted. Literature further highlights the contributory of effect the disjuncture between the language of instruction and the language frequently spoken at home, where the confluence between the two is associated with comparatively better performance. Furthermore, there are other factors that are related to both the performance in the subject and participation in S4F FM programme, called confounding factors.

3.6.3 CONFOUNDING FACTORS

For the present study, the effect of the p4F FM Programme is best interrogated using the learners' achievement marks from both participating and non-participating schools. The effect of the inherent selection bias between the two groups needs to be minimised. I discuss the confounding factors which I used to minimise preselection differences between the two groups of schools below. I categorise them as those that found within the school and those from outside the school. The reader must bear in mind that the confounding factors and their relevance to this study are further explained in the next chapter (cf. 4.3.2).

In the next section, I only point out the justification for each of the confounding factors, based on the literature.

3.7 IN-SCHOOL CONFOUNDING FACTORS

Toilet facilities for learners, physical infrastructure in the form of the condition of the classrooms, learner-class ratios as well as the learner pregnancy are considered as in-school confounding factors. This means that they are school-based factors affecting participation in the S4F FM programme and performance in Mathematics.

3.7.1 TOILETS

The lack of toilet facilities indirectly affects learning outcomes, including that of Mathematics. For example, Cuesta, Glewwe & Krause (2016: 20) found in their meta-analysis that the majority of studies they reviewed had established a significant association between access to decent toilet facilities and learning outcomes. Ramorola and Nyaumwe (2000: 136) in concurrence identify the direct results of a lack of toilets as increased absenteeism amongst both the teachers and learners. This in turn has a direct bearing on learner achievement, particularly in rural areas.

Given the preceding discussion on the link between school infrastructure and learning outcomes, I consider learner: classroom and learner: toilet ratios as confounding factors in the present study. The availability of such data on the Eastern Cape Department of Education (ECDoE) database also motivated their inclusion as elements to be used in selecting the comparison group.

3.7.2 PHYSICAL INFRASTRUCTURE

Physical infrastructure is considered the third most important factor affecting learners' cognitive development, following teachers and curricular programming (Sotuku, Okeke, Mathwasa, West & West, 2016: 28). In their meta-analysis of the literature on this topic, focusing on developing countries around the world, Cuesta et al. (2016: 10) corroborate these findings. According to these authors, the availability of quality classrooms with space, proper floors, walls and roofs positively contribute to learning outcomes. Visser, Juan & Feza (2015: 5) add that physical infrastructure at school has lately, contrary to previous studies, become a predictor of performance in Mathematics in South Africa.

The implications for classroom space, as Chisholm (2005: 6) notes, is the overcrowding that characterises rural school classrooms in South Africa, despite the stipulated norms of 1:40 and 1:35 teacher-to-learner ratios in the secondary and primary schools respectively. In the Eastern Cape Pieterse (2010: 182) and Botha (2011: 173) identify overcrowding, in other words class sizes larger than optimal learner: classroom ratio, as one of the barriers to effective Mathematics education in the foundation and intermediate phases, respectively.

3.7.3 CLASS SIZE

On the flipside of overcrowding is a small class size, of which the effect on academic achievement is subject to debate in the literature. On the one hand, Van der Berg (2008: 10) found that the impact of class size is insignificant as a predictor of learner academic achievement. He concludes that the quality rather than the quantity of educators is more important. On the other hand, Visser et al. (2015: 2) recount contradictory effects of class size advanced as an explanation for the poor South African performance in TIMSS. Based on the 2011 TIMSS results, these authors argue that the class size effect has evolved, over the years, from being insignificant to one of the most critical determinants of Mathematics achievement in the country.

Findings from elsewhere in the world indicate concurrence with the observations from South Africa that smaller classrooms are associated with better Mathematics learner achievements, especially in schools from communities with low socioeconomic profiles. For example, Angrist and Lavy (1999: 535), while acknowledging the difficulty of measuring the effect of class size, conclude that reducing the class size in Grades 4 and 5 substantially increases learner test scores in Israel. In Denmark, Nandrup (2014: 31) found similar results for Grades 3 to 5, and attributed the different outcome in Grades 6 and upwards on the age-related competency of older children. Dahl (1991: 60) goes further to quantify the benefit of a smaller class size and suggest that, on average, a decrease from 22 to 15 learners per teacher results in a 6% increase in Mathematics marks. Besides the physical infrastructure and class size dynamics in school, learner pregnancy is also a factor on learner performance .

3.7.4 LEARNER PREGNANCY

Motala et al. (2007: 79) argue that pregnancy in South Africa's quintile 1, 2 and 3 schools counts as the principal reason for girls' slow progress in education. This relates to a higher repetition rate. The pregnancy challenge is also relevant for the present study, despite the supposed young age of the participant learners for the current research. In support, reports from the Department of Basic Education show that 15 out of 109 and 17 out of 26 Grade 3 learners fell pregnant in 2009 and 2010, respectively (Department of Basic Education, 2010: 29). While there is a paucity of similar statistics in subsequent years, 2017 statistics for schools in the OR Tambo Inland District made it possible to include pregnancy as a confounding factor in learner achievement, including Mathematics. I next discuss the out of school confounding factors.

3.8 OUT OF SCHOOL CONFOUNDING FACTORS

In South Africa, like in the United States, the learners' family socioeconomic background affects academic achievement far more than government funding patterns to schools (Taylor & Yu, 2009: 4; Dumont et al., 2012: 55; Yeşil Dağlı & Jones, 2012: 3062). In concurrence, Sulku (2015: 422) found, from the analysis of TIMMS data, that family income as a socioeconomic indicator substantially influences the Mathematics academic achievement of learners from countries at different stages of economic development.

Smith (2011: 12) analysed the effect of such socioeconomic variables as educational resources available at home, living circumstances and nutritional value food intake at home on Grade 6 academic achievement in Mathematics amongst South African learners, from the SACMEQ II survey. Collinson (2010: 3), on the other hand, investigated the influence of community-based service delivery issues like household family heads, household income, water sources, household sanitation, toilet facilities, energy sources and access roads on academic achievement. Both authors concluded that these "*out of school factors*" have a greater influence on learners' academic achievement than school-bound social factors (Smith, 2011: 22; Collinson, 2010: 13).

In this study, therefore, I considered both school and out of school factors as possible cofounders to Mathematics achievement of learners in the OR Tambo District. Chiefly, I used these factors to create a control group out of the whole population.

3.9 CONCLUSION

The social issues of teenage pregnancy, the economic realities of temporary migration and the health challenges of HIV and AIDS make a compelling case for the adoption of the concept of the family rather than parental involvement in education. Therefore, while I might have been using the two concepts interchangeably, in this study, the thinking is that of a family member who represents a parent on matters of education, rather than a biological mother or father.

Further, the literature shows that different versions of Family Math have been evaluated for their effect on the academic achievement and perceptions of family members, teachers and learners. The UFS version, even though it has been in operation for almost twenty years, has not been formally studied on both accounts. The study seeks to address this pragmatic paucity in research. The focus is on the perceptions of family members, teachers and learners towards Mathematics education and family involvement, as well as learners' scholastic achievement in the subject.

The literature further highlights the importance of the perceptions of stakeholders towards Mathematics education. The interrelationship between learners and family members' perceptions manifests itself where positive learner perceptions lead to favourably perceived general and specific invitations by families to become involved in their children's education. Teachers, on the other hand, generally have negative perceptions about family involvement in education. The literature further highlights the importance of context in teachers' perceptions.

Therefore, the research endeavour undertaken in this study takes cognisance of the context as it relates to rurality, community socioeconomic background, educational background of families, educational resources allocation and the social structure of families in the study area. The discourses on the perceptions of the school community exposed in the literature review also make a compelling case for an empirical work such as this study to understand these perceptions from the lived experiences of the participants in this study. Lastly, the empirical work of this study needs to uncover the extent to which the S4F FM programme is able to mitigate poor Mathematics foundational skills at ECD level, as well as the cumulative learning deficits experienced by learners in the intermediate and senior phases

of primary education. The next chapter outlines the research methodology for the study, which is considered to be a theoretical basis for research methods.

CHAPTER 4: THE METHODOLOGY

4.1 INTRODUCTION

To achieve the main objective for this study, Chapter 3 explored literature regarding the difference between the concept of family and parental involvement. I deemed the former to be relevant in the context of this study, following a discussion of the theoretical perspective in Chapter 2. The literature study also described the background and nature of the S4F FM programme in South Africa, which revealed that the FM programme exists in different forms around the world, and has value for Mathematics education. The value of the programme lies in the fact that it provides a platform for interaction among the three spheres of influence in a child's education, namely home, school and community. The programme, according to literature, also allows for the moderation of perceptions of family members and children towards Mathematics education, and teachers towards family involvement in education. These aspects of the literature review formed the basis for the qualitative aspect of this study.

To build towards the basis for the quantitative aspects of the study, Chapter 3 (cf. 3.6), I reviewed school and other confounding factors that influence scholastic achievement. This was done to minimise the adverse effects of the bias between schools in the S4F FM programme and those not part of the programme. These confounding factors were factored into a statistical programme to select the control and treatment groups from the population of all primary schools in the OR Tambo District. Selecting a control group allowed for statistical comparisons of learners' marks in Mathematics between schools in the S4F FM programme and a group of comparable schools not in the programme.

In this chapter I outline the methodology for the empirical aspects of this study. The philosophical basis for the empirical work of this study was laid in Chapter 2 (cf. 2.2). Within this mixture of methods, the constructivist-aligned strategies predominate due to the nature of the current study, which empirically explores the background to the S4F FM programme and the perceptions of teachers, learners and family members. The quantitative aspect of this study, with positivist leanings, is used to methodologically triangulate the qualitative aspect of the research. Over and above outlining the strategies and procedures for data generation, analysis and interpretation, this chapter also clarifies the implicit

contradictions in the methodological stance of this study and explains the research design for the study.

4.2 RESEARCH DESIGN

My master plan for this research is a sequential (QUAL + QUAN + QUAL) research design of mixed methods for data generation, analysis and interpretation (Creswell, 2009: 3). In this type of design, the research community uses qualitative research design to explore research questions that seek to understand how people interpret their world, construct knowledge and make meaning of their experiences (Merriam, 2009: 11). Researchers also use quantitative methodologies to test hypotheses through the objective collection and statistical analysis of numerical data (Creswell, 2009: 4). For the purpose of clarity, I represent the flow of activities of the research in a diagram.

Figure 4-1 below diagrammatically represents the research design for exploration and description of the changes that were brought about through the S4F FM programme in a rural school community in South Africa. The diagram illustrates the flow from the objective of the study, strategy for data generation, research approach, the alignment of methodological philosophies aligned to each strategy, to the use of mixed methods. The diagram also indicates the type of results from each aspect of the research endeavour. The results are synthesised to form an understanding regarding the changes the S4F FM programme brought about in Mathematics education.

In the following sections, I describe the data generation and analysis strategies aligned to each of the methodologies, as well as possible threats to the validity, credibility and reliability of the study. I also discuss the mitigation of those threats. Figure 6 diagrammatically depicts the composite research design for the study, which displays the interrelationship between the three methodologies and the corresponding data generation procedures.

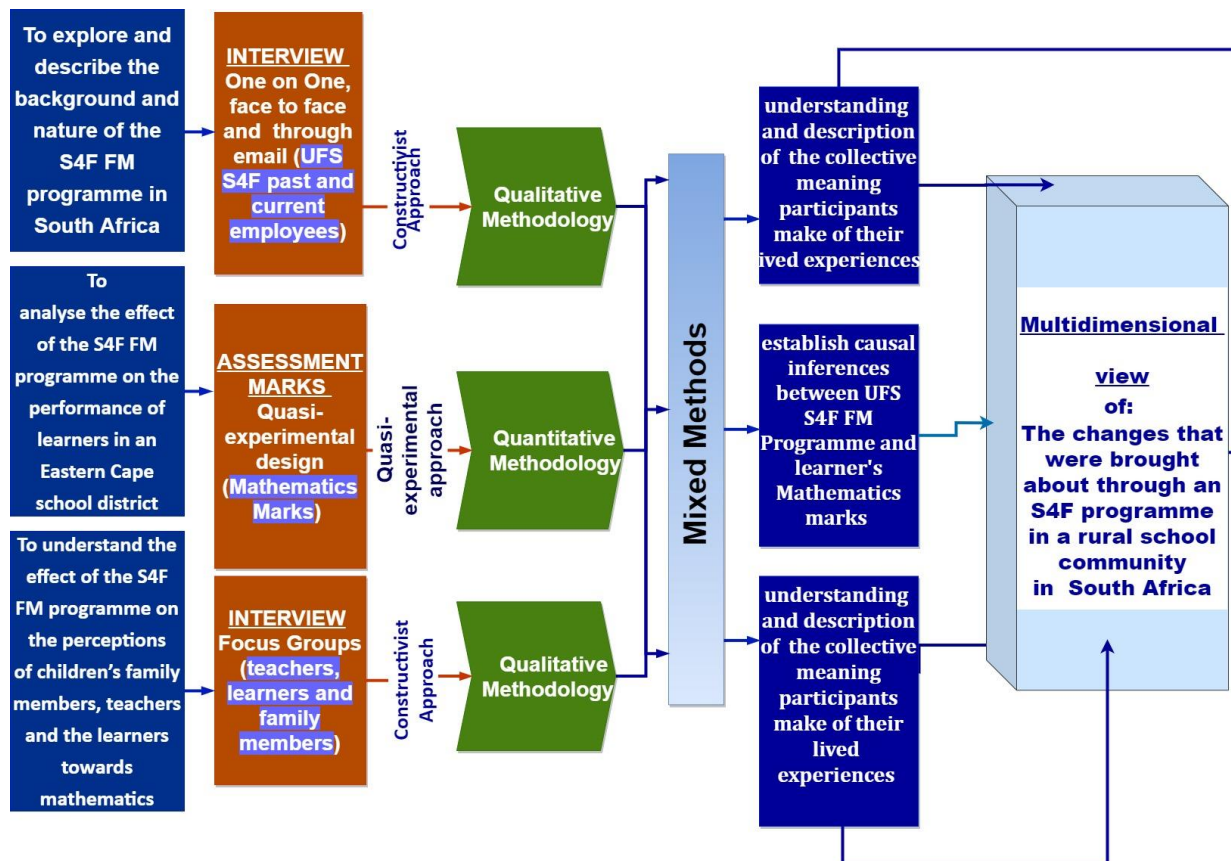


Figure 4-1: Diagrammatic representation of the research design for exploration and description of the changes that were brought about through an S4F FM programme in a rural school community in South Africa

4.3 METHODOLOGICAL CONSIDERATIONS

Mixed methods: Chapter 2 (cf. 2.2) discussed the philosophical foundation for the methodological considerations of this study. I decided to employ a quantitative research methodology, within this predominantly qualitative study, to fully understand the changes brought about by the S4F FM programme. I therefore used mixed methods. Johnson et al. (2007: 123) define mixed methods as a “*class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language in a single study or set of related studies*”. Among the strengths of mixed methods is that narratives, pictures and observations can be used to enhance the meaning of numbers, and vice versa. It harnesses the strengths of qualitative and quantitative methodologies, and offers persuasive evidence through the “*convergence and corroboration of findings*” (Johnson & Onwuegbuzie, 2009: 21). White and Sabarwal (2014: 11) further

advice that a quasi-experimental design should be used together with qualitative methods, to enhance the validity of the conclusions. In the section below, I explain the research approaches as they pertain to the qualitative research and quantitative (quasi-experimental design) methodologies of the study.

4.3.1 THE QUALITATIVE METHODOLOGY

Qualitative research is used to explore and understand the meaning that individuals and groups, in their individual and collective capacities, ascribe to a social or human experience (Creswell, 2009: 5). In this research, I interpreted these accounts to make sense of the meaning that participants make of their interaction with the S4F FM programme. In the following sections, I describe data sources, data generation and data analysis.

4.3.1.1 DATA SOURCES

Consistent with the common practice in qualitative research, the selection of participants for data generation in this research was purposeful (Creswell, 2009: 178; Merriam, 2009: 17). This is usually done to allow participants, familiar with the subject or phenomenon of research, to reflect on their personal experiences and organisational contexts of that subject of research (Willis, 2012: 56). In this study I discussed the history of the FM programme and perceptions of the school community with the participants, as an act of data generation for the qualitative aspects of the study.

To explore the background and nature of the S4F FM programme offered by the University of the Free State, I purposefully selected people who currently work or have previously worked with the S4F FM programme. In total, I interacted with three individuals, who were all female. Table 4.1 provides other details about the participants.

Table 4-1: Profile of participants for the history of FM and school community members' perceptions

Exploration and description of the background and nature of the S4F FM programme in South Africa (history of S4F FM)			
Interviewee name (pseudonyms)	Years of experience with UFS S4F FM	Type of interview	Date of interview
1. Marie Pretorius	8 years	Email	11 July 2017

2. Andrietta Jonker	6 years	Face to face	14 March 2019
3. Elna Kriel	4 years	Face to face	14 March 2019
Total UFS S4F staff	3		
Understanding the effect of the S4F FM programme on the perceptions of the school community towards mathematics (perceptions of school community)			
4. Family members	Number of interviewees (school and group)	Type of interview	Date of interview
	Lufefe PS = 5	Focus Group	27 February 2019
	Kuyasa PS = 12	Focus Group	4 March 2019
	Cawe PS = 7	Focus Group	12 March 2019
Total family members	24		
5. Teachers	13 Schools	Focus Group	30 November 2018
Total teachers	13		
6. Learners	Lufefe PS = 7	Focus Group	27 February 2019
	Kuyasa PS = 17	Focus Group	4 March 2019
	Cawe PS = 12	Focus Group	12 March 2019
Total learners	36		

The second empirical research sub-question was responded to using a quantitative research methodology, which is dealt with later in this chapter (cf. 4.3.2). The process of inquiry in response to the third empirical research sub-question, on the other hand, was dealt with in terms of a qualitative research methodology. This question is: what was the effect of the S4F FM programme on the perceptions of children's family members, teachers and the learners themselves towards Mathematics? In aiming to answer this sub-question, the data sources were also purposefully selected, and included teachers, learners and family members from schools that are part of the S4F FM programme.

The teachers were the first group of the school community that I interviewed. I did this because I deem teachers to be the gatekeepers of the learners and their family members (Willis, 2012: 63). I therefore felt that I needed to establish contact and the rapport with the teachers first. I could then use this relationship to arrange interviews with the learners in their respective schools, and subsequently also the children's family members.

4.3.1.2 DATA GENERATION

History of the S4F FM programme: In-depth interviews were the main data generation strategy used to understand the history of the FM programme in South Africa. The first interview I conducted through email was with Marie Pretorius (pseudonym). Marie Pretorius was a staff member at the Research Institute for Education Planning (RIEP) of the UFS when the exploratory visits that culminated in the adoption of EQUALS FM and Family Science were made to the USA, until her retirement in 2007.

I therefore purposefully selected Marie Pretorius as a participant in this research, primarily to provide the perspective from a different era of the S4F programme. My supervisor for this PhD study introduced me to Marie through email. The two of them had known each other as former UFS colleagues. At the time of her retirement, Marie was the project leader. She had been trained as a facilitator in the Edenboro University of Pennsylvania (EUP) in the USA. The leadership position and the training she received in the USA provided Marie with a unique understanding. Interviewing her was valuable to me as it allowed me insight into the dynamics of the origins of the S4F FM programme. I emailed questions to Marie through email, to which she responded in extensive detail.

I also conducted face-to-face, one-to-one, semi-structured interviews with two of the current staff members of the S4F FM programme at the Bloemfontein campus of the UFS. The first was Andrietta Jonker (pseudonym) who had worked in the programme for six years. The second was Elna Kriel (pseudonym) who joined the programme in 2014. Both interviews lasted approximately 45 minutes. I requested permission from both interviewees to record the interviews to assist me with transcription, and they both agreed.

Perceptions of teacher participants: As a strategy to mitigate against gatekeeping (Cohen et al., 2007: 128), the teachers were the first group that I interviewed in order to understand the perceptions of the school community towards Mathematics. I regard teachers as the gateway to the learners and family members of the children they teach in their respective schools. Consequently, I needed to establish contact and rapport with the teachers first. Using that relationship, I would then be able to arrange interviews with the learners in their respective schools, and also with their family members. In total, 13 Grade 3 Mathematics teachers were available for the single sitting of group interviews out of a possible 18 from participating schools in of S4F FM programme. It is my considered view that this a number

is adequate. In qualitative research, according to Perry (2001: 312), there are no rules that prescribe the number of participants required to answer a particular question. Instead, participants should be added for as long as new insights emerge, until data saturation is reached (Perry, 2001: 312).

Willis (2012: 195) advises that group interviews should preferably be conducted in a venue with which the group is familiar and comfortable. These authors argue that the venue, together with its physical arrangement, therein offers a psychological sense of security for the interviewees. In this regard, the interviews took place in the provincial Leadership Institute located in the periphery of the town of Mthatha. The Institute is where provincial and district training and workshops for teacher development usually take place. This venue was therefore familiar to the teacher participants in this study. We occupied one of the many seminar rooms available in the building. There was no other activity in the adjoining rooms, leaving us to continue with relative calm and minimal noise levels.

The seats in the room were arranged in a semi-circle, with no teacher sitting behind another. For ease of reference, I numbered the teachers from left to right in my notebook so that the teacher on the extreme left was referred to as teacher No. 1, and the last one on the right as teacher No. 13. The interviews commenced after the exchange of pleasantries, signing of consent forms and a brief discussion of the ethical issues concerning the study.

Perceptions of learner participants: I conducted focus group interviews with Grade 4 learners from three different schools. There were seven learners (four girls and three boys) in the first school first, Lufefe Primary School (pseudonym). The school is located about 30 kilometres outside of the Mthatha CBD. I interviewed only learners whose family members had turned up for the parents meeting convened by the school on that day. This was to ensure that I interviewed learners whose family members had consented, by signing the parents' consent form. I guided the learners through signing the assent forms and explained to them their rights as contained in the ethical clearance. I followed the same procedure with the other two schools. The learners were seated in a single row with me in front of them. Learners were numbered from left to right for the purposes of reference, with the first letter indicating the school where the interviewee came from (e.g. L for Lufefe PS) and the letters B and G signifying the learners' gender as Boy or Girl, respectively. In the end, their numbering was LGNo.1, LGNo.2, LGNo.3, LBNo.4, LBNo.5, LBNo.6 and LGNo.7.

The second school, Kuyasa Primary (pseudonym), is located about 5 kilometres outside the Mthatha CBD, and had 17 learners, seven boys and 10 girls, who were interviewed. The same procedure and criteria outlined for school number one above were followed. The learners were seated in two rows, and numbered from KGN0.1 to KGN0.10, with KBN0.1 to KBN0.7 intermingled in-between.

The third school was Cawe Primary School (pseudonym). It is located about 40 km outside of Mthatha. Twelve learners were interviewed, and there were five boys and seven girls. They were numbered in a similar way to the other two schools, prefixed by the letter C.

Table 4-2: Identifiers for the family member and learner interviewees

Lufefe PS			Kuyasa PS			Cawe PS		
Family member	Girl learner	Boy learner	Family member	Girl learner	Boy learner	Family member	Girl learner	Boy learner
LFMNo.1	LGN0.1	LBN0.1	KFMNo.1	KGN0.1	KBN0.1	CFMNo.1	CGNo.1	CBNo.1
LFMNo.2	LGN0.2	LBN0.2	KFMNo.2	KGN0.2	KBN0.2	CFMNo.2	CGNo.2	CBNo.2
LFMNo.3	LGN0.3	LBN0.3	KFMNo.3	KGN0.3	KBN0.3	CFMNo.3	CGNo.3	CBNo.3
LFMNo.4	LGN0.4		KFMNo.4	KGN0.4	KBN0.4	CFMNo.4	CGNo.4	CBNo.4
LFMNo.5			KFMNo.5	KGN0.5	KBN0.5	CFMNo.5	CGNo.5	CBNo.5
			KFMNo.6	KGN0.6	KBN0.6	CFMNo.6	CGNo.6	
			KFMNo.7	KGN0.7	KBN0.7	CFMNo.7	CGNo.7	
			KFMNo.8	KGN0.8				
			KFMNo.9	KGN0.9				
			KFMNo.10	KGN0.10				
			KFMNo.11					
			KFMNo.12					

Perceptions of family member participants: As explained above, the parent participants in the focus group interviews came from the same schools as the learner participants. The

interviews were also conducted on the same day. The number of family members did not correspond with the number of learners, as one family member would for example represent more than one learner in some instances. The seating position and the specific school were used to determine the identity of the family member participants. The code CFM#, for example, represents a family member of the Cawe PS.

In summary, I conducted group interviews with 36 learners from three different primary schools during three different sessions. Twenty-one girls and 15 boys constituted the learner participant group. I also conducted group interviews with 13 teachers, each representing her school, in one session. All the teachers were female. The last group interviews I conducted was with 24 family members from three different schools in three different sessions, which came immediately after each learner session. One-to-one interviews with three female UFS S4F members, during three different sessions, were also conducted.

4.3.1.3 ANALYSIS OF DATA

I conducted the focus group interviews in isiXhosa. I then transcribed the generated data in English using MS Word. As a native isiXhosa speaker, I felt I was in a good position to do the translations. Still, in my reporting, I provide quotes in both English and isiXhosa, so that their correctness can be confirmed by those able to read and understand isiXhosa. I followed up the transcription process with coding.

I coded the data through a computer programme called MAXqda, which Creswell (2009: 188) describes as “*excellent*” in analysing qualitative data. Even with the computer programme, I still had to purposefully select segments from the transcripts and assign them labels as codes. I found the MAXqda software helpful in the subsequent stages of “*grouping, reorganising and sorting of the codes, and thus generating themes*” (Saldaña, 2009: 26–27).

I then read through the document to obtain a broad sense of the meaning, starting with an initial cycle of coding and re-coding, using Creswell’s condensed steps (2009: 127). Coding, according to Creswell (2009: 127) is the process of arranging the participant responses into segments of text before bringing meaning to information. It is, however, Saldaña’s coding manual (2009: 3) that brings more clarity to the step by step process of coding.: 3) describes a code as “*a word or short phrase that symbolically assigns a summative, salient, essence-*

capturing, and/or evocative attribute for a portion of language-based or visual data." Cohen et al. (2007: 369) advise that such a label can be predetermined, come from the words participants used, or be a product of the meaning-making process from the data itself. In the case of the present data, I derived codes from all three sets of sources. I also found that basing the interview questions on a theoretical framework, a literature review and the research question, helps generate codes and subsequent themes. In the section below, I explain the research methods related to the quantitative aspect of the study.

4.3.2 THE QUANTITATIVE METHODOLOGY

In this section, I deal with the quantitative methodology of enquiry to respond to the fourth sub-question of this study: *what was the effect of the S4F FM programme on the performance of learners in the Eastern Cape Education District of OR Tambo Inland?* I collected and analysed numerical data, which was comprised of the achievement marks in Mathematics of the learners who had been exposed to the 4F FM programme in the OR Tambo Education District.

I sought and obtained approval from the Eastern Cape Department of Education (ECDoE), specifically the Education Management Information System (EMIS) office, to have access to the 2016, 2017 and 2018 Mathematics results. The Mathematics learner marks are derived from the schools' assessments scores in term four of each year, in the subject. The dependent variable, namely learners' Mathematics achievement marks, were the results of internal (school) assessments. I now discuss the selection of schools into the S4F FM programme.

4.3.2.1 SELECTION OF SCHOOLS INTO THE S4F FM PROGRAMME

It is necessary that I explain the selection of schools participating in the S4F FM programme, and the subsequent inappropriateness of that selection in the light of this experimental inquiry. I further clarify the alternative research design that I followed as a result of randomised experimental design, considered a "*gold standard*" for quantitative research (Kim & Steiner, 2016: 395), not being feasible in this context. I also justify the choice of the method with the view to give due consideration to the possible threats to validity and reliability (Creswell, 2009: 162-158) in this study.

The OR Tambo District coordinator for the S4F FM programme, explained that ten schools voluntarily took part in a SANRAL road safety awareness competition, and were subsequently recruited into the SANRAL-sponsored S4F FM programme. These schools happened to be located in the more affluent areas of the OR Tambo District. The education administrators of the District were interested in expanding the influence of the S4F FM programme to more remote parts of the District. Consequently, the District added eight more schools, based on their rural location and minimal involvement in other intervention programmes.

This points to administrative and self-selection bias, based on the geographic location of the schools (Heinrich, Vázquez & Maffioli, 2010: 12). The participating schools were not randomly selected, which equally precludes the random selection of the control group of non-participating schools. Consequently, to establish two comparable groups for statistical analysis, the treatment and control groups, I used the Propensity Score Matching (PSM) strategy of quasi-experimental research design. Later in this chapter, I expound on the PSM as a strategy to build a comparison group to the treatment group. Below is a summary of primary schools in the OR Tambo Inland District, and in the UFS S4F programme. I also discuss the resultant quasi-experimental research design in response to the observed selection bias.

Table 4.3 shows a summary of the numerical data for this study. The data was replicated over three years, 2016 – 2018, and seven grades (R – 6) were under review. During this period, 16 schools were part of the S4F FM programme in the OR Tambo Inland District. The schools outside the intervention varied from a minimum of 247 to a maximum of 252.

Table 4-3: Number of schools, participating (treatment) and not participating (control) in the S4F FM programme in Grade R to Grade 6 during 2016 - 2018

	2016		2017		2018	
	Control	Treatment	Control	Treatment	Control	Treatment
Grade R	248	16	250	16	251	16
Grade 01	250	16	250	16	251	16
Grade 02	250	16	251	16	251	16

Grade 03	250	16	250	16	252	16
Grade 04	250	16	250	16	250	16
Grade 05	249	16	250	16	250	16
Grade 06	247	16	247	16	248	16

Finally the data that I analysed had 145455 records of learner's mathematics marks at a level of learner granularity. The records were constituted as follows: - For each school had 7 (grades R- 6) x 3 (years, 2016- 2018) = 21 x number of learners from each school. When printed out these records make 1532 pages, which makes it near impossible to include in the list of addenda. I included data for one school, just to provide the reader with an idea to the structure of the layout. Similarly, baseline data for used for the selection of the treatment and control groups is displayed in the list of addenda.

4.3.2.2 QUASI-EXPERIMENTAL RESEARCH DESIGN

Researchers use quasi-experimental designs where the conventional experimental control of other factors or randomisation are not possible (Kim & Steiner, 2016: 395; White & Sabarwal, 2014: 2). Randomisation, according to Ravallion (2003: 2), is one strategy to take care of extraneous factors, which could possibly affect the outcome in the same way that the variable of interest could. However, randomisation is also not always possible, especially in the social sciences. Situations such as convenience sampling, ethical practicalities and budgetary considerations mitigate against randomisation (Creswell, 2009: 155; Ravallion, 2003: 3). Quasi-experimentation came into existence as a result of the flaws in inquiries using first principles by original natural philosophers, on the one hand, and the implausibility of using experimentation and randomisation in social sciences, which came to replace the intuitive use of the first principles (Shadish, Cook & Campbell, 2005: 2).

Therefore, according to Kim and Steiner (2016: 395), quasi-experimental designs are as reliable as randomised control studies, and are able to minimise threats to the validity of a study. It highlighted that the observed differences in learners' mathematics achievement between the schools in the S4F FM intervention programme and the schools that are not part of the programme, are not because of the selection bias caused by participation in the programme. I consequently chose propensity score matching (PSM) as a statistical strategy

in this research to mitigate the selection bias and enable the causal inferential conclusions between the S4F FM programme and learners' Mathematics achievement marks (White & Sabarwal, 2014: 1).

4.3.2.3 RATIONALE FOR SELECTION OF A COMPARISON GROUP

In traditional scientific research, I would need to satisfy three principles mentioned by Shadish et al. (2005: 6), to establish whether the S4F FM programme, which is the treatment, affects learner Mathematics achievement marks, the dependent variable. The first of these is that the cause must occur before the effect. In other words, learners, teachers and family members should be exposed to the S4F FM programme activities before the change in mathematics marks can be observed. Second, there needs to be a relationship between the cause and effect. In the case of this study, the FM activities must be aimed at improving learner performance in the subject, which is the case. Lastly, there should be no other credible explanations for the effect, other than the treatment.

In the case of the present study, there could be many alternative and plausible explanations for the change in learner performance in Mathematics, which cannot be explained through FM activities. The reason for this handicap is that baseline characteristics were not equalised during selection into the intervention. I cannot eliminate all these alternative explanations, but I can minimise them by employing a suitable quasi-experimental design strategy such as propensity-score matching (PSM).

4.3.2.4 PROPENSITY-SCORE MATCHING (PSM)

PSM is one of the quasi-experimental strategies that match the control group to the treatment group in as many baseline confounding factors as possible (Kim & Steiner, 2016: 400; White & Sabarwal, 2014: 2). As a statistical method, PSM uses these quantifiable cofounding factors in the population from where the treatment group originates to find a match for each member of the treatment group. This creates a comparison or control group (Ravallion, 2003: 4). PSM is particularly suitable in a case where, like in this study, the list of the confounding factors is long (White & Sabarwal, 2014: 2). I enumerate and briefly discuss the possible factors, which I considered to be confounding factors, from the ECDoE (cf. 3.6) and StatsSA (cf. 3.7) databases.

4.3.2.5 IMPLEMENTATION OF PSM IN THE STUDY

Technically, selection into a control or treatment group is a binary variable (Bhattacharjee, 2012: 47–48), denoted by T . $T = 1$ is used to indicate designation into the treatment group, while $T = 0$ is used for the control group designation (Heinrich et al., 2010: 12–13). On the other hand, the observed outcome Y , that is Mathematics achievement marks in the case of the present study, for an individual school would be Y_1 if the school comes from the treatment group and Y_0 if it is from the control group. The mathematical expression of the concept is $Y = (1 - T) Y_0 + T Y_1$. If we substitute 1 in the place of T where the subject is treated, since $D=1$ for that subject and 0 for a subject that comes from the control group, since $D=0$ for that subject, then the formula becomes simplified as follows: $Y = 0 \cdot Y_0 + 1 \cdot Y_1 = Y_1$. Concisely, this means that the observed outcome Y equates to the potential outcome, if the subject was treated. Substituting a zero in case of non-treatment for the same subject in the original formula yields the potential outcome $Y = Y_0$. The potential outcome in the absence of treatment is referred to as counterfactual, because it is not observed.

White and Sabarwal (2014: 3) and Elze, Gregson, Baber, Williamson, Sartori, Mehran, & Pocock (2017: 347) highlight five steps in implementing PSM in a study. The steps include:

1. **Sample representativeness:** the sample must be large enough to represent participant and non-participant subjects in the intervention. In the current study, there were 268 primary schools in the OR Tambo District. A maximum of 252 did not participate in the S4F FM programme, while 16 did from 2016 to 2018 (table 4.2.) Baseline data made up of variables that can also explain the treatment effect of the variable of interest, learners' Mathematics achievement marks in the case of this research, needs to be as exhaustive as possible, and predate the commencement of treatment. The choice of these variables, also known as determinants of selection into the intervention, which influence eligibility into the intervention programme, is problematic in research. The consensus is that the existent body of knowledge, based on literature, should guide this process (Ravallion, 2003: 4; Lane, To, Shelley & Henson, 2012: 193; Patorno, Grotta, Bellocco & Schneeweiss, 2013: 3–4).
2. **Estimation of Propensity Scores:** The Propensity Score (PS) for a treated and untreated individual subject in the population is defined as the probability of being selected to participate in the intervention given all covariates deemed relevant (Elze et al., 2017: 347). The propensity scores are programmatically estimated using a logistic

regression with participation in the intervention as the dependent variable. A logistic regression model of treatment was fitted on the independent variables identified as confounding factors, which, based on the literature, I believed to influence eligibility for selection into the intervention programme. These are also known to affect learners' achievement marks in general, and in Mathematics in particular. The model predictions generated the propensity scores upon which matching was done.

3. **PS matching:** PS matching attempts to find one or more individual(s) in both the treatment and control groups, with similar PS. In effect, PS matching generates a quasi-population with a balance of covariates between the treatment and control groups. In the present study, for each school in the S4F FM programme (treatment), the closest match from the schools that were outside the programme (control) was sought. Of the many matching algorithms available, I chose the closest match pairing strategy, which is defined as a subject (school) from the control group being paired with a similar subject in the treatment group, based on the PSs (Austin, 2011: 404; Caliendo & Kopeinig, 2008: 8–9). The simplicity of computational manipulation motivated the choice of the closest match pairing strategy (Elze et al., 2017: 347), as well as the fact that this type of matching has well-developed diagnostics for weighing the quality of the resultant match when compared to others (Patorno et al., 2013: 8–9). I also derived confidence in the closest match pairing strategy from Da Costa, Gahl and Jüni (2014: 764–765), who compared the pairing strategy to randomised trials, which yielded similar results.
4. **Weigh the quality matching:** Once the matching has been done and a new matching control group, with respect to the underlying characteristics, is selected from the original control group, the next step is to evaluate whether the matching was a success. To do this evaluation in the present study, the distribution of propensity scores in the treatment and the new control group were compared. Matching is deemed a success if the treatment and control density charts look similar, or if there is an overlap between the two (Elze et al., 2017: 349).

In Figure 4-2 I illustrate the weighing of the quality matching and the interpretation of its results, as I understand it. This illustration assisted in the interpretation of the results in Chapter 6, since such charts constitute the bulk of the results. The colour-coded areas

A and C in Figure 4-2 represent subjects (schools) with extreme PSs, and are usually trimmed out during matching. They are said to fall outside the area (B) of common support (Heinrich et al., 2010: 39–38). The bigger the area of common support, the higher the predictive power of the given covariate (Elze et al., 2017: 348–349).

Thus, over and above the weighing of the quality of matching, the propensity score distribution charts, used together with the information value and multicollinearity assessment, as was the case in the present study, provide the researcher with the tools to gauge and predict the appropriateness of each covariate (Achour, Boumezbeur, Hadji, Chouabbi, Cavaleiro & Bendaoud, 2017: 194–195; Hartas, 2015: 621).

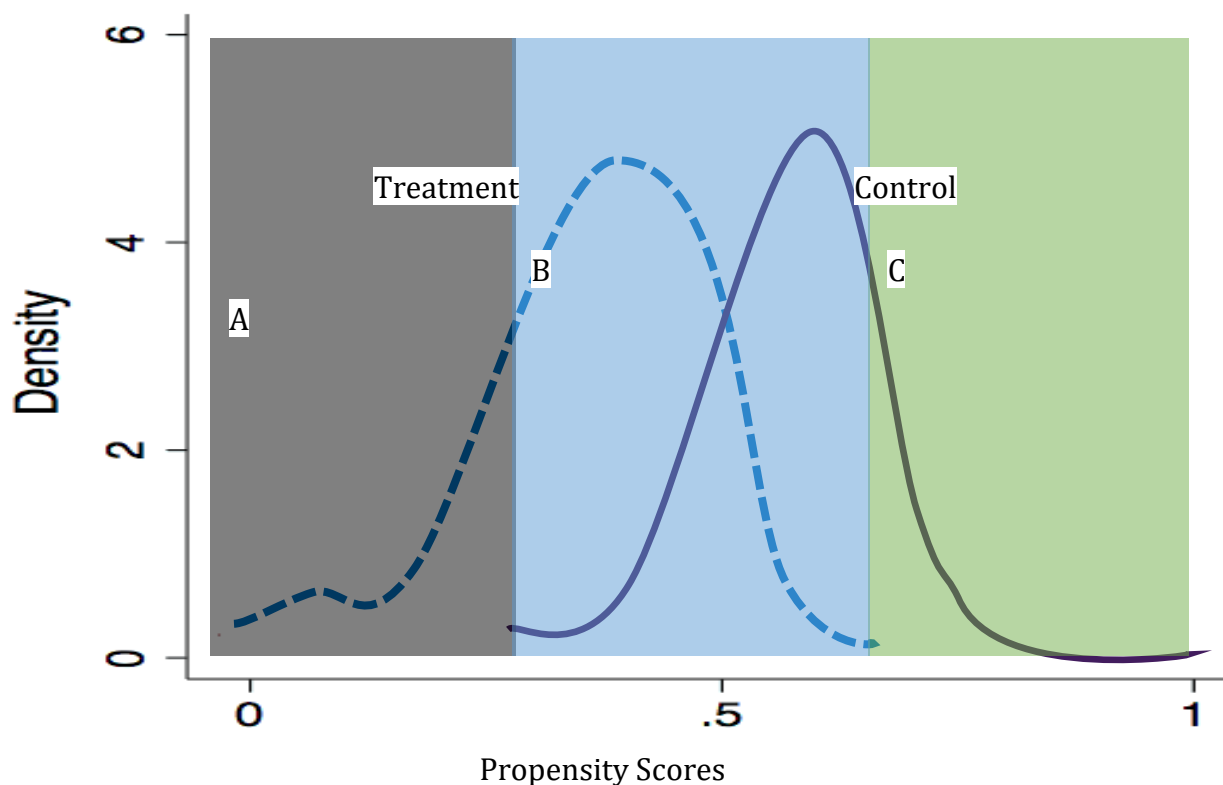


Figure 4-2: A diagrammatic representation of the distribution of propensity score, for any given confounder/s

5. Estimation of intervention effect and interpretation of results: Finally, the treatment and control groups are compared (White & Sabarwal, 2014: 5). In the case of the present study, the dependent variable, which is the Mathematics achievement marks of learners from schools in the S4F FM programme, is deemed as the treatment. This is compared to the Mathematics achievement marks of learners from schools not in the programme, which is the control group. Inferences about the effect of the S4F FM programme on Mathematics marks are made based on this comparison. In this regard,

the quantity of interest to be determined at the end, according to Heinrich et al. (2010: 9–10) is the Average Treatment Effect on the Treated (ATT), given by the formula: $ATT = E(Y_1 | T = 1) - E(Y_0 | T = 1)$.

For the purpose of clarity on the logic of the implementation of Propensity Score Matching, I took just 10 subjects from the quantitative data for this study and explain the application as simply as possible.

Table 4-4: Demonstration of operation of a selection of a comparable control group from untreated subjects based on the confounding factor

DATA				MATCHING			
School (i)	D	Learners per classroom (X)	Maths marks (Y)	Match	Y_i	Y_0	Difference
Mlanbo	C	15	35				
Mfula	C	59	55				
Ntlanjeni	C	45	56				
Thambeka	C	29	51				
Thafeni	C	195	34				
Dongeni	T	29	51	Thambeka	51	51	0
Liwa	T	39	69	Ntlanjeni	69	56	13
Hlathi	T	26	51	Thambeka	51	51	0
Ndulwini	T	62	65	Mfula	65	55	10
Ntabeni	T	52	58	Mfula	58	55	3
				ATT			2,6

According to this oversimplified example, based on the actual data for this study, the S4F FM programme (intervention) has had a positive impact on learners' Mathematics achievement, with $ATT = 2.6$. ATT is given by the average of $Y_1 - Y_0$ for the observed schools. Table 4.2 explains the procedure towards obtaining this ATT value. A match for each school from the intervention (T) had to be found from the schools that were not in the intervention (C), based on a covariate X. For example, the match for the treated school, Dongeni with the value for Learners per Classroom (X) = 29 was Thambeka, with the same

value for X . X is the confounding factor. In the second example, the treated Liwa with $X = 39$ was matched with Ntlanjeni, $X = 45$, because 45 is the closest number to 39 in the available list of values for the untreated (C). The type of matching is the nearest neighbour covariate matching (Heinrich et al., 2010: 19). The difference between the outcome if treated ($Y1$) and if not treated ($Y0$) = 0 for the first match and = 13 for the second. The average of the differences = 2.6 = ATT. Next, I discuss the confounding factors that were used to minimise the effect of the selection bias.

4.3.2.6 THE CONFOUNDING FACTORS

The quantitative analysis of data in this study centres on the use of propensity scores to eliminate selection bias inherent in the inclusion or exclusion of schools into the S4F FM programme. As explained above, the generation of these propensity scores is dependent on confounders that the researcher deems relevant. Therefore, it is necessary that I explain the selected confounding factors, and how they are applied in the analysis data and interpretation of results.

There are two broad types of confounding factors to generate propensity scores: continuous and categorical variables (Rawles & Bignall, 2019: 33). Continuous variables are numeric and made up of rational numbers without a predetermined incremental. Categorical variables, on the other hand, have a defined number of categories or discrete group intervals (Austin, 2011: 412; Rawles & Bignall, 2019: 34). For example, gender is a categorical variable, with male and female being the categories. The algorithm of computing continuous and categorical variables into the generalised linear regression model differ, which makes it necessary that I indicate which variables belong to which category in the present study. Table 4.4 shows the description confounders for the present study, and the division into continuous and categorical variables. PSM, similar to many other regression analysis techniques, has challenges, and the analyst should be aware of these and manage them.

Table 4-5: List of confounding factors that affect learners' Mathematics marks

VARIABLE	DESCRIPTION
CONTINUOUS VARIABLES	
Enrlmnt_GradeR	2015 - 2017 Enrolment Trend in Grade R
Enrlmnt_Grade1	2015 - 2017 Enrolment Trend in Grade 1

Enrlmnt_Grade2	2015 - 2017 Enrolment Trend in Grade 2
Enrlmnt_Grade3	2015 - 2017 Enrolment Trend in Grade 3
Enrlmnt_Grade4	2015 - 2017 Enrolment Trend in Grade 4
Enrlmnt_Grade5	2015 - 2017 Enrolment Trend in Grade 5
Enrlmnt_Grade6	2015 - 2017 Enrolment Trend in Grade 6
LearnersPerEducator_2017	Learner:Educator Ratio during 2017
LearnerToilet_2017	Learner:Toilet Ratio during 2017
LearnersPerClassroom_2017	Learner:Classroom Ration 2017
Pregnancies_2017	Number of learners pregnant during 2017
Education	Number of people falling within an Education Level category
MedIncome	Number of households in the local municipality falling within an Income bracket
PropElectricity	Number of households in the local municipality with access to electricity
PropEmployed	Number of individuals with some form of employment in the local municipality
CATEGORICAL VARIABLES	
WaterSource	Number of households in the municipality where the school is located with access to a water source:- Municipal supply River or other
Toilet	Number of households in the local municipality where the school is located, utilising a specific type of toilet facility: Flush toilet Pit toilet with ventilation Pit toilet without ventilation None
AreaType	Number of people in the local municipality where the school is located living in a specific type of residential area: - Formal Traditional

4.3.2.7 CHALLENGES OF PSM

Endogeneity: One of the challenges with observational educational research is mitigating against the resultant biased estimation of the effect of treatment as a result of an omitted variable in the model (Crosnoe & Cooper, 2010: 282; Olmos & Govindasamy, 2015: 71). Reasons for the omission of confounders in the estimation of propensity scores can either be ignorance, or non-observability or non-quantifiability (e.g. motivation). Ideally, predictor variables or confounders should be independent of other factors, whether

unobserved or inadvertently omitted. The confounders should be exogenous, rather than endogenous. (Ravallion, 2003: 6–7). Failure to meet this assumption leads to either an overestimation or underestimation of the treatment impact, and can lead to inaccurate inference claims, which in turn leads to inappropriate decisions (Crosnoe & Cooper, 2010: 22).

Endogenous variables or endogeneity in a regression occurs when there is a factor, such as the teacher's years of teaching Mathematics (factor Z), that might explain learners' Mathematics marks (Y). On the other hand, Z is can also explain the selection into the S4F FM programme(X), yet Z was omitted in the model. This is purely an explanatory example, as teachers' years of experience did not determine the selection of schools into the S4F FM rogramme in the OR Tambo Inland District.

Multicollinearity: The second challenge of non-experimental research designs is multicollinearity. This occurs when a multiple linear regression model is run, due to a strong correlation between two or more predictor variables (Rawles & Bignall, 2019: 220). Strong correlations among confounders in the multiple regression model result in the weakening of the predictive power of one or more of the correlated variables, as indicated by a high confidence interval of the coefficient of that confounder. Eventually, these multicollinearity complications lead to difficulties in interpreting the results. This has an impact on the uncertain statistical significance of the findings from a research endeavour (Kraha, Turner, Nimon, Zientek & Henson, 2012: 1–2).

Kraha et al. (2012: 3–4) propose several statistical strategies to mitigate the effects of multicollinearity, of which the Pearson correlation test and relative importance weights were used in this study. Highly correlated variables were omitted from the model (Laidra, Pullmann & Allik, 2007: 7–8).

Information Value (IV), which Achour et al. (2017: 193–194) describe as a quantitative measure of the predictive capability of each confounding factor relative to other confounding factors, was also used in the present study as a relative importance weight. IV assists in curtailing the number of confounders during the early stages of preparation for Logistic Regression, particularly when the list of these confounding factors is long. IV values, according to Siddiqi (2006) as cited in Achour et al. (2017: 193–194), are used as

follows: if < 0.02 , the confounder is useless for modelling. Between 0.02 to 0.1 the confounder has only a weak predictive strength. From 0.1 to 0.3 the confounder has a moderate predictive strength relationship. Above 0.3 the confounder has a strong predictive value. I discuss the analysis of the data that emanated from the learners' achievement marks in Mathematics in the section below.

4.3.3 DATA ANALYSIS

The analysis of the data on the effect of S4F FM programme was robust, both at the level of personalities involved (Cox et al., 2018: 309) and data processing. Firstly, the statistical analysis of the data was done in the department of Mathematical Statistics and Actuarial Science at the University of the Free State, on my behalf. Second, I consider myself independent of the S4F FM programme, as I am neither an employee of UFS nor a practitioner in the programme, whose effect on Mathematics achievement marks is being evaluated in this analysis. No one therefore felt obligated to contrive any specific outcome, positive or negative, about the programme.

In analysing data, several researchers in quasi-experimental designs using propensity scores, recommend a combination of covariates in the selection and outcomes models (Becker & Ichino, 2002: 361–362; Li, Zaslavsky & Landrum, 2013: 1–2; Elze et al., 2017: 348; Da Costa et al., 2014: 764–765; Patorno et al., 2013: 10–11). Consequently, the statistical programming environment, R, was used to perform linear regression models (LM), generalised linear model (GLM) and linear mixed models (LMM). In total, five models were built to analyse the data, from selection to assignment into either the treatment or control group. However, before any model was fitted, data was explored to facilitate decision-making on the exact computational algorithms suitable for the data and the estimates required.

4.3.3.1 DATA EXPLORATION, ESTIMATION OF PS AND EVALUATION OF MATCHING VARIABLES

Cox et al. (2018: 47) explain that the initial stage of data analysis is exploratory and involves inspecting the data in order to make decisions about subsequent analysis. Visual inspection, which includes distribution plots, is one of the techniques available to the analyst to explore data (Da Costa et al., 2014: 763; Heinrich et al., 2010: 38; Cox et al., 2018: 10). Therefore, density distribution plots were generated for the treatment and control groups to check the

distribution of each school for a given variable. The plots were later contrasted with distribution plots of the same variable, after matching through propensity scores was done.

4.3.3.2 GENERALISED LINEAR MODEL TO PREDICT PROPENSITY SCORES (MODEL 1)

The GLM model of the treatment was fitted on the predictor variables identified as important through the multicollinearity and correlation tests. GLM, according to Cox et al. (2018: 183) allows for the fitting of many different models, including the binomial, as is the case in the present study. The advantage of running a logistic regression, over many other algorithms of predicting propensity scores, is that the summary output allows for assessing the model fit (Olmos & Govindasamy, 2015: 78), in other words how successful the model has been in predicting the propensity scores. The model prediction formed the propensity score on which matching between the treated and untreated schools was undertaken to establish a balanced comparison group.

Density distribution plots, as Olmos and Govindasamy (2015: 78) recommend, were generated to evaluate the distributional similarity of the propensity scores between the emergent treatment and control groups. Based on these distribution plots and pre-matching evaluation, which included multicollinearity and variable importance, some confounding factors were omitted in subsequent models.

4.3.3.3 LINEAR REGRESSION MODEL TO ESTIMATE THE EFFECT OF INDEPENDENT VARIABLES ON THE LEARNERS MARKS (MODEL 2)

A linear regression model (LM) of the learners' average marks (LearnerAverage) was fitted on the identified explanatory variables. However, it is important to remember the structure of the data in this research in order to understand the requirement for certain model choices for the data analysis, including the LM under discussion here. The structure is a multilevel one, with learners (level 1) nested within classes/grades (level 2), which are in turn nested within schools (level 3) (Smith, 2011: 11–12). In such situations, shared influences regarding performance may exist amongst learners attending the same school (Smith, 2011: 11–12), a concept referred to as non-independence (Brauer & Curtin, 2018: 389–390). On the other hand, data collected from one learner in one year should be independent of the preceding data collected from the same learner in another year, although this cannot be guaranteed (Cox et al., 2018: 221). If the independence assumption of the linear regression could not be managed at the design stage, as is the case in the

present study, then the use of mixed models at the analysis stage becomes indispensable (Cox et al., 2018: 221).

Regarding the above discussion, learners' classes (SubjectGrade) and the treatment, were included as fixed variables in the LM model 2. The year of assessment (DataYear) was included as a random variable. Fixed and random variables were factored in alongside the confounders previously used to predict propensity scores. The confounders were LearnersPerEducator_2017, Pregnancies_2017, LearnerToilet_2017, Education, PropEmployed, WaterSource, Enrlmnt_Grade3, MedIncome, PropElectricity and Propensity.

Model 2, LM, was therefore used as a preliminary step to determine whether the fixed variables, random and predictor variables each have a significant relationship with the learners' average mark. Subsequent models exclusively looked at the effect of the random and mixed variables on learners' achievement marks.

4.3.3.4 LINEAR REGRESSION MODEL TO ESTIMATE THE EFFECT OF NESTED VARIABLES ON THE LEARNERS MARKS (MODEL 3)

It is necessary to orientate the reader about the nature of the data analysed in the present research. The assessment marks (the outcome) came from learners, who are organised into classrooms. Classrooms are found in schools. This multilevel data structure necessitates a model that evaluates the effect of the variables nested within others (Peugh, 2014: 8–9). For example, in the case of the present study, one may ask: do similarities or differences between classrooms of the same and across schools contribute to the variance in the model prediction of the outcome? Model 3 of the present study addresses this question.

4.3.3.5 LINEAR MIXED MODEL TO ESTIMATE THE EFFECT OF FIXED AND RANDOM EFFECTS ON LEARNERS' MARKS (MODEL 4)

There was a need in this study for the model structure to accommodate nesting. Nesting, as Cox et al (201: 166–167) point out, presupposes that there is a relationship between groups. For example, as is the case in the present study, learners from one classroom are assumed to be similar to others in the same classroom in a way that distinguishes them from the learners of another classroom. Similarly, learners from one school are assumed to be similar to others in the same school in a way that makes them distinct from learners in other schools. Thus, according to

Cox (2017: 166–167), learners' achievement marks are nested within classrooms and those classrooms are in turn nested within schools. The linear mixed model is therefore used in the present study to take into account the variability between classrooms and schools.

Specifically, in the present study, of the two packages for mixed models in R, the lme4 package was chosen over the nlme package. Four criteria, outlined by Bates, Mächler, Bolker and Walker (2015: 2) motivated for the choice. First, lme4 utilises more efficient linear algebra tools, resulting in improved performance on complex algorithms. Second, a simple syntax is used in lme4, which gives rise to a proficient application with which to fit crossed random effects models. Third, the resulting output parameters include a profile of likelihood confidence intervals on random effects. Lastly, lme4 also can fit generalised linear mixed models.

4.3.3.6 LINEAR MODEL TO ESTIMATE THE AVERAGE TREATMENT EFFECT FOR EACH GRADE (MODEL 5)

In the final model, the average treatment effect was estimated within each grade, and an overall estimated treatment effect was calculated by taking a weighted average across grades. This procedure assumes that there are no systemic differences between the two groups. The matching through propensity scores was successful, thereby yielding an unbiased estimate of the average treatment effect (Elze et al., 2017: 350–351).

This final model, and the estimation of the grade by grade and the overall effect of the S4F FM programme on the Mathematics marks, conclude the quantitative aspect of the study. The quantitative analysis, combined with the qualitative aspects reported on in Chapters 5 and 7, give this study its mixed methods character.

In this study the two research methodologies, qualitative and quantitative, are systematically brought together to answer the main research question. In fact, these research methodologies should not be considered as discretely separate methodological worldviews that cannot coexist in the same research endeavour. Instead, the two represent the opposite ends of the same continuum, with mixed methods in the middle (Creswell, 2009: 3). Researchers have long ignored the dichotomous approach to research, and rather focus on what would be effective to answer their research questions. This is often done with

a combination of qualitative and quantitative methodologies (Johnson & Onwuegbuzie, 2009: 22).

Given the above discussion, I considered mixed methods appropriate to achieve the primary objective of this study, namely to *explore and describe the changes brought about through an S4F programme in a rural school community in South Africa*. I used the qualitative and quantitative and research methodologies as described in 4.3.1 (cf. 4.3.1) and 4.3.2 (cf. 4.3.2), respectively, to understand the changes brought about by the programme. I describe, in detail, the type of mixed methods I chose and their challenges thereof, in the following sections.

4.3.3.7 TYPE OF MIXED METHODS

In the sequential strategy of mixed methods, quantitative data collection, analysis and interpretation strategies are undertaken within a mostly qualitative study to address different research sub-questions (Creswell, 2009: 15). I started with the qualitative data collection to explore the background to the S4F FM programme, followed by the quantitative processing of learner achievement marks in Mathematics from the schools participating in the S4F FM programme. I then followed up this quantitative phase of the study with group interviews of teachers, learners and children's family members. According to Creswell (2009: 214), this ordering of procedures and scale of mixing the qualitative and quantitative methodologies are some of the characteristics of a sequential strategy. Johnson & Onwuegbuzie (2009: 22) recommend the QUAL + QUAN + QUAL depiction of this type of mixed strategy.

I deemed the sequence of mixed methods suitable for this study for two reasons, as outlined by Creswell (2009: 214). The first was to gain a deeper understanding of the changes brought about as a result of the S4F FM programme on the rural school community of the Eastern Cape. Second, beyond building confidence in the conclusions reached, I used quantitative research strategies within a qualitative research framework to examine the subsequent changes to learners' Mathematics performance. I have also considered the disadvantages that are inherent in the strategies of enquiry I have chosen. One such drawback I believe is essential for this study, as Creswell (2009: 214) points out, is that the imbalanced nature of the two databases make it difficult to resolve discrepancies when they arise. In the section below, I expand on the challenges associated with a mixed method.

4.3.3.8 CHALLENGES OF MIXED METHODS

Collins et al. (2012: 581) concisely articulate the challenges pertinent to the mixed method research methodology. There are four such challenges, according to these authors. The first is the extent to which the researcher can unearth sufficient meaning from both the numerical and textual data, referred to as the “*representation challenge*”. The second are the interrelated difficulties of coming up with credible findings, and framing reliable and transferable inferences emanating from the qualitative and quantitative aspects, called “*challenge of legitimation*”. Thirdly is the extent to which the researcher establishes some form of consistency between the inferences and the theoretical framework, called the “*problem of integration*”. The last challenge relates to the issues of ethics and politics, reflecting the extent to which conclusions are socially balanced as well as ethically acceptable and valuable to the research consumer community.

In summary, the challenges associated with mixed method range from its cumbersome nature, the diverse knowledge requirements of methodologies which necessitates a longer research period, and the fact that the researcher is exposed to the onslaught of purists from both sides, both quantitative and qualitative (Johnson & Onwuegbuzie, 2009: 21). With these inherent challenges in mind, I explain below in detail the ethical consideration, threats to the legitimacy of the study and strategies I used to mitigate against the challenges.

4.4 THE INTEGRITY OF THE STUDY

In the following subsections, I discuss the integrity of the study regarding the ethical considerations, my biases, and the validity of the study.

4.4.1 ETHICAL CONSIDERATIONS

I considered it ethical to apply for and obtain approval to conduct research in schools in the Eastern Cape. It is in actuality departmental policy that permission should be granted by the provincial Department of Education before any research is undertaken in schools in the province. The application included a request for permission to interact with learners and teachers in group interviews, and access to Mathematics achievement marks of the study area, the OR Tambo District. A conditional approval was granted. The conditions, which I complied with, included:

- Schools and participants must not be identifiable from the reports that emanate from the research.
- The research could not be conducted during working hours.
- The scope of the research would be limited to those schools for which permission was granted.
- The department could publish the results of the research in its website.

In view of these conditions, and the commitments I made to the UFS during the application for ethical clearance, I felt it prudent to undertake a number of activities before the commencement of the focus group and one-to-one interviews. Firstly, I distributed the consent forms and allowed participants time to go through these forms, while drawing their attention to some critical ethical issues contained in the consent forms. I explained the purpose of the study, and stated that I had obtained ethical clearance from the UFS and permission from ECDoE to conduct the research.

Secondly, I clarified that the university had granted ethical clearance (UFS-HSD2017/1007) because I had undertaken to keep all information from the participants confidential. Their identities would also be kept confidential and not be recorded anywhere during any stage of the research project. Each interviewee's answers would be assigned to a fictitious name and code number, based on the seating arrangements. Interviewees would be referred to in this way in the data, or any publications or other research reporting methods such as conference proceedings that might emanate from this project.

Thirdly, I made participants aware that all answers may be reviewed by the people responsible for ensuring that the research is done properly. This could include research supervisors, the transcriber, or members of the Research Ethics Committee. Lastly, I explained to them that they reserved their rights to withdraw from the study at any stage, that there would be no remuneration for participants, and how the data would be stored. To enhance the credibility of the study, I also had to reflect on my position as a researcher.

4.4.2 MY BIASES AND PREJUDICES

I must state from the onset that I am not associated with the past or present sponsors of the S4F, in particular SANRAL, to whose reports I referred as data sources for this study.

Creswell (2009: 191) considers self-reflection as one of the hallmarks of qualitative research. It is essential, therefore, to state my identity, biases and prejudices, as they are a potential threat to the internal validity of this study (Merriam, 2009: 15). Over and above the methodological triangulation explanation I gave in section 4.1 (cf. 4.1) above, here I explain how I mitigated the adverse effects of these biases and prejudices.

I have learnt a number of lessons over the twenty years I spent in the teaching profession in the rural Eastern Cape, which I brought into the interview process. One is that conducting a meeting in English only stifles free expression and engagement amongst teachers. My professional teaching career includes both school and office-based experience. The latter further exposed me to teachers' aversion to policy and technocratic language. During on-site monitoring and support during school visits as a district official, I had also observed that teachers would do their best to conceal their vulnerabilities and portray a "perfect" image of themselves and the school.

The hierarchical relationship between a district official and teachers usually dictate that teachers expect a district official who is more knowledgeable on educational matters than they are. Their responses to questions can therefore be regarded as either right or wrong, according to the official's technocratic knowledge. I suspect that my malehood as opposed to an all-female group of foundation phase teacher interviewees added another dimension to this relationship (Creswell, 2009: 192). Lastly, my experience is that teaching and learning in remote rural schools is less effective when compared to urban and semi-urban schools. Reasons for this imbalance include, amongst others, the unfavourable post-provisioning that rural schools attract as a result of poor learner enrolment, leading to teacher overload (Motala et al., 2007: 31). As researcher, I brought these prejudices and biases into the interview room, so I need to clarify how I mitigated against their adverse effects on the research process.

4.4.3 VALIDITY

Validity and reliability are very important attributes of a qualitative research endeavour (Creswell, 2009: 191; Merriam, 2009: 228; Cohen et al., 2007: 148). In the context of mixed methods, Onwuegbuzie and Johnson (2006: 48) describe validity as the quality and defensibility of a research study to the research community and other stakeholders regarding the different components of that study, the conclusions drawn and the

applications founded on that study. Merriam (2010: 211) sums up the concept of validity as the “*authenticity and trustworthiness*” of a research study, according to the rigours drawn from the paradigm the study is founded on. The extent to which findings from a study can be dependable, credible, trusted, transferred to another context, and space and time are further additions to the description of validity (Onwuegbuzie & Johnson, 2006: 52).

Merriam (2009: 211) advises that the researcher needs to consider the philosophical assumptions of the paradigm that underlie the study when reviewing validity issues. In this regard, I dealt with validity issues of this study from the perspective of mixed methods and I feel it is necessary, though, to elaborate on the external and internal validity as they pertain to qualitative research methods of data generation, analysis and interpretation on focus group interviews.

4.4.4 EXTERNAL VALIDITY

External validity refers to the degree to which the research findings from a sample population can be applicable to other contexts or settings (Willis, 2012: 273). Merriam (2009: 19) questions the applicability of this generalisability construct in qualitative studies, and rather prefers the concept of transferability. With transferability, the original inquirer’s role is to provide a detailed description of the setting and context in which the research was conducted. The decision on transferability is left to the consumer of the research product (Cohen et al., 2007: 137). In this regard, sections 4.3.1 and 4.3.2 (cf.4.3.1 & 4.3.2) above provide a full description of the context under which data was generated, with respect to participants, and the venue and setting of the interviews.

4.4.5 INTERNAL VALIDITY

Internal validity in qualitative research refers to the extent to which the research findings resonate with reality as participant’s experience that reality (Creswell, 2009: 190; Merriam, 2009: 213). In effect, then, does the researcher, who is the principal research instrument, actually measure what he or she intended to measure. In order to minimise threats to internal validity, I considered four strategies as recommended by Merriam (2009: 216), namely triangulation, member checks, research position and peer examination.

4.4.5.1 TRIANGULATION

Triangulation refers to the use of various methods during different stages of the research process to validate the findings (Johnson et al., 2007: 113). Traditionally, according to Merriam (2009: 216), triangulation is conceptualised around the three-dimensional views from which reality can be viewed. She, however, argues for more than three perspectives in qualitative research, and prefers the term crystallisation instead. The research design in this study is meant to address multiple methods of triangulation as data is collected and analysed, both qualitatively and quantitatively. Findings from the analysis of interviewing the school community regarding their perceptions about Mathematics education are contrasted with the analysis of learner achievement marks in the subject, for the sake of confirmation or disconfirmation (Creswell, 2009: 55). Johnson et al. (2007: 115) recommend methodological triangulation, arguing that one methodology compensates for inadequacies that are inherent in another methodology. Triangulation is a research technique that is also used as a means to enhance the reliability of a research study (Merriam, 2009: 222).

4.4.5.2 MEMBER CHECKS

Member checking allows the participants to review and reflect on the accuracy of the researcher's interpretation of what was said during the interviews (Creswell, 2009: 191). I first interviewed the teachers. When I returned to the schools for the children's and family members' interviews, I took along the interview transcripts, and generated themes and categories, for feedback from the teachers. They agreed with my interpretation. It was, however, logistically not possible to conduct member checks with the family members and learners. I was able, though, to engage the services of a fellow doctoral candidate to review my interpretation of the interview data, including those from learners and families, during peer examination.

4.4.5.3 PEER EXAMINATIONS

A colleague who is familiar with qualitative research (Merriam, 2009: 220), is qualified to review on the findings of a peer against the raw transcripts from interviewees, by reading and commenting. To this end, a fellow PhD candidate who is also involved with qualitative research reviewed my findings from all the groups of interviewees. He provided me with very useful insights that also helped in my personal growth regarding qualitative research.

That growth also involved self-reflection about my integrity with respect to my biases and prejudices as a primary measurement instrument.

4.4.6 VALIDITY IN MIXED METHODS

In mixed method research, Onwuegbuzie and Johnson (2006: 48) acknowledge the complexity of integration of the two combined methodologies, and recommend the term “*legitimation*” instead of validity. They pinpoint nine legitimation concerns that are specific to the mixed method. The majority of these concerns (Onwuegbuzie & Johnson, 2006: 57) are about issues of meta-inferences of “*substantive theory*” that emanate from the combination of qualitative and quantitative (Venkatesh & Brown, 2013: 23). I discuss those legitimation issues as identified by Onwuegbuzie and Johnson (2006: 57) which I consider relevant to this study, in the section below.

4.4.6.1 SAMPLE INTEGRATION LEGITIMATION

First, sample integration legitimation is applicable in situations where the researcher seeks to generalise based on the research sample. Sample integration, as Onwuegbuzie and Johnson (2006: 57) explains, is threatened if the same people that participate in the qualitative part of the study do not also take part in the quantitative aspect. In addition, according to Collins et al. (2012: 859) philosophical ambiguity threatens sample integration. As such, my intention as a researcher is to make sense of the school community’s perceptions of Mathematics education (Creswell, 2009: 8), and use quantitative data, in the form of learner achievement marks in Mathematics, as a form of “*cross-method triangulation*” (Johnson et al., 2007: 114).

I therefore place less emphasis on external validity, as it implies the applicability of the findings of this research in another context. Instead, the findings of the current research are intended for local conditions (Merriam, 2009: 225). Moreover, according to Merriam (2009: 225), the researcher does not need to concern him/herself with issues of transferability.

4.4.6.2 INSIDE-OUTSIDE LEGITIMATION

Second, inside-outside legitimation issues arise where there is a lack of clarity on the philosophical stance upon which the researcher bases his/her research (Collins et al., 2012: 858). These authors believe that ambiguity regarding the ontological, epistemological and methodological assumptions that underlie the study, can lead to an inappropriate balance

regarding the views of both insiders and outsiders. Insiders' views are those of the participants, while the outsider's views are usually those of the researcher (Onwuegbuzie & Johnson, 2006: 58). The researcher can, as Onwuegbuzie and Johnson (2006: 58) suggest, either be ethnocentric or become overly involved. It is necessary, therefore, that I explain how I have tried to manage the inside-outside legitimation issues.

The explanation I provided on the worldviews in Chapter 2 (cf. 2.2) above also addresses the inside-outside legitimation issues, as it attempts to clear any ambiguities regarding the paradigm for the study. Concerning the representation of the views of an outsider, in other words mine as researcher, with the participants' lived experiences, I requested a work colleague, who is also a PhD candidate, to do peer debriefing (Cohen et al., 2007: 136). Peer debriefing, according to Cohen et al. (2007: 136), happens when the researcher takes his/her rich descriptions of the phenomenon to a disaffected experienced colleague for review. In support of my choice of reviewer, Creswell (2009: 200) points out that a fellow doctoral student or research assistant is suitable for peer debriefing. The peer reviews the plausibility of the research findings, based on the collected data (Merriam, 2009: 220).

4.4.6.3 WEAKNESS MINIMISATION

The third legitimation issue I considered, as Onwuegbuzie and Johnson (2006: 58) suggest, is weakness minimisation. This type of legitimation, according to these authors, refers to the extent to which the researcher can design the study in such a way that the weaknesses in one method are compensated for by another method. One such defect, in the present study, is that there is a multiplicity of factors that could cause changes in Mathematics performance, other than the S4F FM programme. As researcher I have no control over these. Meanwhile, my primary objective for the study is to understand what changes were brought about as a result of the S4F FM programme. Further complicating any findings on inferences about causal relationships or associations between the cause and the effect is the manner in which the participating schools became part of the S4F FM programme.

4.4.6.4 PARADIGMATIC MIXING

The fourth legitimation issue is paradigmatic mixing. This refers to the degree to which the enquirer's epistemological, ontological, axiological, methodological and rhetorical stances that form the basis for the quantitative and qualitative approaches, are appropriately mixed (Onwuegbuzie & Johnson, 2006: 57). This legitimation issue, as Collins et al. (2012: 56)

explain, arises in cases where the researcher lacks philosophical clarity, which potentially leads to a cascade of other threats to the validity of a study. In such cases, according to these authors, the researcher may be unclear about the nature of reality. As a result, the researcher's ability to coherently conceptualise his/her study may be compromised. This handicap, in turn, could diminish the enquirer's ability to conceptualise a study rationally, which, in turn, would decrease his/her capacity to design the mixed research study adequately. This might lead to an adverse effect in the implementation of the mixed research study, and its conclusions.

To deal with the paradigmatic mixing legitimations issues of this study, I explained in detail, in Chapter 3, the philosophical positions that underlie this study. Also, while this a mixed method research, I separated the quantitative and qualitative chapters so that there would be no confusion of the philosophical view at any stage of the research process.

4.4.6.5 MULTIPLE VALIDITIES LEGITIMATION

Lastly, multiple validities legitimation, as Onwuegbuzie and Johnson (2006: 57) describe it, refers to the extent to which addressing the legitimation of the quantitative and qualitative aspects of the study result from the use of the research methods that are associated with those methodologies. This leads to reliable findings, and refers to the degree to which the researcher addresses validity issues that are specific to the qualitative, quantitative and mixed method aspects of the study. This has implications for the conclusions drawn from a study (Collins et al., 2012: 857).

In this study, when discussing the inside-outside legitimation above, I have incidentally explained some of the strategies that researchers use to mitigate against internal validity threats. These threats include, as Merriam (2009: 217) enunciates, member checking and peer review. Merriam (2009: 217) also mentions other strategies such as triangulation, "*adequate engagement in data collection*", which (Creswell, 2009: 199) refers to as "*long terms and repeated observations*", and the researcher's position.

4.4.7 RELIABILITY

Traditionally, the reliability of a study refers to the degree to which the same results would be obtained, using the same instruments and methods, in a sample from the same population (Merriam, 2009: 220). In the case of a qualitative study, Venkatesh and Brown

(2013: 34) argue that proving validity is enough to determine dependability and consistency, the equivalents of reliability. It is therefore not surprising that literature that deals with validity and reliability issues in mixed methods have much to offer on validity, and little on reliability. It is necessary, though, that I discuss reliability as it relates to the quantitative aspects of this study.

Cohen et al. (2007: 146) outline conditions that need to be considered for this repeatability to be realised. The time lapse between the first and subsequent measurements is one such consideration. Too short a span may compromise reliability, as participants may still remember their responses in the previous test. Allowing more time to elapse between tests may compromise reliability, as exogenous factors may have crept in during the interim period. Another consideration contributing to the reliability of a study, according to Cohen et al. (2007: 147), is the consistency of instruments, including human ones, repeatedly yielding the same results. The last factor that has a bearing on the reliability of a quantitative study is "*internal consistency*", which Cohen et al. (2007: 147) describe as the extent to which particular tests reliably measure the intended construct. One example cited by these authors to clarify the concept, is that of a test which is broken into two halves in terms of the level of cognitive demand, and administered to the same group of learners. If a significant correlation is established in the test scores from the two tests halves, then internal consistency is established. This factor of internal consistency has some relevance in the present study, as test scores in Mathematics are used to evaluate the FM programme. A description, therefore, of the nature of the learners' Mathematics marks, is warranted.

4.5 SUMMARY

Interviews and document analysis constituted the backbone of data generation for both the exploration of the school communities' perceptions towards Mathematics education, and background to the S4F FM programme.

The quantitative aspect of the study had to pronounce on the causal linkages between the S4F FM programme and learners' Mathematics marks. Data that allowed for the determination of the impact of the programme on Mathematics education was made up of learners' marks in standardised assessments and school-level assessments. I chose the quasi-experimental design to mitigate against a lack of randomisation in the selection of schools into the S4F FM programme in the ORTI District. Various strategies are available to

make valid claims about causal inferences even where randomisation is not possible, as in the case of this study. The most popular strategy, which, I chose for this study, is Propensity Score Matching (PSM).

In PSM, confounding factors, which constitute the baseline characteristics of the subjects, schools in the case of this study, are used to predict eligibility into the intervention (UFS S4F FM programme). The comparison group was therefore selected from schools outside the programme. The resultant comparison group is similar on the baseline characteristics, and therefore any differences in the dependent variable (learners' Mathematics marks) can only be explained in terms of the independent variable of interest (S4F FM programme).

Notably, the preceding discussion is on methodological worldviews that are diametrically opposite to one another. The use of two methodologies in a single research endeavour places the study into a third methodology, namely mixed methods, which harness the strengths of both the qualitative and quantitative methodologies in one study.

In conclusion, this chapter demonstrated that it is possible to synthesise research methods that are predicated on different philosophical dispositions in mixed-methods, and to situate these within the pragmatism paradigm. The task of transcending the different methods of research, and distilling the results into a unified coherent body of knowledge on the effect of the S4F FM programme, lies in the interpretation of the results. The analysis and interpretation begins in Chapter 5.

CHAPTER 5: HISTORY OF FAMILY MATH IN SOUTH AFRICA

5.1 INTRODUCTION

In the previous chapter, the study dealt with the methods of the research, data generation and data analysis for this enquiry. In this chapter, I introduce and discuss the findings of the study that pertain to the first empirical objective of the study, namely the history of the S4F FM programme. To make sense of the data, I drew from the derived theoretical framework provided in Chapter 2. While some of the data can be aligned with the theory, I also gained new insights that enhance existing theory under the themes that emerged from the data. The secondary research question that guides this chapter is *What is the background and nature of the S4F FM programme offered by the University of the Free State?*

To answer the research question, I used empirical data generated from different role players in the S4F FM programme at the UFS. Interaction with these role players was meant to gain an understanding of the background to the FM programme and the current nature of its implementation. The interviews were conducted in English, and I used pseudonyms to protect the identity of all participants.

5.2 DATA ANALYSIS

Following the generation of data from one-to-one semi-structured interviews with three staff members of the S4F FM programme, as well as from published documents on the programme, I transcribed the interviews and started with data analysis. Guided by the research paradigm for the study, the theoretical framework and concepts from the literature review, I started with the iterative process of data analysis through coding. The coding process resulted in the emergence of themes and subthemes, according to which the data were categorised to make meaning. Figure 5-1 below diagrammatically demonstrates the themes and subthemes.

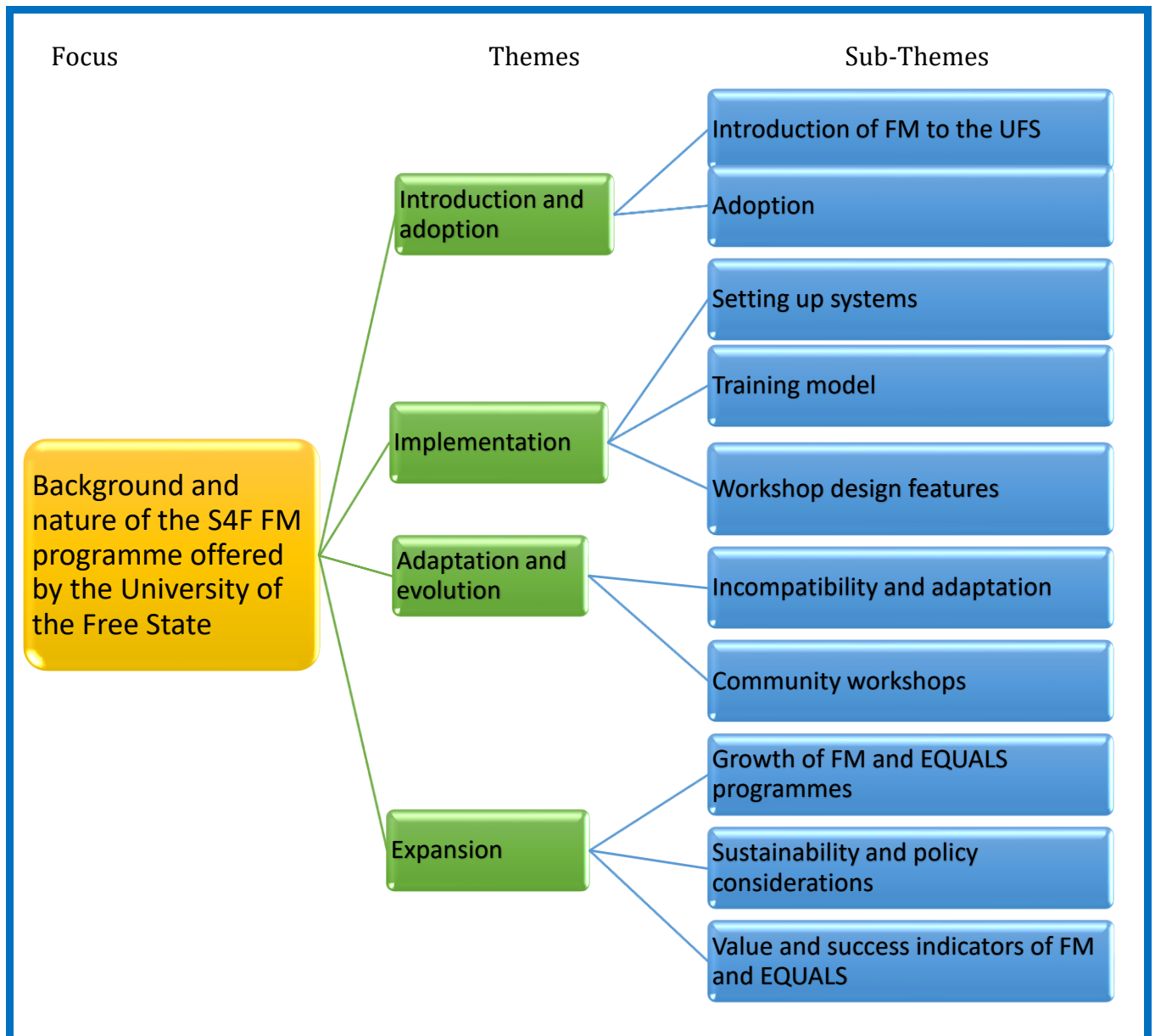


Figure 5-1: Theme and categories that emanated from the interviews with people involved in the UFS S4F programme

5.2.1 THEME 1: INTRODUCTION AND ADOPTION

In this theme, I unpack the introduction of FM into the UFS and its adoption, from the narratives of the participants.

5.2.1.1 INTRODUCTION OF FM TO UFS

It appears that the introduction of FM was a product of the UFS's active search, towards the turn of the previous century, for collaborative partnerships with sister universities from

abroad. The Edenboro University of Pennsylvania (EUP) in the USA became one such potential partner. The partnership hinged on the evaluation and adoption of the S4F FM programme as presented through an activity book from EUP. The Research Institute for Education Planning (RIEP) at the UFS would become the main player in this partnership. One participant explains how the UFS came to know about the Family Math programme as follows:

During 1998 Prof. Benito Khotseng was a member of a University of the Free State (UFS) team, who investigated opportunities for partnerships with universities in the USA. Upon his return, he presented Prof. Jack van der Linde, Director of the Research Institute for Education Planning (RIEP), with an example of the Family Math activity book. He made mention of a possible collaboration with the Edenboro University of Pennsylvania (EUP), to bring the EQUALS Family Math Program to the UFS (Marie Pretorius).

However, not all interviewees knew about the inception of the programme at the UFS. . While older staff members still remember it, staff members who joined the organisation later, when the programme was already up and running, do not have knowledge about the early days. There is even confusion about which university the programme came from (As far as I know it started here at the University of the Free State and it was coming from the Yale University in America (Andrietta Jonker)).

5.2.1.2 ADOPTION

One participant seems to possess a good institutional memory and have an in-depth understanding of the place of origin for the FM programme, the objectives, the scope and the targeted group of people. The participant puts it like this:

For many years the Lawrence Hall of the University of California, Berkeley has developed curricula and teaching strategies to improve mathematics and science education at all levels and to increase public understanding of, and interest in, science and mathematics (Marie Pretorius).

These original founding principles seem to be fading and becoming of less importance with other participants (It comes from America and there they first did it in a certain way and we got permission from America to adapt it for South African conditions. So that we can also implement it in our classrooms in the different schools (Elna Kriel)).

It appears that eventually RIEP decided to adopt the project for implementation in South Africa, with the UFS being the locus of operation. The adoption came after serious consideration of what the project sought to achieve, and juxtaposing that against the challenges faced by Mathematics education in South Africa. Another aspect to consider was content of the EQUALS programme, the parent project to FM, as well as the content of FM itself. One participant explains it as follows:

After some investigation and deliberation, RIEP management and staff agreed to go ahead with arrangements to establish a partnership between the UFS and the EUP for the implementation of the FAMILY MATH program as well as FAMILY SCIENCE (Marie Pretorius).

5.2.2 THEME 2: IMPLEMENTATION

The emerging subthemes under the implementation of the FM programme include setting up the systems, workshop design features and the training model.

5.2.2.1 SETTING UP THE SYSTEMS

Evidence suggests that the focus of RIEP changed, once the decision to adopt EQUALS and FM had been taken, from evaluation practices to setting up systems for implementation. Implementation began with a three-year pilot from 1999 to 2002. The systems that needed to be established included a centre of operations, securing funding, building local partnerships and training the core trainers. To achieve these fundamental systemic goals, the regional centre from where administrative work would take place was located at RIEP in Bloemfontein. One participant details the process as follows:

A regional centre for EQUALS Mathematics and Science Education had been established at the Research Institute for Education Planning (RIEP) (which became the Centre for Education Development (CED)). The three-year pilot project (1999 - 2002) was funded with seed money from the United States Agency for International Development (USAID) Centre for Human Capacity Development. It [funding] was administered by the Association Liaison Office for University Co-operation in Development (ALO) through the American Council on Education (ACE) and done in collaboration with the Edinboro University of Pennsylvania (EUP) as the leading United States partner (Marie Pretorius).

The second set of activities in setting up the systems for the implementation of the EQUALS and FM programmes was the building of alliances with local institutions, identifying and training the first core of trainers for the South African version of these programmes. From the selection of the communities in which the programme implementation would be piloted, it appears that the selection was sensitive to the diversity of the South African society. Therefore, race and class were considered, as one participant explains:

EUP and the UFS worked in collaboration with the Mangaung University of the Orange Free State Community Partnership Programme (MUCPP) and the Free State Education Department. The training of the first twelve South African core facilitators was done by Dr. Dale Hunter from the Edinboro University of Pennsylvania (EUP). These facilitators were chosen from the staff of RIEP, the staff of the Mangaung University and specialist teachers from Heidedal, Mangaung and Bloemfontein. The pilot project was first rolled out in the primary schools of Mangaung, Heidedal and the greater Bloemfontein area (Marie Pretorius).

Lastly the training content, model and materials for the workshops also had to be developed as part of setting up systems. Consistent with the founding principles of EQUAL, experiential learning seems to have been the preferred training model. This allowed the teachers to bring to the training sessions the contexts and realities of their classrooms and communities, as they perceived them. Consequently, this form of training made it possible to confront challenges, co-construct new knowledge and adapt the programme to suit local contexts. One participant explains it as follows:

The workshops were referred to as 'make-and-take' workshops. Not only was subject content addressed, but the relevant teaching support materials were manufactured during the workshops. At the same time classroom practice and methodology were discussed e.g. we did not have a lecture on how to organise and implement cooperative teaching and learning; we experienced it in the workshop the same way as learners would. This allowed for discussions on positive effects and possible problems, and what could be done to solve these challenges (Marie Pretorius).

5.2.2.2 WORKSHOP DESIGN FEATURES

The way in which the S4F FM programme workshop content and materials are packaged and delivered during training, reflect the workshop design features. In this regard, the co-

construction of knowledge is encouraged by allowing workshop participants, especially during the training of trainers, to develop an appropriate learning approach for subsequent training sessions. Marie Pretorius explains how the approach to training was developed: “At the same time classroom practice and methodology were discussed e.g. we did not have a lecture on how to organise and implement cooperative teaching and learning; we experienced it in the workshop the same way as learners would”. The same technique was applied to the development of workshop materials, as Marie Pretorius expresses: “The workshops were referred to as ‘make-and-take’ workshops. Not only was subject content addressed, but the relevant teaching support materials were manufactured during the workshops” (Marie Pretorius).

Although in a different context and format, this workshop strategy of the co-construction of knowledge continues to date. Andrietta Jonker explains the seating arrangements during parent workshops that accommodate different levels of literacy:

So that parent that cannot read or write, we advise the teachers to let that parent sit in a group of able people, it's not necessary to be able to write down the stuff in the parent's workshop but the manipulatives will help that parent understand the concept and even if that parent just sits there with the grandchild (Andrietta Jonker).

From this evidence, manipulatives are a core feature of the workshop design and the training model.

5.2.2.3 TRAINING MODEL

The training model of the S4F involves strategies to ensure the cascading of knowledge beyond the initial core facilitators. It is evident that the plan was to establish the basis for the sustainability of the programme during its initial stages, through the training model. Marie Pretorius explains this training model: “It was envisaged that these facilitators would train others to become facilitators in their respective communities [a train-the-trainer model]”.

It seems that manipulatives have become an essential feature of the training model, as Andrietta Jonker articulates the approach:

When a teacher has come for the first year and the learners are in the programme for the first year, we supply them with all these materials that are manufactured at this then maybe we can give them 1 or 2 examples so they can make their own material at their school. We can lead them in knowing which is the cheapest sustainable way in manufacturing the manipulatives because we believe in our sold items. I always tell the teacher all of you have Kellogg's boxes if, for instance, we do 2 D shapes and we give them cut-out square they can easily make their own square out of the Kellogg's box (Andrietta Jonker).

5.2.3 THEME 3: ADAPTATION AND EVOLUTION

The adaptation and evolution of the program are further investigated below in terms of incompatibility and adaptation, and the focus on community workshops.

5.2.3.1 INCOMPATIBILITY AND ADAPTATION

It emerged that the EQUALS and FM programmes still very much had the characteristics of the communities for which they were originally designed. These were mostly marginalised groups in the USA, including women and minorities. These characteristics manifested in the language used in the workbooks, units of measurement and the types of materials for teaching and learning. These three aspects were not always compatible with the South African context, and were therefore adapted. One participant who was involved with EQUALS and FM programmes at the initial stages reasoned the need for adaptation as follows:

The original FAMILY MATH workbooks could not be used because of American English spelling and terminology as well as Imperial Units. Also, some of the material used was not freely available in South Africa or not user-friendly for South African learners. Thus, activities of the original Family Math and Family Science books were adapted for South African use and were also translated into English, Afrikaans, Sesotho, isiXhosa and Setswana. A material 'factory' was established and worksheets were developed to suit learners in South African schools (Marie Pretorius).

There is evidence that over time, the lived experiences of many of South African communities, as perceived by UFS S4F staff, precipitated the need for further adaptation. The adaptations that took place in during later years of the programme went beyond mere changes of language, units of measurement and materials. The value of the primary

approach of organising Family Math sessions for family members and their children diminished. One participant rationalises the emergent approach as follows:

The Family Math as they did in America, it was just for families and as you know the American population is much different to as compared ours. So there they use it as a topic, for instance, they do Mental Maths and then add an activity to do it with the mother and father and to whoever but that was not suitable for the South African situation because in America most of the places where they roll this out the father and the mother were educated and they had degrees or whatever and the school system is different from ours so we adapt and change the programme to fit the South African situation (Andrietta Jonker).

The nuances of the South African parent community seem to have informed the adaptations that followed later. These adaptations gave the current S4F its character. Amongst these distinguishing characteristics are parents' attitudes ("in South Africa the parents are not really part of the children's' education" (Andrietta Jonker)). The family structure of many families with children of school-going age, is devoid of a nucleus family character. This has also necessitated adapting the approach of the original programme. ("Because the situation in our country now is that many of our primary school learners stay with grannies. In the rural areas I know that most or some of those people cannot read or write, so how do you involve them in the education of the child" (Andrietta Jonker)).

5.2.3.2 COMMUNITY WORKSHOPS

It emerged during community workshops that the security and socioeconomic characteristics of each area would dictate the logistical arrangements of the workshops, as well as the profile of the attendees. The scheduling of the workshops and the availability of family members were often challenging for the organisers. Marie Pretorius explains the many considerations taken into account when organising community workshops:

Evening workshops were not possible as it was far too dangerous to use the streets at night. Also, the school buildings were locked up at 16:00 every day. Workshops had to be presented directly after school and at the school. The four Heidedal schools requested workshops on Saturday mornings to enable more parents to attend. Real 'family' workshops were not always feasible. The parents/caregivers of many children were not able to attend, thus we allowed all learners, and where necessary, the facilitators and other parents acted as 'family' (Marie Pretorius).

5.2.4 THEME 4: EXPANSION

The evidence from participants indicate that the expansion of the programme included the growth of FM and EQUALS, paying attention to sustainability and policy considerations. The value and success indicators of the programme were also evident.

5.2.4.1 GROWTH OF FM AND EQUALS PROGRAMMES

Evidence suggests that the initial uptake of the programme by school communities was positive. The EQUALS and Family Math programmes were welcomed by communities, who wanted to learn how to use the supplied materials. The value of these programmes was also advocated to corporate bodies, who embraced them and financially helped with the programmes' expansion. Marie Pretorius details the marketing and early success of introducing the programmes in South Africa:

Some adult community members attended on their own because they saw an opportunity to learn. The material was instrumental in generating much interest in mathematics amongst learners and their parents. EQUALS, which together with FM falls under the umbrella project called Science for the Future (SFF), was actively marketed by RIEP staff during presentations and also by the Corporate Marketing Team of the University of the Free State, with offices in Bloemfontein and Johannesburg (Marie Pretorius).

Community interest and effective marketing culminated in the growth of the programmes, both in extent and expanse. The entire basic education system from the foundation phase to FET became involved with the programmes. By the end of the pilot period in 2002, the growth of EQUALS and FM had permeated into other provinces such as the Northern Cape and KwaZulu-Natal. Marie Pretorius details the initial expansion success:

A cadre of Foundation Phase educators, from the Northern Cape, attended a week-long training workshop which enabled them to establish FAMILY MATH at their schools and in their communities. This group has contributed largely to the success story of the FAMILY MATH programs of today. Preliminary discussions indicate that the FET subject advisors are interested in an EQUALS Institute for all mathematics teachers from the five districts of the Northern Cape (Marie Pretorius).

Evidence from participants indicates that currently the programmes have expanded to other provinces beyond the locus of inception (“We work in the Northern Cape, Gauteng, KwaZulu Natal, Eastern Cape and Free State. It is actually widespread. Training takes place in the UFS” (Elna Kriel)), and continues to expand (“From when I started working here until now, this programme has been growing and growing” (Andrietta Jonker)). Penetration in these provinces is also far and wide, and not just limited to one location (“At this stage we are in the Free State, in the Northern Cape, Postmasburg Region, the Kuruman Region, the Eastern Cape in Mthatha, Libode, Coffee Bay and Port St Johns, we are in KwaZulu Natal, Gauteng in the Tshwane Region, Pretoria, Hammanskraal, also in another Eastern Cape District Graaff-Reinet and another Northern Cape District Priska” (Andrietta Jonker)).

It appears that the expansion of the programmes goes beyond geographic borders, but also includes a diversity of socioeconomic backgrounds. The importance of socioeconomic background as an influencer of perceptions, is highlighted in Chapter 3 (cf. 3.4.5).” We have four groups in the entire region, it’s not rural only. We did a lot of work for three years in Botsabelo in Thaba Nchu, so that is not really rural. If you talk about rural you can go to the Kuruman area where we did a lot of work even in the Eastern Cape” (Elna Kriel)).

5.2.4.2 SUSTAINABILITY AND POLICY CONSIDERATIONS

It seems as if funding is a key prerequisite for the sustainability of the programmes. Sources of funding varied over time, and there were always ongoing attempts to solicit funding of the programmes. Marie Pretorius expresses her views on funding as follows: “Unless more and regular funding was secured to supply workshop material to the schools, the sustainability of the project was in jeopardy. Although a material ‘factory’ was established at the CED (Formerly RIEP), many schools just could not afford what was needed to serve their learners” (Marie Pretorius). Some of the initial sponsors are no longer part of the programmes, suggesting a neverending need to market the programmes to increase their sustainability. However, community participation seems to have played a reciprocal role in the marketing of the programmes. Funding allowed the programmes to be rolled out while community participation attracted more funding. Marie Pretorius explains the complementary roles of participation and funding: “EQUALS activities form an integral part of Family Math community workshops and in this way, large numbers of adults and children have benefited from them. Community workshops are presented regularly in Heidedal and

Mangaung. As a result of these inputs, funding was received (and more is forthcoming) to present full EQUALS Institutes” (Marie Pretorius).

Later, as evidence suggests, S4F staff had to work towards participation beyond teachers, learners and communities to ensure the sustainability of the programme. The Department of Education, at least at District level, is one such key stakeholder that needs to be consulted, while at the same time satisfying the donor conditions. Andrietta Jonker explains the interfacing role played by the S4F staff: “SANRAL said they want to develop the communities next to the roads they are building because they use that road from Mthatha to Port St Johns, so it started alongside that road but we cannot start if we do not get the Department of Education on board” (Andrietta Jonker).

It also appears, from Marie Pretorius’ inputs, that the proponents of the UFS version of EQUALS and FM, beyond the uptake by communities, were also concerned with the sustainability regarding policy compliance of the programmes. Sustainability hinged on continued funding. Policy compliance, on the other hand, pertained to alignment with the curriculum delivery model of that period, and the accreditation of certificates issued at the end of training sessions. The evolution of the education policy is evident in the jargon that participants use, which is educationally relevant to a confined period. Marie Pretorius explains as follows:

It was imperative that more funding must become available to include (many) more teachers to the EQUALS Institutes. Funds were used to supply workshop material to the schools as well as training of Learning Area Facilitators and specialist teachers. Regarding compliance with policy, EQUALS and FM training were tailored to conform to the Seven Critical Outcomes and five Developmental Outcomes of Outcomes-Based Education (OBE). Also, negotiations were underway to have the EQUALS course registered with the South African Qualifications Authority (SAQA) as a short course towards teachers’ professional development credits (Marie Pretorius).

To stay relevant, the practitioners of S4F constantly track policy developments of the Department of Basic Education and adjust their materials and approach to supporting communities, families and learners accordingly. Participant insights bear testimony to the

education policy that had changed from Outcomes-Based Education (OBE) to Curriculum and Assessment Policy Statement (CAPS). Andrietta Jonker explains with examples:

Because we link it with the CAPS document we alert the language we use as the CAPS preferred otherwise it would not make sense, so if in all the concepts for instance when you do 2 D shapes for in space and shape and they talk about a corner in the CAPS curriculum they say no in foundation phase you must talk about a Vertex, not a corner. We are led by the language that is used in the CAPS Curriculum and then we know it's the correct language suitable for the South African circumstances because even the CAPS Curriculum for the other languages (Andrietta Jonker).

5.2.4.3 VALUE AND SUCCESS INDICATORS OF EQUALS

It is clear from Marie Pretorius that the value of EQUALS and FM lies in the fact that they address the critical filter nature of Mathematics in the country, which is as a result of design and attitudes. It is by design, because the result of education policies of the apartheid era is a lack of suitably qualified Mathematics educators in some communities, leading to poor teaching in the subject. Mathematics is also a critical filter because some communities continue to hold onto a belief that the subject is for a select intellectually able few in society

The EQUALS Institute was implemented for educators who were underserved or disadvantaged regarding Mathematics education. It was destined to equip educators with knowledge, skills and positive attitudes towards the teaching of Mathematics. These challenges arose out of South Africa's past education policies, which gave rise to a large number of teachers being under- or unqualified in especially a subject like Mathematics (Marie Pretorius).

However, the lived experiences of the current S4F staff during interactions with subject advisors, teachers, learners and families, allowed for programming that is responsive to the needs of each of the stakeholders. These needs include a lack of mathematical knowledge that emanates from inherent deficiencies in the home language of stakeholders.

The problem is that these home languages do not have mathematical language. I'm talking regarding Mathematics because that is my field of expertise. Mathematics is actually a terminology; it is a specialised subject. You need to know the math terms and that is very important and that is difficult for other teachers. Even some of the Subject Advisors come to me after training and tell me 'you know

what Mem for the first time I do understand now'. That is actually scary for me, do we really make an impact (Elna Kriel).

5.3 EVIDENCE FROM PUBLISHED REPORTS

I also interrogated the evidence from published reports on the background to S4F regarding its growth, value and success indicators.

5.3.1 INTRODUCTION

Published reports about Family Math and Family Science, both currently under the umbrella of the S4F programme are the UFS, come from the South African National Roads Agency (SANRAL), one of the sponsors of these programmes. SANRAL provides funding for S4F as part of the agency's community development programme and has accordingly reported on the S4F programme in its annual reports since 2012. The reports also acknowledge the contribution of cosponsors like ABSA Bank and Old Mutual (SANRAL, 2012: 48). Other reports come from the Family Math and Family Science web page on the UFS website. Indications are that the webpage was last updated in 2014. It still provides useful information about the Family Math programmes, however.

According to SANRAL (2012: 48), the School of Open Learning (SOL) at the UFS launched its Family Math and Family Science programmes in 2009 in the Free State and Northern Cape provinces. The programmes were biased in favour of predominantly rural areas of these provinces, with the aim to enthuse learners about Mathematics and Science, and to improve attitudes towards the subjects. To achieve this aim, subject advisors were trained as programme coordinators who in turn trained and supported educators.

5.3.2 GROWTH OF FM AND EQUALS PROGRAMMES

By 2018 the number of people that were actively involved in the programmes had grown extensively. There were 38 subject advisors, up from the 12 that were involved in 2011, from Free State, Northern Cape, Eastern Cape and Gauteng (SANRAL, 2018: 69). The number of learners had increased six-fold to 66 303, and teachers by three-fold to 631 from a total number of 278 schools.

SANRAL (2017: 64) attributes the phenomenal growth of the programmes to the S4F unit's initiative of producing and supplying learning and activity materials to the schools under

the programmes. Teachers and learners find these materials to be supportive of learning and teaching in the classroom (SANRAL, 2017: 64).

In 2012, the province of the Eastern Cape became part of only the Family Math programme and not the Family Science program as well, as is the case with the other provinces. Family Math was rolled out in two districts, namely Libode and Mthatha (SANRAL, 2013: 71). These two districts have since been reconfigured and renamed, and are now called the OR Tambo Coastal (ORTC) and OR Tambo Inland (ORTI) Districts, respectively. By 2018, the statistics of participation indicated that there were three subject advisors, 94 teachers and 6819 parents, trained from 52 schools in the province. In total, there were 9023 learners, predominantly from Grade 3, who were actively involved in the Family Math programme (SANRAL, 2018: 69).

Mention is made of a school in the Eastern Cape, on the S4F webpage, that was exposed to FM in 2013. The school is in the Sterkspruit area, and it seems as if it was part of the programme as a once-off arrangement with the principal (UFS, 2014).

The webpage also provides some important milestones on the evolution of FM and FS under the auspices of Centre for Education Development (CED) at the University of the Free State. Notable amongst these is the enrolment of foundation phase teachers and subject advisors into short (160 notional hours) learning programme during 2013.

5.3.3 VALUE AND SUCCESS INDICATORS OF FM AND EQUALS

A preliminary evaluation of the Family Math programme indicates that the programme has had a positive effect on learner marks. The average learner marks of before and after the FM intervention, based on the ANAs, common papers and school-based assessments, indicated an improvement ranging from 5.2% to 25% in all provinces. In the Eastern Cape, as observed from school-based assessments, the improvements were 9.5% and 12.7% in ORTI and ORTC, respectively (SANRAL, 2018: 70).

5.4 SUMMARY

Four main themes emerged from the analysis of data generated through interviewing former employees of the S4F FM programme. These themes include introduction and adoption, implementation, adaptation and evolution and expansion.

Firstly, the introduction and adoption provide evidence of how, in the first place, the programme that eventually evolved into the S4F FM programme was introduced into the university. When this evidence is considered, together with evidence from written texts, especially on motivations for the genesis of EQUALS, then a picture of an emancipatory mindset emerges as a key driver of the adoption of the programme at the University of the Free State.

Second, implementation evidence suggests that the pioneers of the programme were enthusiastic and passionate about the programme in establishing the institutional foundations, workshop design and training models. These processes exposed the pioneers to the stark differences between the original programme in the USA, and the South African education and social system. The need therefore arose to adapt the system to suit the local context.

The adaptation of the programme to suit the South African social landscape was the third theme that emerged from the analysis. The focus was on the language used in the training materials, the units of measurement referred to in the materials, as well as the artefacts and other support materials. This adaptation would prove to be the beginning, as evidence suggests, of the evolution of a unique UFS programme, today called the S4F FM programme. Evidence also points to the changing funding patterns, which saw the cessation of funding from the USA. This might have meant the cutting of the proverbial umbilical cord, and in so doing facilitating and acceleration of the development of the particular UFS version of the programme.

The last broad theme to emerge from the analysis of data on the background to the S4F FM programme is its expansion. Evidence suggests that aggressive marketing and interest in the programme facilitated the expansion regarding both scope and extent. The programme reached into the other provinces from the locus of origin in the Free State. There was also growth in the coverage of the phases in the basic education system of the county. One of the drivers of interest was the use of artefacts, which bridged the gap between the divide in literacy levels and connecting school to home, which had also been adapted in response to specific needs.

5.5 CONCLUSION

To conclude, I presented the empirical work in this chapter to describe the background and nature of the S4F FM programme in South Africa. In this regard, the description depicts a background of a dynamic and adaptive programme, which has developed into a uniquely UFS product while still pursuing the basic tenets as the first proponents of EQUALS. The first proponents observed an imbalance and sought to achieve gender equity in access, participation and performance in Mathematics, with female learners being the most disadvantaged in this regard.

The research revealed that African Languages are inherently deficient in Mathematical language, which serves as an obstacle to learning Mathematics by the speakers of these languages. The study further exposed an interplay between socioeconomic background and levels of literacy. This has an effect on the level of family involvement in a child's education.

Lastly, the study was framed within multiple theories, which I integrated to form a unified guiding lens. The theories include Hoover-Dempsey and Sandler, and Epstein and Sanders models, Vygotsky's Sociocultural theory, and Social constructivism. The integrated theoretical framework, as described in Chapter 2, places the school at the centre of the whole concept of family involvement. This placement emanates from the school's strategic positioning, both academically and socially, with an expectant functional role to facilitate family involvement and learners' cognitive development, leading to the outcomes of attitudes, perceptions, and performance. In this regard, as evidence suggests, schools continue to be loci of convergence for S4F FM programmes, as well as facilitator-teacher, facilitator-family member and teacher-learner social interactions to achieve children's cognitive development. These interactions, as gleaned from evidence, also draw the home environment as one sphere of influence closer to school (another sphere of influence), thereby creating a continuous and congruent learning environment between home and school for the child.

CHAPTER 6: EFFECT OF THE S4F FM PROGRAMME ON THE PERFORMANCE OF LEARNERS IN MATHEMATICS

6.1 INTRODUCTION

The overall aim of this study is to *explore and describe the changes brought about through an S4F FM programme in a rural school community in South Africa*. To achieve this aim, Chapter 5 explored and described the background and nature of the S4F FM programme in South Africa. Literature showed that the practical lived experiences of women and minorities in the USA motivated for establishing intervention programmes that encouraged participation. These eventually improved performances in Mathematics by these marginalised groups. I therefore concluded, from the exploration of literature, that the origins of the S4F FM programme were predicated on feminist theory. Evidence from the empirical enquiry in Chapter 5 suggests that a uniquely UFS FM programme has evolved over the years, while maintaining some of the founding principles of the original programme in the USA.

This chapter reports on the results of the quantitative analysis of Mathematics achievement marks, and makes inferences about the effect of the S4F FM programme. In Chapter 7 I report on the results of the empirical enquiry into the perceptions towards Mathematics education of the rural school community in South Africa. After the completion of this chapter and Chapter 7, and by taking into account Chapter 5, I was in a position to pronounce on the changes brought about through an S4F FM programme in a rural school community in South Africa. However, it is necessary that I remind the reader about how the quantitative enquiry, reported on in this chapter, fits into the study. The background to the quantitative enquiry below serves to reorient the reader.

6.2 BACKGROUND TO THE QUANTITATIVE EMPIRICAL WORK

The basis for the quantitative empirical work of this study derives from the theoretical framework on which this study is based. The theoretical framework is discussed in detail in Chapter 2.

This chapter describes the results of the analysis of learner marks in Mathematics. In the methodology Chapter 4, I describe the quantitative data collection, analysis and interpretation of the results of this study, as they pertain to mixed methods, and related validity, credibility and reliability issues.

The derived theoretical framework for the study, on the other hand, places the attitudes, perceptions and learners' academic achievement as products of the Family Maths programme. Evidently, these outcomes are both qualitative and quantitative in nature, and this chapter focuses on the quantitative aspect. According to the theoretical framework, four models provide the medium through which the mediation of family members' involvement in the child's education, and learners' cognitive development, occur. Learner marks are the indicators of cognitive development under consideration in this chapter.

Consequently, regarding the above discussion, this report is aligned to quasi-experimental research design (cf. 4.3.2.3). The following sections conform to the analysis steps of PS Matching, the chosen technique for quantitative data from non-randomised experimental design, as is the case in this study. In these sections, I briefly describe the analysis technique and provide a detailed analysis of the model outputs.

6.3 INTERPRETATION OF DATA

The data analysis and interpretation in this research follow sequential logical steps. For practical purposes of space and sense making, the reporting and interpretation of the data, however, may conflate these steps and cause confusion to the reader. To mitigate this challenge, I preface the textual description of data analysis with a diagrammatic representation of the process (Figure 6-1), which also contextualises this chapter within the study.

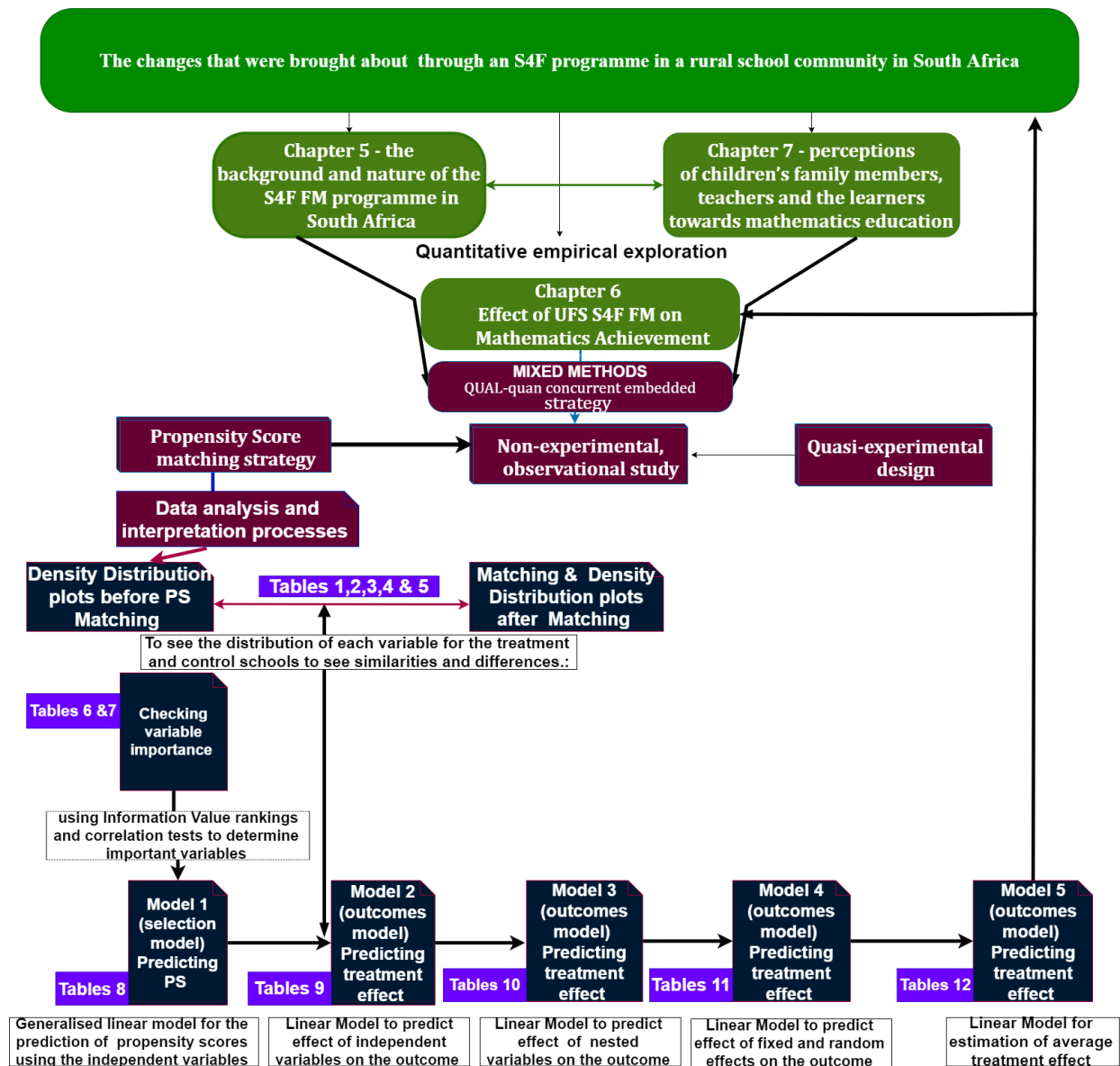


Figure 6-1: A wide contextual and diagrammatic representation of data analysis in Chapter 6

Data, made up of the dependent variable Learners' average marks and 17 predictor variables, were analysed using the R software environment, as explained in Bates et al. (2015: 1–3). This software environment was used to transform and explore the data through the generation of density distribution plots. Tables 6-1 to 6-5 below describe the output of the density distribution plots as contrasted against the plots after matching for both the treatment and control groups.

The sequence of data interpretation in this chapter begins with data exploration, prediction of propensity scores and matching. Evaluation of the predictive power of each confounding

factor, through the generation of information values and multicollinearity checks, followed. The last step is an assessment of the effect of the independent factors on the learners' Mathematics marks, the dependent variable. Tables 6-6 and 6-7 below provide the outcome of the evaluation of the predictive power of the confounding factors.

Following the evaluation of the predictive power, a selection model (Olmos & Govindasamy, 2015: 71), the Generalised Linear Regression Model (GLM), was utilised using the selected independent variables (model 1). The selection model, which is independent of outcome (learner marks), was a binary outcome model, assignment into the treatment (S4F FM programme) or control group, thus setting the family argument to binomial. The outcome of this regression model was propensity scores, which were then used to create two matched groups, namely treatment and control. To evaluate the success of the matching process, density distribution plots were generated for each confounder. This second set of distribution plots were contrasted with the first set that emanated from data exploration. Over and above the fitted GLM model, there were four more other models that were fitted to complete the analysis.

The remainder of the fitted models, namely two, three and four, collectively called the outcome models, evaluated the treatment effect, and included variables associated with the outcome (learners' average marks). While the first multiple linear regression model (model 2) included confounding independent variables to predict the learners' average marks, the second nested model (model 3) exclusively fitted variables that contained variability from within other levels like Treatment within schools, and the repeated measures of DataYear and SubjectGrade within classrooms and schools. A nested model, to remind the reader, is a model, which has variables that are contained within other variables (Cox et al., 2018: 165–168). Classes or grades, for example, are nested within schools.

In model 4, the linear mixed effects model for the analysis of the relationship between the intervention, or treatment (S4F FM programme), and the outcome, the learners' average marks were also fitted. The *lmer* function of the *lme4* package in the R software environment was used to fit the linear mixed effects model (Bates et al., 2015: 1–2; Brauer & Curtin, 2018: 191–192) in which the fixed and random effects were fitted. The school (indicated by EmisCode) and year of assessment to obtain learner marks (indicated by

DataYear) constituted the random effects. Alternatively, the SubjectGradeMathematics Treatment constituted the fixed effects.

6.3.1 DATA EXPLORATION, ESTIMATION OF PS AND EVALUATION OF MATCHING VARIABLES

In this study, 17 confounders were used as predictor variables through Propensity Score Matching (PSM) for selection into the S4F FM programme. Table 6-1 shows the density distribution curves for each confounder before and after matching. As explained in Chapter 4 (cf.4.32), the purpose of plotting the density distribution charts is to qualitatively evaluate the success (or lack thereof) of the matching process. Specifically, each density distribution curve displays three parameters: nature of distribution, the overlap between the treatment and control group, and the tail of each curve. In this report, confounders that display similar patterns regarding each parameter are grouped and explained together. The confounders in this report are also subdivided into continuous line plots and categorical bar plots.

6.3.1.1 CONTINUOUS VARIABLES

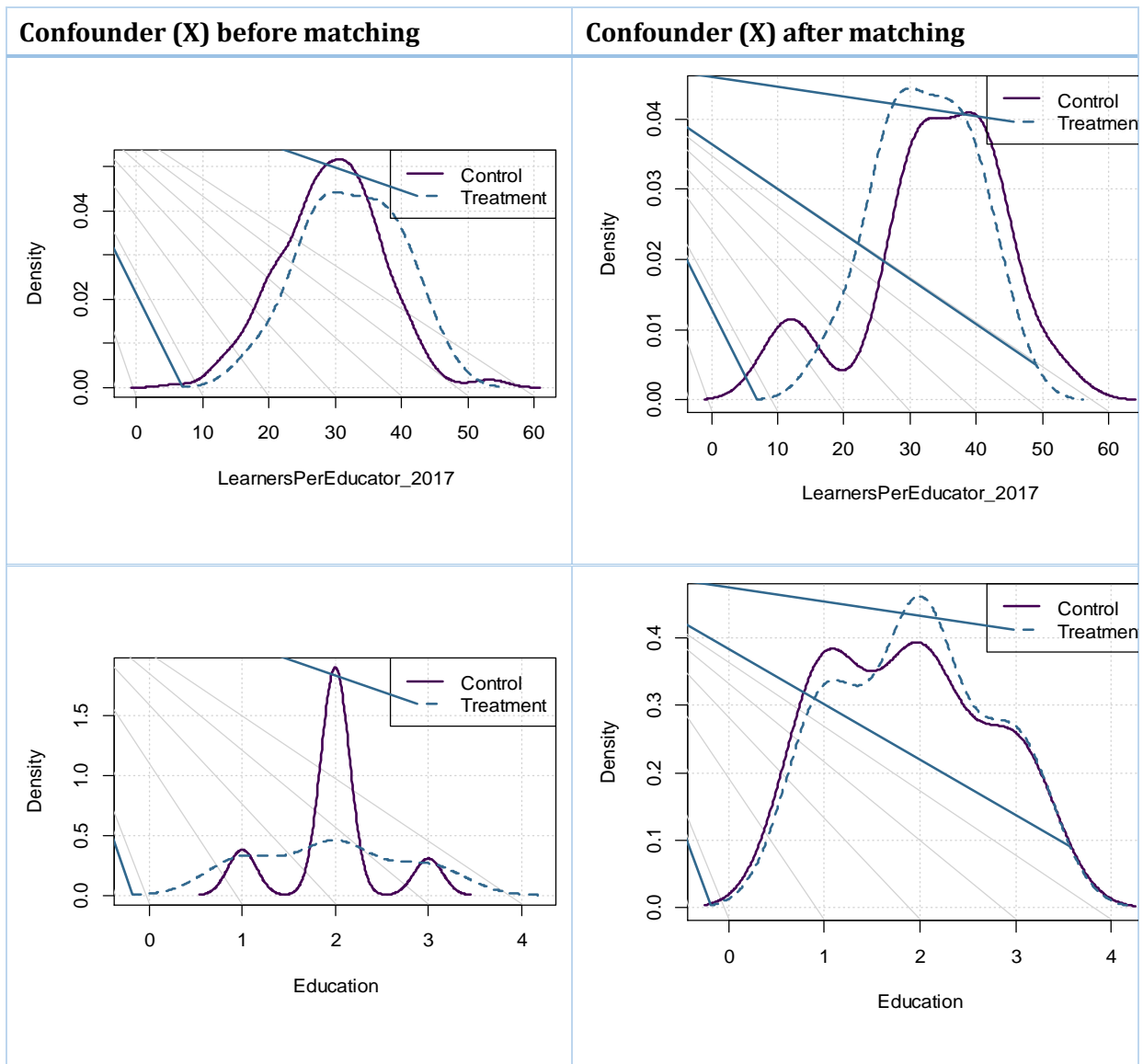
The confounders with normal distributions: LearnersPerEducator_2017 and Education had normal distributions for both the control and the treatment groups before and after matching. First, for clarity, let us look at the LearnersPerEducator_2017. The distribution peaked around 30 before and after matching, respectively. This means that most schools in the S4F FM programme and those outside the programme had classrooms of approximately learner to educator ratio of 30:1, which remained the same after matching.

While there was also a high overlap between the control and treatment curves, the curve for the treatment was slightly on the right of the control curve. With LearnersPerEducator_2017 there were tails on either side for the treatment group, while there were short tails on both sides for the control group after matching. These tails outside the area of overlap indicate that there were schools that have a low probability of selection into the S4F FM programme.

There was also a large area of overlap or common support in the treatment and control curves of LearnersPerEducator_2017, both before and after matching. The big area of overlap before matching suggests that the two groups, treatment and control, are similar on the baseline factor of the ratio of learners to teachers. Despite this overlap, the treatment curve, before matching, is located slightly to the right of the control curve. This suggests

that for any given learner: educator ratio, there were slightly more schools selected into the S4F FM programme, at least in most cases. Matching resulted in balanced groups, although the treatment slightly inclined to the left.

Table 6-1: Density distribution curves for Treatment and Control groups of LearnersPerEducator_2017 and Education before and after matching.

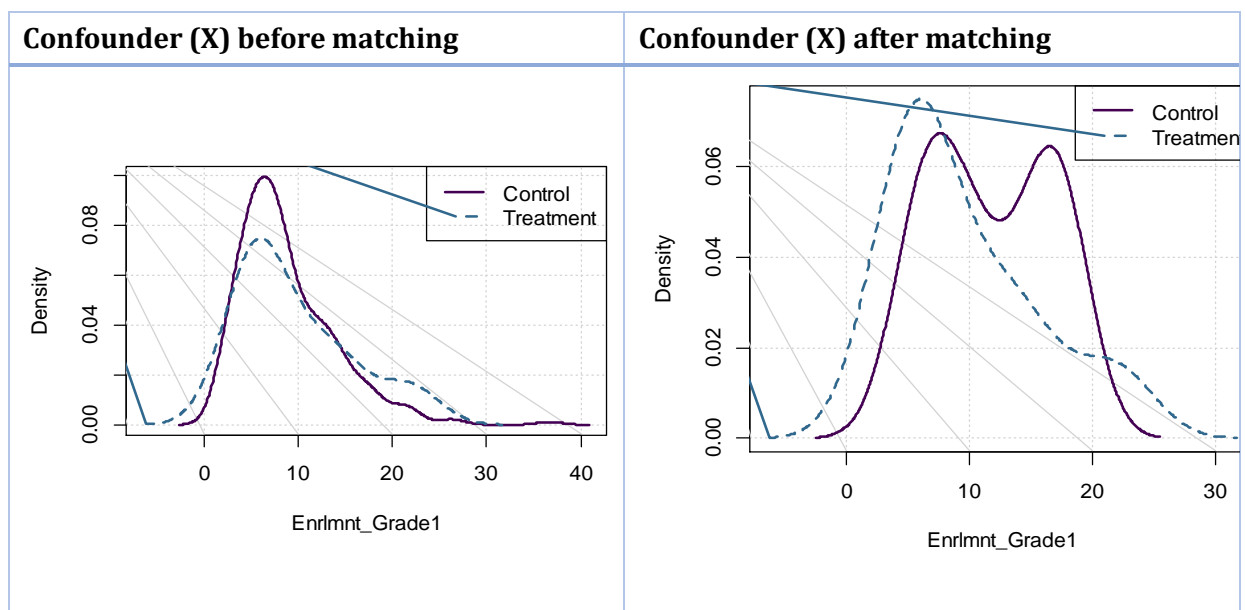


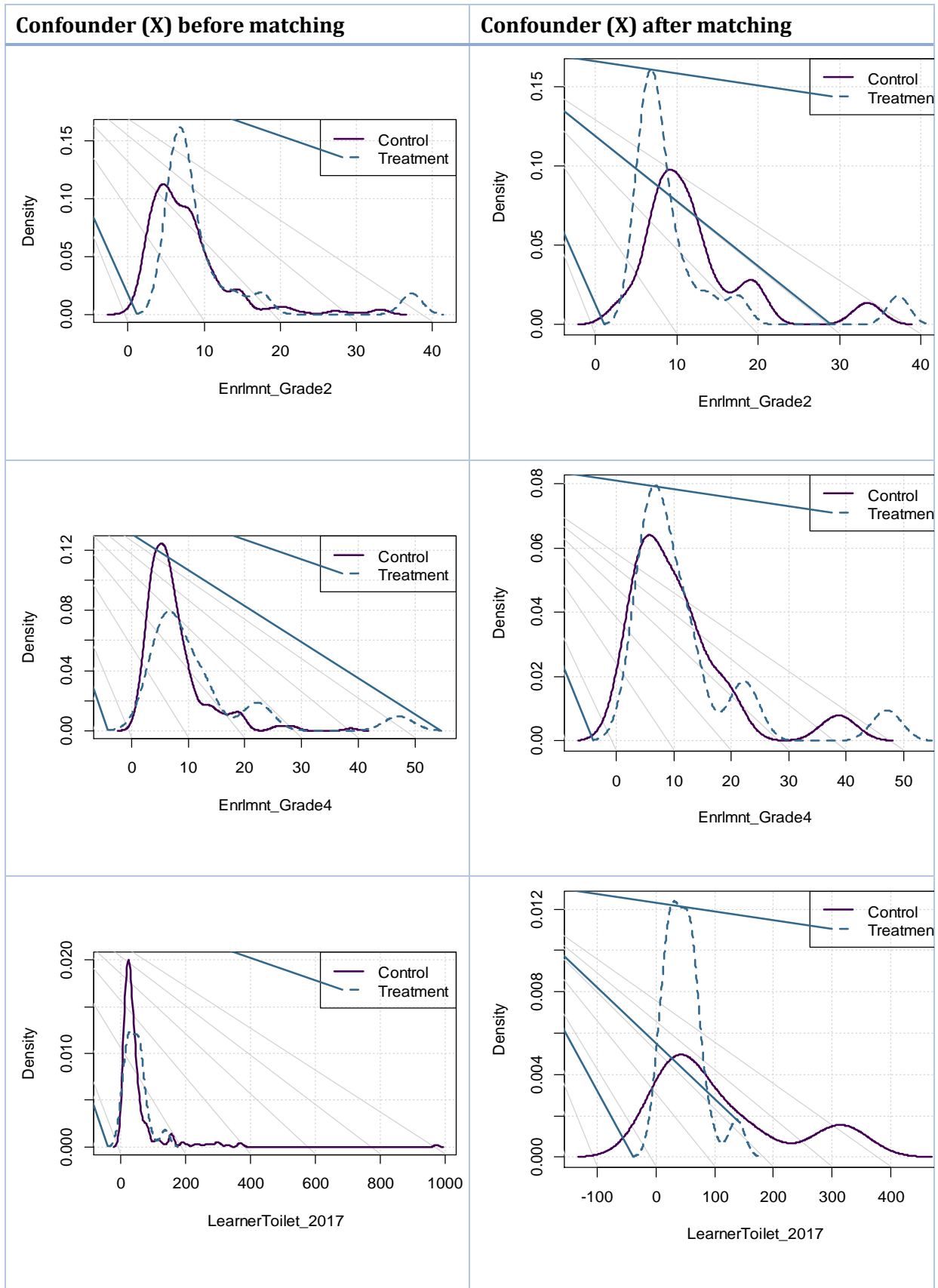
Second, with education as confounder or predictive variable for selection into the S4F FM programme, the density distribution curve shows a peak around 2, with a relatively flat curve for the treatment followed by a near superimposition overlap after matching, indicating that the match was a success. The curves, after matching, also show no tails, which indicates that there were no outlier schools that would need trimming.

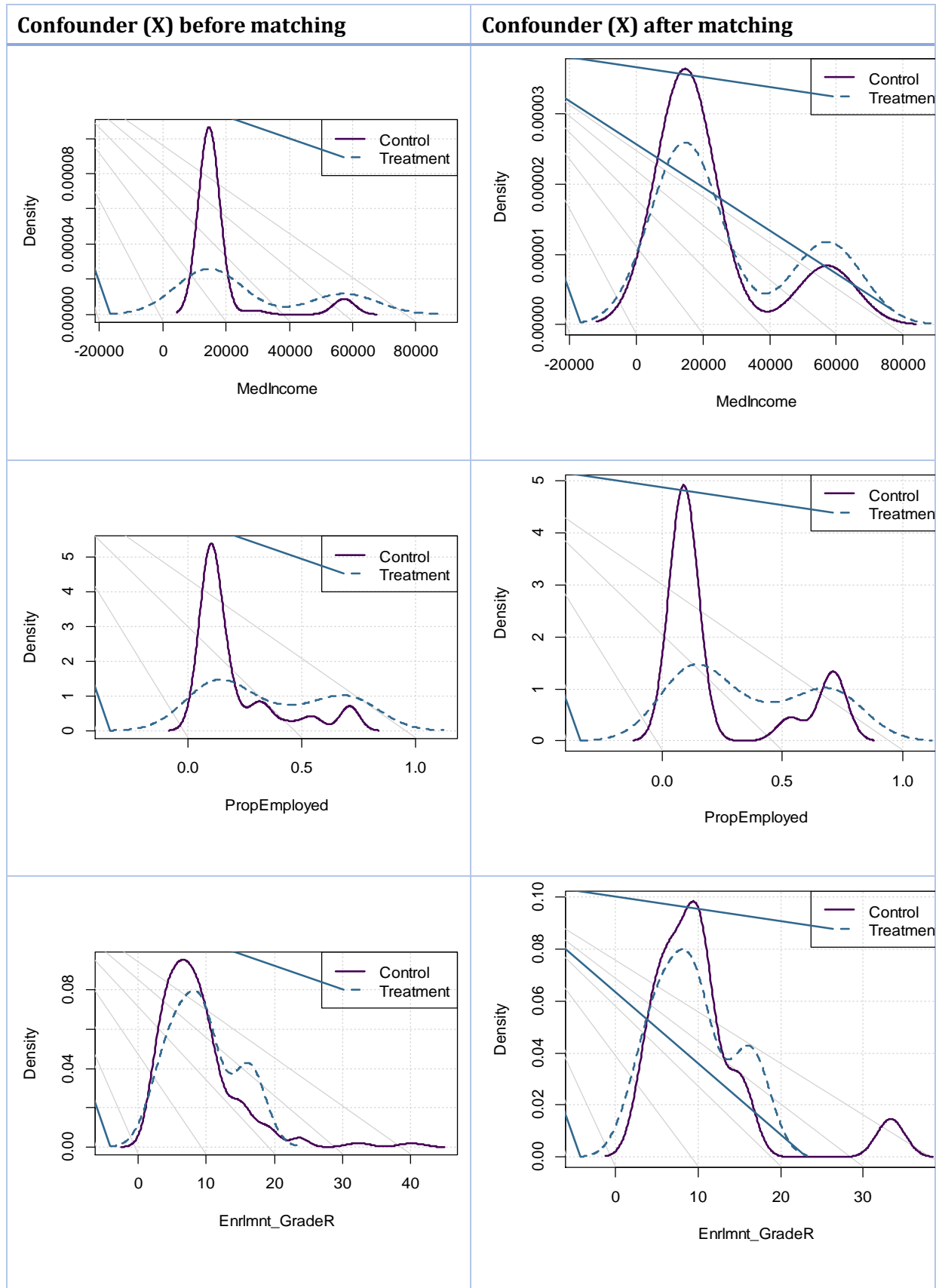
Skewed to the left with high overlap: The distribution curves of confounders in table 2 show a high area of overlap or common support between the treatment and control schools. This overlap suggests that the two groups were similar on the baseline factors given the specific confounder. This type of overlap indicates that these confounders can be relied upon as predictor variables for selecting schools into the intervention (S4F FM programme).

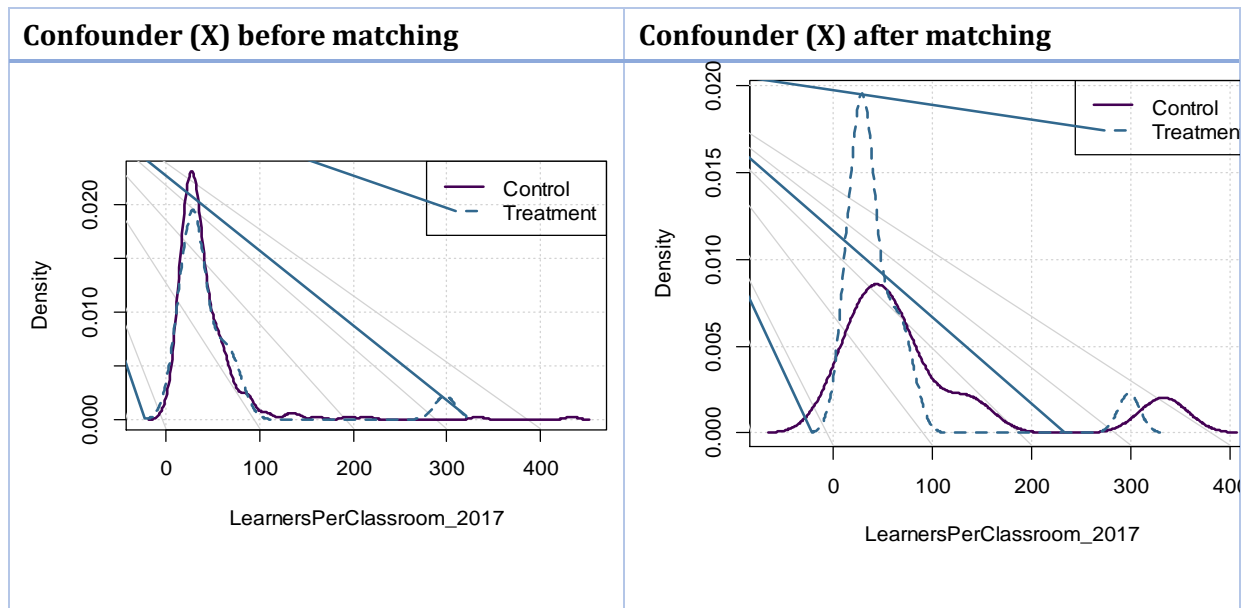
With the exception of `Enrlmnt_Grade1` after matching, the other confounders in table 2 show skewness towards the left, with a fairly long tail to the right running near the zero density, even after matching. The left skewness suggests that most schools, both in the treatment and control groups, were on the lower values in each confounder, an indication of baseline similarity before and good quality of a confounder as a predictor variable for selection. The tails indicate that there were few schools with high values for each confounder, called the outliers. These schools are good candidates for trimming out when the final treatment and control groups are formed. That is, the schools that lie on the extremes have a high probability of being excluded in both the treatment and control groups.

Table 6-2: Density distribution curves for Treatment and Control groups of `Enrlmnt_Grade1`, `Enrlmnt_Grade2`, `Enrlmnt_Grade4`, `LearnerToilet_2017` and `MedIncome`, before and after matching





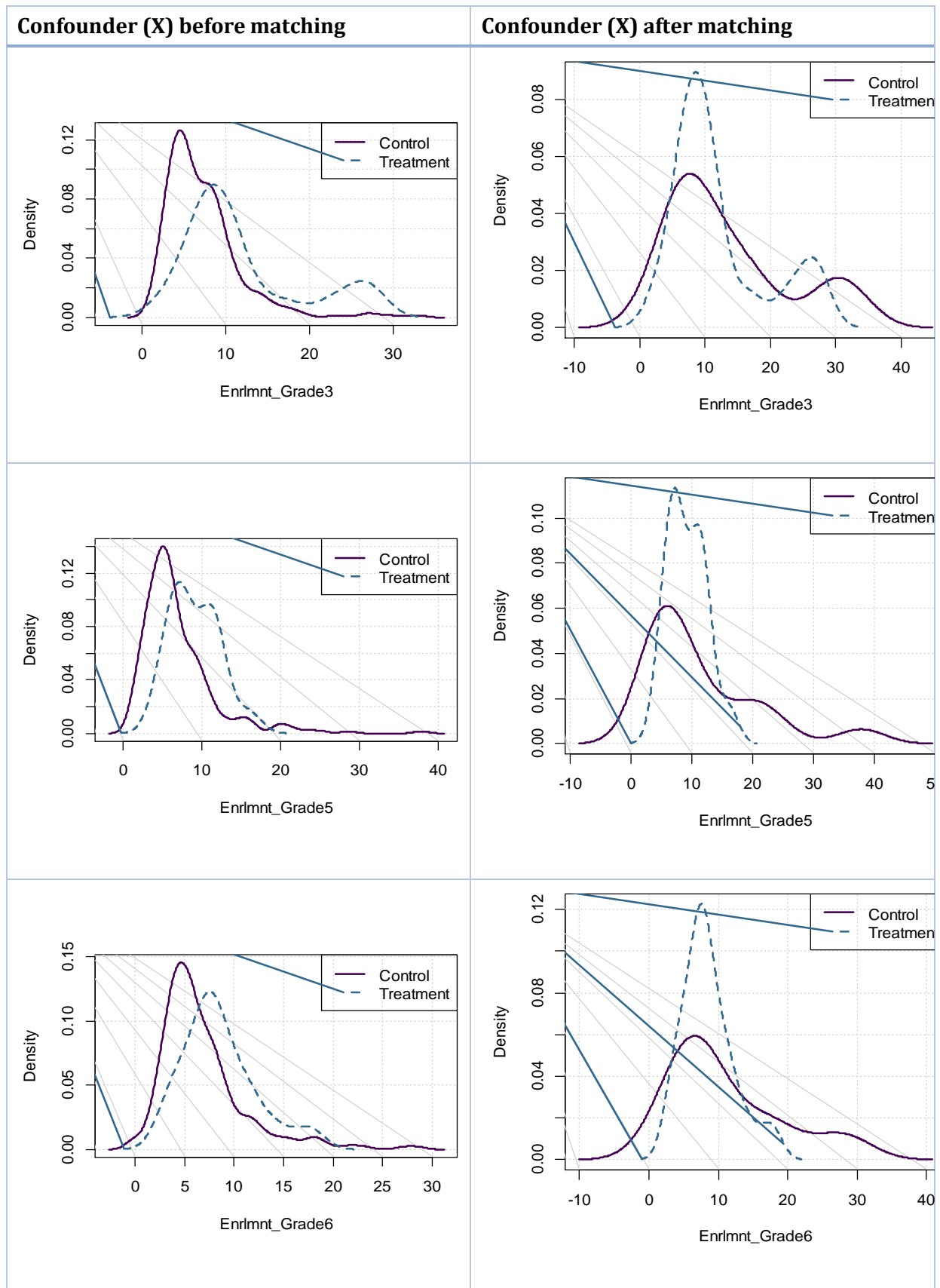


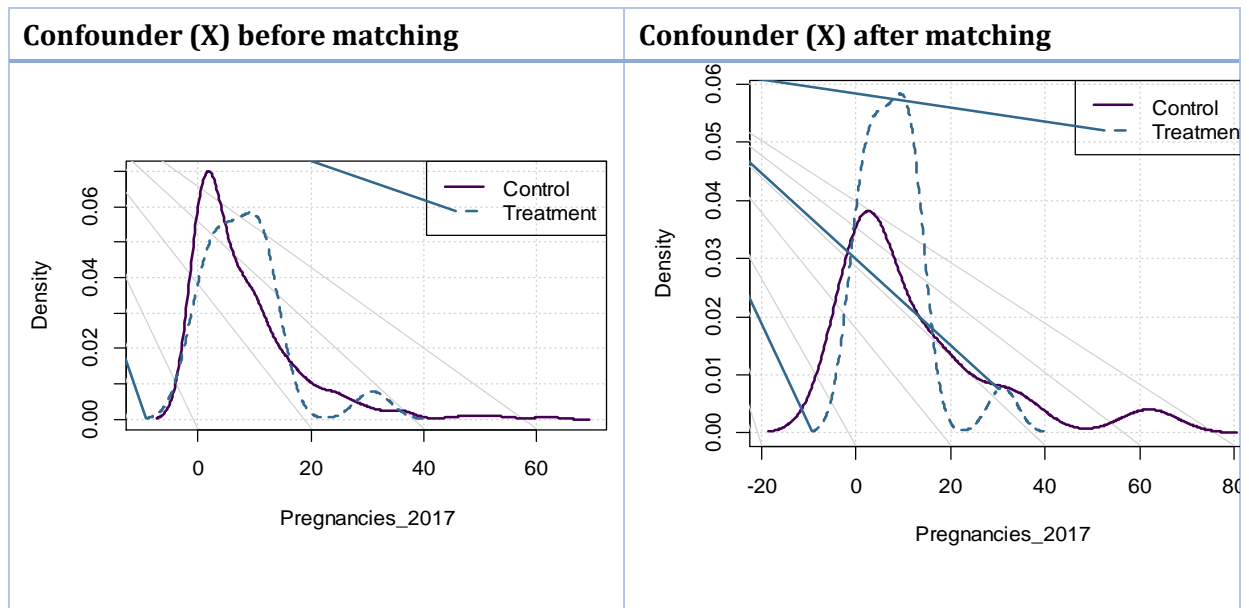


Confounders that are skewed to the left with poor overlap: Similar to the confounders found in table 2, table 3 shows confounders with density distribution curves that are skewed to the left with fairly long tails to the right. The explanation for the observed skewness is the same as that given for the confounders in table 2. Poor overlap is the difference between those in table 2 and 3, where it is poor in the latter (table 3). Poor overlap indicates a small area of common support between the schools selected to participate in the intervention and those outside the intervention. For example, most schools outside the intervention had approximately five learner pregnancies per year, while there were approximately 15 pregnancies in schools that were in the S4F FM programme.

These differences indicate baseline differences between the two groups based on the `Enrlmnt_Grade3`, `Enrlmnt_Grade5`, `Enrlmnt_Grade6` and `Pregnancies_2017`. Therefore, these confounders might not have been ideal as predictors for selection into the intervention, hence the need for PS to balance out the baseline differences. Indeed, the overlap improved after matching.

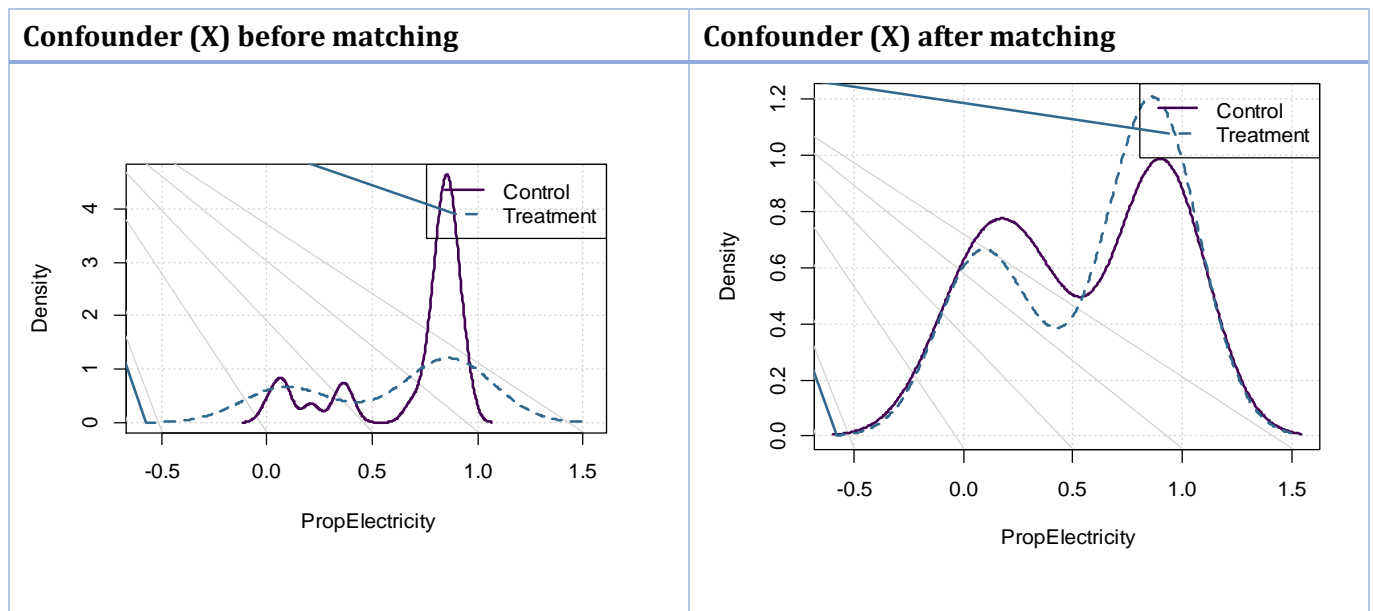
Table 6-3: Density distribution curves for treatment and control groups of Enrlmnt_Grade3, Enrlmnt_Grade5, Enrlmnt_Grade6, Pregnancies_2017, before and after matching





Skewed to the right with high overlap

Combined with a large area of common support, the right skew indicates that most schools in both the intervention programme and outside, came from communities with a higher proportion of households with access to electricity. The differences in the peaks of the curves suggest that a comparatively higher number of these schools came from the control group, which also imply differences between the two groups in terms of households with access to electricity. Matching enabled the balancing of these baseline differences between the two groups, thus contributing towards the establishment a control group for the study.

Table 6-4: Density distribution curves for treatment and control groups of PropElectricity before and after matching

6.3.1.2 CATEGORICAL VARIABLES

Regarding the categorical variables, there were proportionally higher numbers of people who resided in land that is under traditional authority than those from formal residential areas. This was true for both the treatment (S4F FM programme) and control groups - see 5(A). While there was a slight reduction in differences after matching using propensity scores, matching did not yield marked improvement. Failure to match might indicate less reliability of AreaType as a predictor of selection into the intervention.

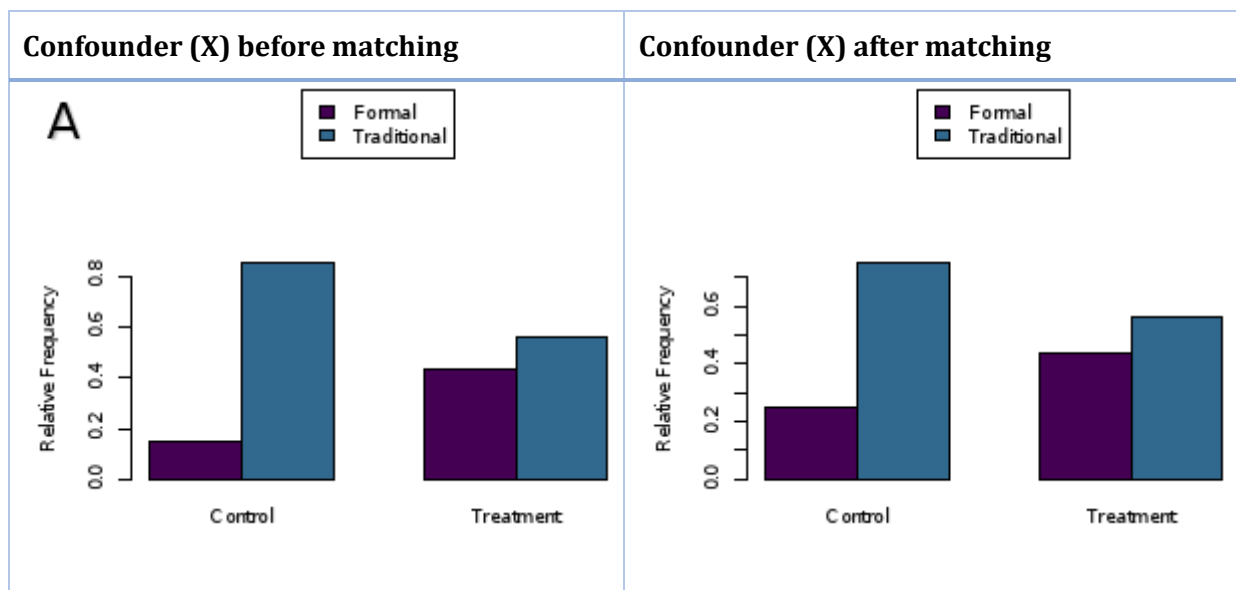
The number of households accessing water from municipal provisioning or other sources, including the river, is the second of the categorical variables, table (5B). The outcome of matching for the source of water (5B) as confounder was almost the same as that of AreaType. That is, the relative frequency distribution histograms of the number of households with access to municipally provided water or other sources, including the river, after matching, mirror those that were observed before matching. The implications for predictive reliability of the confounder are the same as those of the AreaType.

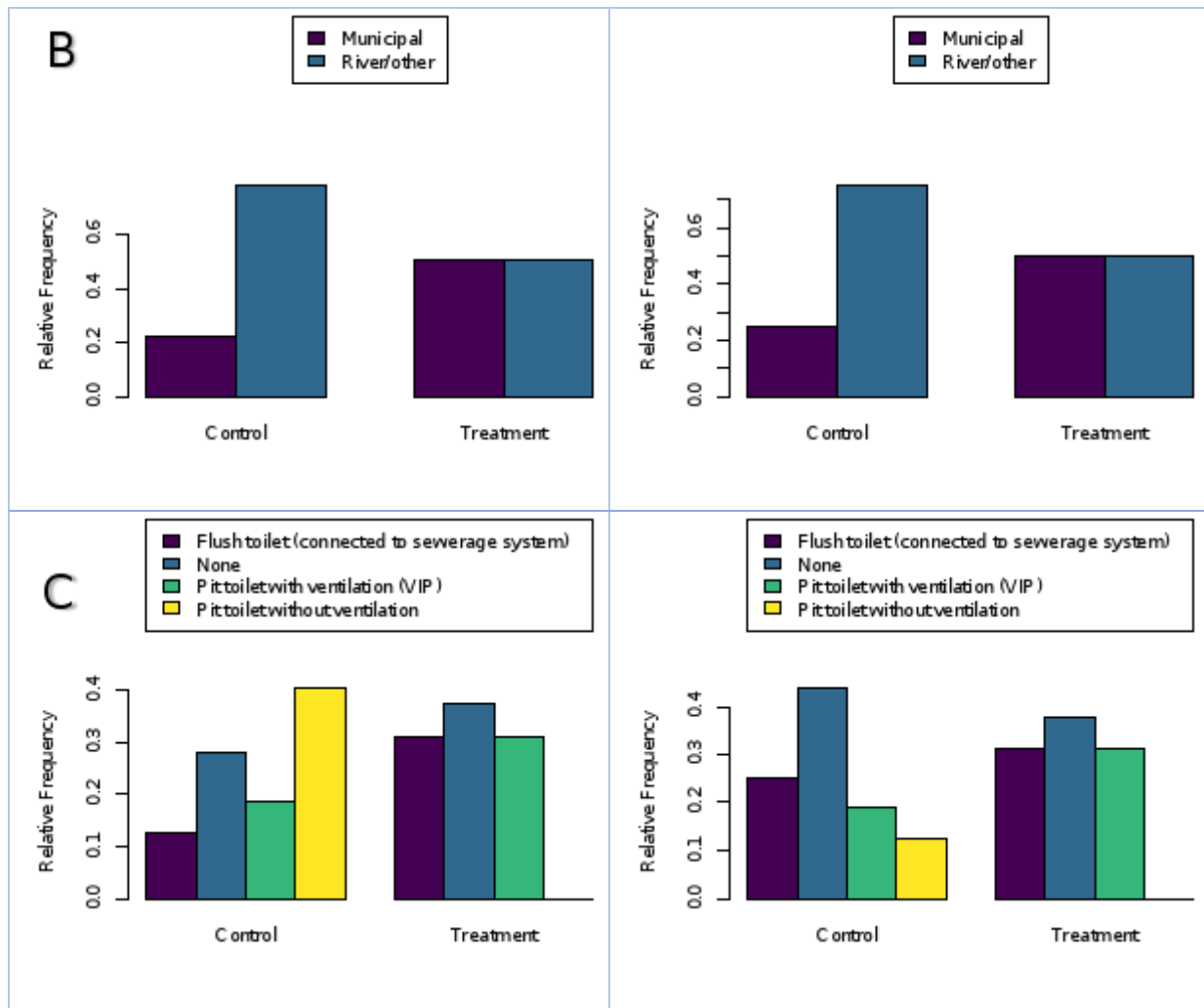
Lastly, regarding the categorical variables. The number of households using one form of toilet facility, including flush toilets, pit toilets with ventilation, pit toilet without ventilation and no access to any form of toilet facility (5C), display some degree of success of the

matching process. One glaring baseline dissimilarity between the schools in the S4F FM programme and the rest of the primary schools in the old Mthatha District was the pit toilets without ventilation. No school in the programme, from a local municipality area, had households using toilets without ventilation.

The significance of the baseline difference highlights the potential for selection bias that could compromise the causal inference conclusions. In particular, the differences in the toilet facilities can also explain differences in the treatment effect, as explained in Chapter 3 (c.f. 3.6.1). Matching, through PS drastically reduced the frequency of schools from areas with households using pit toilets without ventilation, though a few of these made it into the matched control group, thus mitigating against selection bias.

Table 6-5: Relative frequency distributions of categorical variables indicating the distribution of number people according to area type (5A), households according to the source of water (5B) and toilet facility (5C)





6.3.2 VARIABLE IMPORTANCE

6.3.2.1 INFORMATION VALUES

In order not to confuse the reader, it is important to highlight the systematic sequence followed in calculating these results. The Information Values (IV) displayed in table 6 were computed after the distribution plots of each variable for the treatment and control schools (left side of the tables), and before the matching through propensity scores (right half of same tables) above. The idea behind this is to get the sense of the order of importance of the variables before they are fitted into models to generate PS, and in the assessment of the treatment effect (cf. 4.3.2).

The IV values indicate that PropEmployed, Enrlmnt_Grade5, AreaType, Enrlmnt_Grade3, Enrlmnt_Grade6, WaterSource, Enrlmnt_Grade4 and MedIncome have comparatively stronger predictive power for selection into treatment, the S4F FM programme. Pregnancies_2017, LearnersPerEducator_2017, Enrlmnt_Grade2, Toilet,

LearnerToilet_2017, PropElectricity, Enrlmnt_Grade1 and Education, on the other hand, have moderate predictive power for selection into the intervention programme. Lastly, Enrlmnt_GradeR and LearnersPerClassroom_2017 have weak predictive value and can be discarded and not fitted into the PS matching model. Based on the above, I would recommend dropping *LearnersPerClassroom_2017*, *Enrlmnt_GradeR*, and possibly *Education* from the analysis.

Table 6-6: Ranking of the predictive power of independent variables based on the Information Value

Variable Number	Variable	IV	Predictive usefulness
15	PropEmployed	0.68	Strong predictive power
10	Enrlmnt_Grade5	0.55	
16	AreaType	0.44	
8	Enrlmnt_Grade3	0.43	
11	Enrlmnt_Grade6	0.43	
17	WaterSource	0.35	
9	Enrlmnt_Grade4	0.34	
13	MedIncome	0.32	
3	Pregnancies_2017	0.28	Medium
2	LearnersPerEducator_2017	0.27	
7	Enrlmnt_Grade2	0.26	
18	Toilet	0.26	
4	LearnerToilet_2017	0.19	
12	PropElectricity	0.17	
6	Enrlmnt_Grade1	0.14	
14	Education	0.12	
5	Enrlmnt_GradeR	0.06	Weak, can be discarded
1	LearnersPerClassroom_2017	0.01	

6.3.2.2 CORRELATION APPROACH

Independent predictor variables that are correlated with one another are undesirable in modelling, as their unique effects cannot be distinguished (Kraha et al., 2012: 5) as described in section 4.3.2.8 of Chapter 4. According to table 7, LearnersPerClassroom_2017

and LearnersPerEducator_2017 are highly correlated with Pregnancies_2017, MedIncome, Education, PropEmployed and treatment, as the correlation coefficient exceeds 0.7.

Table 6-7: Correlation test among the independent predictor variables and treatment to detect multicollinearity

	LearnersPerClassroom_2017	LearnersPerEducator_2017	Pregnancies_2017	LearnerToilet_2017	Enrlmnt_GradeR	Enrlmnt_Grade1	Enrlmnt_Grade2	Enrlmnt_Grade3	Enrlmnt_Grade4	Enrlmnt_Grade5	Enrlmnt_Grade6	PropElectricity	MedIncome	Education	PropEmployed	Treatment	
LearnersPerClassroom_2017	1		X										X	X	X	X	1
LearnersPerEducator_2017		1															-0.8
Pregnancies_2017	X		1	X								X	X	X	X	X	-0.6
LearnerToilet_2017			X	1					X			X	X	X	X	X	-0.4
Enrlmnt_GradeR					1							X	X			X	-0.2
Enrlmnt_Grade1						1							X	X		X	0
Enrlmnt_Grade2							1					X	X				0.2
Enrlmnt_Grade3								1				X	X				0.4
Enrlmnt_Grade4				X					1			X	X				0.6
Enrlmnt_Grade5										1		X	X				0.8
Enrlmnt_Grade6											1		X	X			0.2
PropElectricity			X	X	X		X	X	X	X		1					0.6
MedIncome	X		X	X	X	X	X	X	X	X	X		1				0.8
Education			X	X		X		X						1		X	0.2
PropEmployed	X	X	X	X		X		X			X				1		0.2
Treatment	X		X	X									X			1	1

6.3.3 GENERALIZED LINEAR MODEL TO PREDICT PROPENSITY SCORES (MODEL 1)

Some variables were on radically different scales and needed to be standardised for stable modelling. To achieve standardisation, I rescaled all the numeric variables using the mean and standard deviation.

A generalised linear model was fitted following the determination of the important variables. The purpose of fitting this model was to predict the propensity scores using

variables that were deemed to be important. Enrolment_Grade3, MedIncome and PropElectricity were used for predicting propensity scores. In turn, these propensity scores were later used to find matches for each school in the treatment group from those outside the treatment. The selected independent variables for predicting propensity scores fell within the acceptable range in the Information Values scores, and had very low correlation coefficients as depicted in tables 6 and 7 above. Table 8 shows the summary output of the logistic regression model to predict the propensity scores.

The summary of Generalised Linear Model (GLM) shows deviance residuals with a median of -0.2000 , which is close to zero. This small median indicates that the model is not biased towards either overestimation or underestimation, and is therefore there a good model fit.

Also, the summary output of the model shows the coefficient table, which is made up the estimate, standard error, z value and $\Pr(>|Z|)$ – the p-value. For the first variable, Enrlmnt_Grade3, the summary estimate suggests that for every one learner change in Enrlmnt_Grade3, the log odds of assignment into the treatment (S4F FM programme) versus being excluded (control), increase by 0.7057, while controlling for MedIncome and PropElectricity the estimate is statistically significant - $\Pr(>|z|) = 0.000445$. Second, controlling for Enrlmnt_Grade3 and PropElectricity, a change in the MedIncome category, the log odds of assignment into the treatment versus being excluded, increase by 0.7730 and the estimate are statistically significant - $\Pr(>|z|) = 0.000529$. Lastly, for one person change in PropElectricity (proportion access to electricity), the log odds of assignment into the treatment versus being excluded decrease by -0.6678 , while controlling for Enrlmnt_Grade3 and PropElectricity, and the estimate is statistically significant - $\Pr(>|z|) = 0.013355$.

Another test for model fit is Residual deviance = 98.158 on 264 degrees of freedom, Null deviance = 121.214 on 267 degrees of freedom and AIC = 106.16. High values for Residual deviance suggest a fairly high standard error of the model in predicting the eligibility for selecting a school into the intervention programme. Lastly, the Number of Fisher Scoring iterations = 6, which simply indicates the number of iterations during the estimation of the model.

Table 6-8: Summary output of a generalised linear model, Model1 for predicting propensity scores.

Deviance Residuals:				
Min	1Q	Median	3Q	Max
-1.25	-0.34	-0.20	-0.15	2.92
Coefficients:				
	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	-3.40	0.40	-8.52	2.00x10 ⁻¹⁵ ***
Enrlmnt_Grade3	0.71	0.20	3.51	4.45x10 ⁻⁴ ***
MedIncome	0.77	0.22	3.47	5.29x10 ⁻⁴ ***
PropElectricity	-0.67	0.27	-2.47	1.34x10 ⁻² *
Null deviance:			121.21 on 267 degrees of freedom	
Residual deviance:			98.16 on 264 degrees of freedom	
AIC:			106.16	
Number of Fisher Scoring iterations:			6	

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

6.3.4 MATCHING

Following the estimation of the propensity score, which is the probability of being selected to participate in the intervention (S4F FM programme) given the covariates identified as important prediction of eligibility, then a match for each individual school from the intervention is found from the rest of the other schools outside the intervention to create balanced samples. The principle with PS matching is to build a model that predicts the probability of including a subject (in this case each school is a subject) into the treatment (S4F FM programme), given the underlying characteristics as determined through all important available factors that are not related to the outcome. Then, the subjects were matched based on their propensity scores (their propensity to have been treated). The idea is that if two subjects have matching propensity scores, they are likely to be similar, except for the random variation.

The Nearest Neighbour Matching is the chosen algorithm for matching, which simply means that for every treatment school, I select the control school with the closest propensity to be

treated as its match. This algorithm creates a sample that can be assumed to be balanced (cf. 6.2.1).

6.3.5 TREATMENT IMPACT

Now I attempt to make inferences on the treatment effect using the more balanced sample. To make these inferences, four models were fitted. The first was the linear model (model 2) to determine the effect of each variable on the treatment. Second, another linear model (model 3) to determine the effect of variables nested within other levels (Treatment, DataYear and SubjectGrade) on the learner average marks was fitted. Thirdly, model 4, the linear mixed model that considered the fixed and random effects, was fitted. Lastly, model 5, another linear model to determine the impact of treatment on each grade, was also fitted. The summary outputs of the different models are interpreted below.

6.3.5.1 LINEAR REGRESSION MODEL TO ESTIMATE THE EFFECT OF INDEPENDENT VARIABLES ON THE LEARNERS' MARKS (MODEL 2)

Table 9 also shows the output summary of the first outcomes model, the linear regression model, which includes, for the first time, the variables that are associated with the outcome (learners' average Mathematics marks). The model fitted these variables: Treatment, DataYear, SubjectGrade, LearnersPerEducator_2017, Pregnancies_2017, LearnerToilet_2017, Education, PropEmployed, WaterSource, Enrlmnt_Grade3, MedIncome, PropElectricity and Propensity.

The linear regression models fitted in this study are given by the formula:

$Y_i = \beta_0 + \beta_1 X_{i1} + \dots + \beta_k X_{ik} + \varepsilon$, where Y_i = fitted values of learners' mathematics marks (dependent variable), β_j = estimates of population parameters (coefficients), β_0 = the intercept, ε = the error term and X_j = independent variables.

Table 6-9: Summary output of a multiple regression model 2 showing the relationship between LearnerAverage (Mathematics marks) and 13 explanatory variables.

Residuals:						
Min	1Q	Median	3Q	Max		
-58.19		0.30	7.22	39.89		
Coefficients:						
	Estimate	Std. Error	t value		Pr(> t)	
(Intercept)	65.86	0.64	103.15	<	2.00 x10 ⁻¹⁶	***
TreatmentTRUE	3.48	0.22	15.88	<	2.00 x10 ⁻¹⁶	***
DataYear	0.03	0.06	0.54		5.88 x10 ⁻⁰¹	
SubjectGradeMathematics (Gr 01)	-1.79	0.24	-7.52		5.68 x10 ⁻¹⁴	***
SubjectGradeMathematics (Gr 02)	-1.46	0.24	-6.16		7.15 x10 ⁻¹⁰	***
SubjectGradeMathematics (Gr 03)	-1.92	0.24	-8.11		5.38 x10 ⁻¹⁶	***
SubjectGradeMathematics (Gr 04)	-7.93	0.24	-33.29	<	2.00 x10 ⁻¹⁶	***
SubjectGradeMathematics (Gr 05)	-7.34	0.24	-30.28	<	2.00 x10 ⁻¹⁶	***
SubjectGradeMathematics (Gr 06)	-6.25	0.25	-25.27	<	2.00 x10 ⁻¹⁶	***
LearnersPerEducator_2017	-0.85	0.09	-9.28	<	2.00 x10 ⁻¹⁶	***
Pregnancies_2017	1.08	0.07	16.52	<	2.00 x10 ⁻¹⁶	***
LearnerToilet_2017	-0.20	0.11	-1.80		7.00x10 ⁻⁰²	
Education	0.70	0.15	4.79		1.71 x10 ⁻⁰⁶	***
PropEmployed	-6.18	0.60	-10.33	<	2.00 x10 ⁻¹⁶	***
WaterSourceRiver/other	-8.93	0.93	-9.56	<	2.00 x10 ⁻¹⁶	***
Enrlmnt_Grade3	1.14	0.14	8.26	<	2.00 x10 ⁻¹⁶	***
MedIncome	4.05	0.31	13.26	<	2.00 x10 ⁻¹⁶	***
PropElectricity	0.13	0.17	0.76		4.60 x10 ⁻⁰¹	
Propensity	-7.28	1.25	-5.83		5.59 x10 ⁻⁰⁹	***
Residual standard error	11.99 on 37301 degrees of freedom					
Multiple R-squared	0.1154					
Adjusted R-squared	0.115					
F-statistic	270.5 on 18 and 37301 DF					
p-value	< 2 x10 ⁻¹⁶					

* $p \leq 0.05$ ** $p \leq 0.01$ *** $p \leq 0.001$

a) Null hypothesis i

The coefficients of the fitted independent variables are equal to zero, meaning that the variables have no effect on the learners' Mathematics marks.

Results: all the coefficients, except for DataYear, LearnerToilet_2017 and PropElectricity, are significantly different from zero at $\alpha = 0.05$ (cf. table 9). Therefore, I reject the null hypothesis that the fitted independent variables are equal to zero for all variables.

The overall p value ≈ 0 indicates the significance of the whole model, considering the effects of all fitted variables. In other words, the variances observed from the model are statistically significant.

b) Null hypothesis ii

The differences among the fitted independent variables are equal to zero, meaning that there are no differences in the effects among the fitted independent variables on the learners' Mathematics marks.

Results: Categorical Variables: Controlling for other variables, the coefficients of WaterSource River = -8.9, while Education = 0.7, TreatmentTRUE = 3.5 and MedIncome = 4.1. These coefficients are statistically significant at $\alpha = 0.05$ (cf. table 9). DataYear = 0.03, on the other hand, and was not significant (cf. table 9). Regarding learners' grades, the model output shows that holding other variables constant: SubjectGradeMathematics (Gr 01) = -1.8, SubjectGradeMathematics (Gr 02) = -1.5, SubjectGradeMathematics (Gr 03) = -2.0, SubjectGradeMathematics (Gr 04) = -7.9, SubjectGradeMathematics (Gr 05) = -7.3 and SubjectGradeMathematics (Gr 06) = -6.3 are all significantly, lower than zero, implying a gradual deterioration in marks relative to SubjectGradeMathematics (Gr R).

Continuous Variables: Holding other variables constant, Propensity = -7.3, PropEmployed = -6.2, Pregnancies_2017 = 1.1, Enrlmnt_Grade3 = 1.1, LearnersPerEducator_2017 = 1.1 are significantly different from zero at $\alpha = 0.05$. I therefore reject the null hypothesis that the differences among the fitted independent variables are equal to zero. Meanwhile, PropElectricity = 0.1 and LearnerToilet_2017 = -0.2 are not significant, $p > 0.05$.

6.3.5.2 DISCUSSION: LINEAR REGRESSION (MODEL 2)

The results indicate that the S4F FM intervention programme had a positive effect on the learners' average marks in Mathematics. The estimated average mark for the learners in the intervention is 3.4797 higher than those in the control group at $65.861 + 3.4797 = 69.3409$, while controlling for all the other variables in the model. This observation suggests that exposure to S4F FM programme activities improves learners' Mathematics marks. Also, the results indicate that for every successive year since 2016, there has been a 0.03369 increase in the learners' average marks, even though this is not really significant.

The results suggest that the language policy of the Department of Basic Education in South Africa affects learners' marks in Mathematics. The coefficients of the multiple linear regression models estimate that the marks for Grades 1, 2 and 3 were higher than those of Grades 4, 5 and 6, as indicated by the amount with which the coefficients for each grade differ from zero. The Grade 2 marks were the highest, while the Grade 4 marks were the lowest (cf. table 9). One possible explanation for this observation is that in Grades 1 – 3, the foundation phase, the language of teaching and learning for all subject is the same as the home language. In Grades 4 - 6, the intermediate phase, the language of teaching and learning is English. Controlling for the other variables, the foundation phase marks classes are -1.79, -1.46 and -1.92 for Grades 1, 2 and 3. These are lower than the model projection would otherwise be (cf. table 9). The marks for Grades 4 – 6, on the other hand, were -7.93, -7.34 and -6.25, respectively, which is lower than the model projection would otherwise be. The results are statistically significant.

Community socioeconomic background as indicated by access to water, income and education, indicates a significant effect on the learners' average marks for Mathematics. The model estimates WaterSource (proportion of households accessing water from either municipal provisioning or other sources, including the river) to have had a negative impact on learner's marks. Since the water source is a categorical variable, this means that the learners' average marks from communities who access water from the river or other sources are -8.9 lower than those who access it from municipal sources. MedIncome and Education, on the other hand, are positively related to the learners' average marks. In the case of MedIncome (number of people earning below, between and above the 14600, 28900 and 57900 Rand per annum), this means that the higher the community income, the more the average learner marks increase. With Education, on the other hand (below matric and

post-matric education), the results mean that the more people with post-matric education, the higher the average marks.

6.3.5.3 NESTED LINEAR REGRESSION MODEL TO ESTIMATE THE EFFECT OF CLASSROOM YEAR AND TREATMENT ON THE LEARNERS MARKS (MODEL 3)

The second outcomes, model 3, a linear regression model, fitted the Treatment, DataYear and SubjectGrade variables. Table 10 shows the summary output of model 3. Model specification being an iterative process, the purpose of this model is to evaluate the predictive power of the fitted variables and assess the best model fit, given the number of specified variables in comparison to model 2 (cf. table 9)

The model output shows that the coefficients have lower margins of differences from the intercept, that is, the effect of the independent variables is reduced (cf. table 10), when compared to model 2 (cf. table 9). DataYear remains statistically insignificant, while the coefficients of the other variables are significant at $p \approx 0$ (cf. table 10).

A comparison of model 3 to model 2 shows that the residual standard error increased from 11.99 to 12.37. Multiple R-squared and adjusted R-squared, on the other hand, decreased from 0.1154 to 0.05911, and 0.115 to 0.0589, respectively. Lastly, the F-statistic = 293 on 8 and 37311 DF increased to 270.5 on 18 and 37301 DF. However, the model fits the data as $p \approx 0$. Thus, this model output indicates that model 2 (cf. table 9) is not an overfit, and its predictions can be used to explain the variability in the learners' Mathematics marks.

Table 6-10: Summary output of a multiple regression model 3 showing the relationship between LearnerAverage (Mathematics marks) and nested effects Treatment, DataYear and Grade

Residuals:				
Min	1Q	Median	3Q	Max
-60.64		-0.15	7.35	40.11
Coefficients:				
	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	59.81	0.19	310.96	2.00 x10 ⁻¹⁶ ***
TreatmentTRUE	2.34	0.13	18.16	2.00 x10 ⁻¹⁶ ***
DataYear	0.07	0.06	1.08	2.81 x10 ⁻⁰¹

SubjectGradeMathematics (Gr01)	-1.58	0.24	-6.45	1.10 x10 ⁻¹⁰ ***
SubjectGradeMathematics (Gr02)	-1.16	0.24	-4.74	2.18 x10 ⁻⁰⁶ ***
SubjectGradeMathematics (Gr03)	-1.67	0.24	-6.88	6.30 x10 ⁻¹² ***
SubjectGradeMathematics (Gr04)	-7.66	0.25	-31.25	2.00 x10 ⁻¹⁶ ***
SubjectGradeMathematics (Gr05)	-6.95	0.25	-27.84	2.00 x10 ⁻¹⁶ ***
SubjectGradeMathematics (Gr06)	-5.82	0.25	-22.86	2.00 x10 ⁻¹⁶ ***
Residual standard error	12.37 on 37311 degrees of freedom			
Multiple R-squared	0.06			
Adjusted R-squared	0.06			
F-statistic	293 on 8 and 37311 DF			
p-value	< 2 x10 ⁻¹⁶			

* $p \leq 0.05$

** $p \leq 0.01$

*** $p \leq 0.001$

6.3.5.4 LINEAR MIXED MODEL TO ESTIMATE THE EFFECT OF FIXED AND RANDOM EFFECTS ON LEARNERS' MARKS (MODEL 4)

The Mathematics marks in this study, which is the independent variable, are derived from the assessment outcomes during the last term of the academic year from 2016 – 2018. As such, learners were clustered into classrooms, which were in turn clustered into schools. The models considered up to this point did not account for within and between classrooms, and the variations between schools. Similarly, the previous models did not assess the random variations emanating from repeated measures, namely annual assessments, which may violate the independence assumption. The mixed model fitted in this section attempted to address these challenges.

The output summary of the random effects, EmisCode (depicting the school identity) and DataYear (indicating the year of assessment) in table 11, shows that the standard deviations in the learners' average marks due to EmisCode and DataYear was 3.89 and 0.36, relative to the residual (unexplained) standard error of 11.67. The differences among teachers, assessment regimes in different schools and school environments might be some of the sources of this variability.

Consistent with predictions of the other two GLM models, the output summary of the fixed effects shows a marked difference between foundation phase and intermediate phase

classes. Those in the foundation phase, including Grade R, start from 60 mark and above, while the maximum for the intermediate phase is 55.5 (Grade 6). The specifics of the predictions of the linear mixed model on fixed effects are as follows: Grade R of the control group was = 58.80, SubjectGradeMathematics (Gr 01) was $58.804 - 1.7905 + 3.219 = 60.2326$; SubjectGradeMathematics (Gr 02) = $58.804 - 1.5391 + 3.219 = 60.484$; SubjectGradeMathematics (Gr 03) was $58.804 - 2.039 + 3.219 = 59.9841$; SubjectGradeMathematics (Gr 04) was $58.804 - 8.0252 + 3.219 = 53.9979$; SubjectGradeMathematics (Gr 05) was $58.804 - 7.4805 + 3.219 = 54.5426$; and SubjectGradeMathematics (Gr 06) was $58.804 - 6.3719 + 3.219 = 55.6512$.

Table 6-11: Summary output of the linear mixed model 4 showing the effect of fixed effects and random effects of the LearnerAverage (Mathematics marks)

Scaled residuals:				
Min	1Q	Median	3Q	Max
-4.49	-0.54	0.02	0.60	3.42
Random effects:				
Groups Name	Variance		Std. Dev.	
EmisCode (Intercept)	15.13		3.89	
DataYear (Intercept)	0.13		0.36	
Residual	136.16		11.67	
Number of obs: 37320	Groups:	EmisCode, 30		DataYear, 3
Fixed effects:				
	Estimate	Std. Error	t value	
(Intercept)	58.80	1.08	54.61	
SubjectGradeMathematics (Gr 01)	-1.79	0.23	-7.74	
SubjectGradeMathematics (Gr 02)	-1.54	0.23	-6.65	
SubjectGradeMathematics (Gr 03)	-2.04	0.23	-8.84	
SubjectGradeMathematics (Gr 04)	-8.03	0.23	-34.55	
SubjectGradeMathematics (Gr 05)	-7.48	0.24	-31.64	
SubjectGradeMathematics (Gr 06)	-6.37	0.24	-26.44	
TreatmentTRUE	3.22	1.43	2.25	

Correlations of Fixed Effects:							
	(Intr)	SGM(G01)	SGM(G02)	SGM(G03)	SGM(G04)	SGM(G05)	SGM(G06)
SbjcGM(G01)	-0.12						
SbjcGM(G02)	-0.12	0.55					
SbjcGM(G03)	-0.12	0.55	0.55				
SbjcGM(G04)	-0.12	0.55	0.55	0.55			
SbjcGM(G05)	-0.11	0.54	0.54	0.54	0.54		
SbjcGM(G06)	-0.11	0.53	0.53	0.53	0.53	0.52	
TretmntTRUE	-0.71	0.00	0.00	0.00	0.00	0.00	0.00

6.3.5.5 LINEAR MODEL TO ESTIMATE THE AVERAGE TREATMENT EFFECT FOR EACH GRADE (MODEL 5)

As a reminder to the reader, the average treatment effect, in the case of this study, is the difference between the treatment and control means for all schools of the matched pairs (Elze et al., 2017,: 347). This procedure assumes that there are no systemic differences between the two groups, and that the matching through propensity scores were successful. This yielded an unbiased estimate of the average treatment effect.

The Average Treatment Effect on the Treated (or ATT) is given by the formula:

$ATT = E(Y_1 - Y_0 | D = 1)$, where E represents average, Y_1 is the potential outcome in case of treatment and Y_0 is the expected outcome in the absence of treatment and D the treatment status. Treatment status is $D = 1$ in the case of treatment and $D = 0$ in the absence of treatment.

To this end, table 12 shows that exposure to the S4F FM programme has had a net positive impact on the learners' marks. The highest impact of the programme is observed in the foundation phase, Grades 1 to 3, at 3.80 for Grade 1, 2.68 for Grade 2 and 3.09 for Grade 3. The effect of exposure into the programme for the intermediate phase grades, on the other hand, yielded a comparatively lower effect, that is less than 2. The least impactful effect in the intermediate phase is observed in Grade 4 at 1.59, followed by Grade 5 at 1.78, while the best effect in this phase is in Grade 6 at 1.92.

Table 6-12: The average treatment (exposure to S4F FM Programme) effect

Grade	Treatment Effect	<i>P</i>
R	1.14	***
1	3.80	***
2	2.68	***
3	3.09	***
4	1.59	***
5	1.78	***
6	1.91	***
ATT	3.22	***

* $p \leq 0.05$

** $p \leq 0.01$

*** $p \leq 0.001$

6.3.6 SUMMARY

The main thrust of this chapter was to analyse and interpret the quantitative data constituted by learner's achievement marks in order to respond to the sub question: What was the effect of the S4F FM programme on the performance of learners in the Eastern Cape school district of OR Tambo Inland? In this summary, I highlight key findings in pursuit of the effect that the S4F FM programme had in the intervention schools.

For obvious reasons, the assignment of schools into the intervention programme were never random, which brought about a selection bias that, if not controlled, would threaten the internal validity of the study and make its conclusions suspect. An elaborate process of balancing baseline differences amongst the schools assigned to the intervention and those not part of the programme, was undertaken using propensity score matching, based on confounding factors identified in the literature.

Using the visual inspection of the success of matching based on each confounding factor, it was observed that these factors varied in the degree to which the schools in the programme differed to those in the control group. The variations observed through visual inspection of the density distribution plots were further interrogated through variable importance check

and correlation tests. Based on these evaluations, combined with variable importance and multicollinearity checks, decisions were made on how to use the variables,

Three variables were chosen for the selection model. These were school enrolment in Grade 3, community income groups and the proportion of households with access to electricity. They were selected to estimate propensity scores in the generalised linear model. Nine variables, namely PropEmployed, Enrlmnt_Grade3, WaterSourceRiver/other, MedIncome, Pregnancies_2017, LearnersPerEducator_2017, LearnerToilet_2017, PropElectricity and Education were fitted in the outcomes model to estimate the treatment effect. The remaining seven variables, which were Enrlmnt_Grade5, AreaType, Enrlmnt_Grade6, Enrlmnt_Grade4, Enrlmnt_Grade2, Toilet, Enrlmnt_Grade1, Enrlmnt_GradeR, LearnersPerClassroom_2017, played no further role in the subsequent outcomes models.

Using the parameters for assessing the model fit, it was determined that the selection model accurately estimated the propensity scores, which were then used for matching with schools in the control group. The quality of matching was assessed by visual inspection of density distribution plots. To give meaning to the outcomes of the matching process, the plots were contrasted with those plotted before matching, which also indicated a varying degree of success of matching for each variable.

The variables then passed stringent qualitative and statistical evaluations. The nine mentioned above were fitted in the linear model to estimate the effect of each, not on assignment into either treatment or control, but on the outcome (learners' marks). Of the variables brought into the study as confounders to determine baseline similarities and differences between the schools in the S4F FM programme and those outside it, the income category in the community where the school is located proved to have the most positive effect on learners' marks. Source of water in the community and proportion of employed household heads seem to have the greatest deleterious effects on learners' marks. Most importantly, however, is that the predicted learners average marks for schools under the treatment was 3.5 higher than those of the control group.

Inter-classroom comparison indicates a marked difference between the predicted marks in the foundation phase and intermediate phase, with the latter (intermediate) displaying the least positive scenarios. The year of assessment, on the other hand, had the least effect and

was not statistically significant. A second linear model that fitted only the treatment, year of assessment and classroom confirmed the results predicted in the first, although in reduced amounts.

Fitting the aspects of classroom and treatment in a linear mixed model, as fixed effects, also produced the consistent patterns of predictions observed in the earlier models. Ultimately, the average treatment effect, fitted in the last model, revealed a positive impact of the treatment for all the grades. The most impact was observed in Grade 1 followed by Grade 3. The least impact was observed in Grade R followed by Grade 4. The average treatment effect on the treated was 3.2193 with the 95% confidence level being (0.4156; 6.023)%. This is a measure of the difference in the mean outcome in all schools' units that received the treatment and the mean outcome in the same schools had they not received the treatment.

6.3.7 CONCLUSION

The results from the analysis and interpretation of this chapter are aligned to the derived theoretical framework of the study. The theoretical framework places the S4F FM programme as input into a network in interacting epistemological assumptions on one hand, and enablers to family-school interaction on the other, giving rise to achievement marks as one of the ultimate outcomes.

The achievement marks, as the findings from this study suggests, are affected by three factors. First is the exposure to the S4F FM programme, the treatment, which resulted in higher Mathematics marks when compared to schools outside the programme, the control. Second is the community socioeconomic background, which has also been shown to be positively associated with Mathematics achievement marks. Lastly is the Department of Basic Education's language policy in the foundation and intermediate phases. Marks for learners in the foundation phase who are taught in their home language tend to score higher marks when compared to their intermediate counterparts who are taught in English. The extent to which treatment, socioeconomic and language factors affect achievement differs.

The overarching conclusion of this chapter is that the exposure of schools into the S4F FM programme significantly increased the learners' achievement marks. The next chapter attempts to answer the last secondary research question.

CHAPTER 7: SCHOOL COMMUNITY PERCEPTIONS OF MATHEMATICS EDUCATION

7.1 INTRODUCTION

In Chapter 6, I quantitatively evaluated the effect of the FM on Mathematics academic achievement of Grade 3 learners. In this chapter, the third and the last empirical one, I bring the perceptions of the school community towards Mathematics education into perspective. To do this, I consolidate the views of the learners, teachers and family members within the derived theoretical framework for the study, which places the school at the centre for creating synergy between the school, home and community for optimal Mathematics education. I discuss validity, ethical considerations, the setting for focus group interviews data analysis and interpretation.

7.2 INTERVIEWS

While I conducted the focus group interviews in IsiXhosa, I transcribed the generated data in English using MS Word. Transcription is the first of the six steps in the analysis of qualitative data (Creswell, 2009: 127). Following the transcription, I proceeded with the coding of transcripts.

I coded the data using the method I explained in Chapter 4. An addition worth mentioning here is that I loaded the data into a computer programme, MAXqda, which Creswell (2009: .188) describes as 'excellent' in analysing qualitative data. Even with the computer programme, I still had to purposefully select segments from the transcripts and assign labels to them as codes. I found the MAXqda software helpful in the subsequent stages of grouping, reorganising and sorting the codes, and thus generating themes.

7.3 THEMES

The next step in my data analysis was to cluster related codes together and labelling them with a descriptive term. Cohen et al. (2007: 186) refer to this process as the creation of a 'domain of analysis', in which a domain is a category that encompasses other categories. Three main themes emerged from this study.

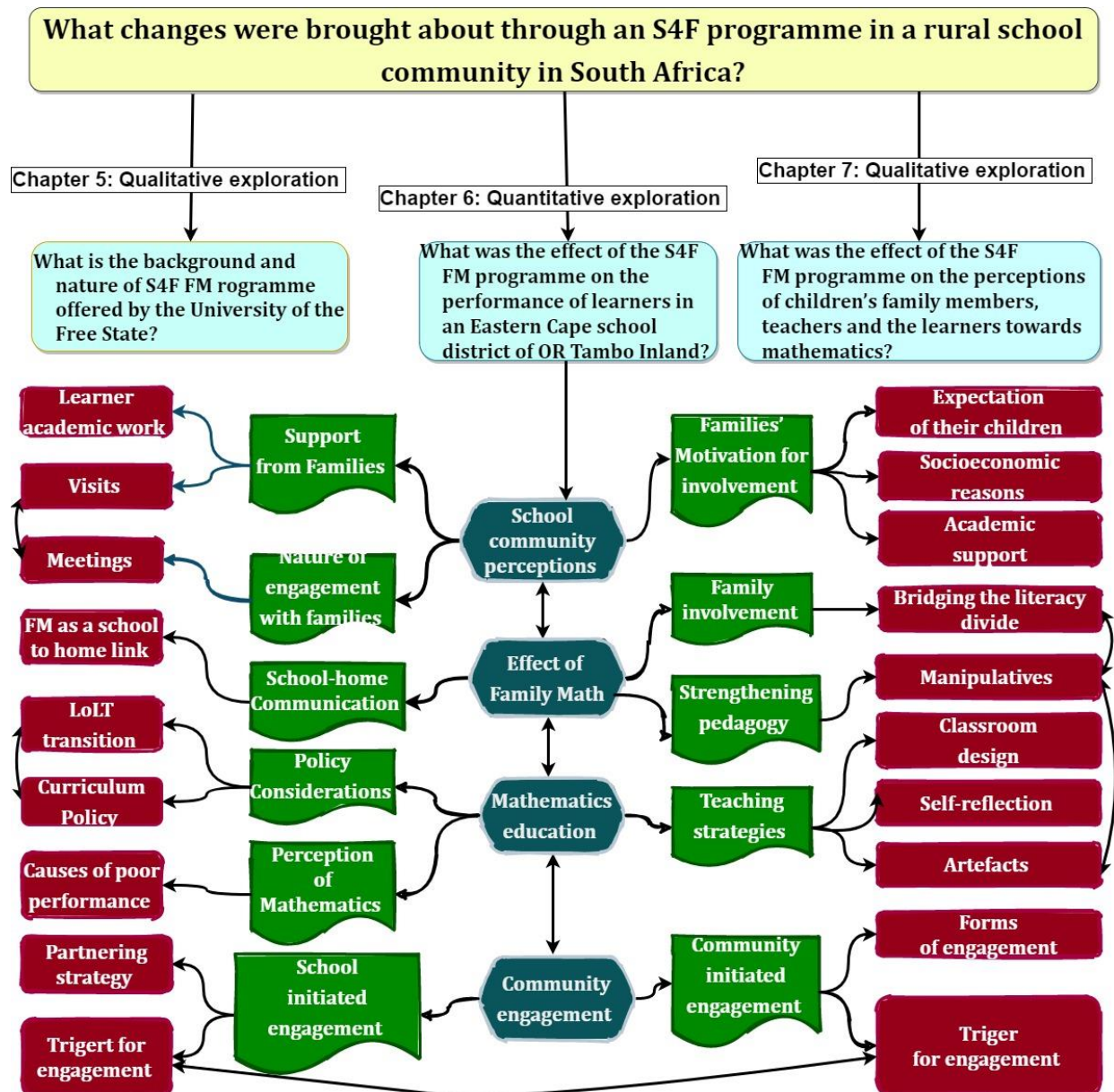


Figure 7-1: The themes, subthemes and categories that emerged from the analysis of school community interviews

Creswell (2009: 188) describes this step as coding, to generate five to seven themes for a study. It is, however, Saldaña's definition (2009: 189) of a theme that makes the process practical. Saldaña (2009: 189) defines a theme as a phrase or sentence that identifies what a unit of data is about and/or what it means. Consequently, four themes emerged from the coding process outlined above, based on the analysis of focus group interviews with the teachers. I further divided each theme into categories according to the information that arose from the interviews. The themes and categories are:

- Teacher perceptions
- Effect of Family Math
- Mathematics education
- Community engagement

7.3.1 THEME 1: SCHOOL COMMUNITY PERCEPTIONS

In this theme I interpret and contextualise the narratives from the participants in relation to how the school community perceives families' support, their motivation and the nature of engagement with school activities at home.

7.3.1.1 SUB-THEME: SUPPORT FROM FAMILIES

Intergroup perception includes perceptions family members as one group, learners as another and teachers constituting the last group and the perceptions each group has about the other. In this regard, teachers' experiences of the support from families is varied, from extremely negative on one end and positive on the other. In some communities, families do not honour invitations by the school and teachers perceive them as having an aversion for the school. One participant expresses this view: '*kwisikolo endikuso ekuhlaleni, abazali abasithandi ncam isikolo*', which means '*In my school in that community, parents do not necessarily like the school*' (# TEACHER 2). This lack of cooperation has a debilitating effect on the teachers and leads to cessation of further attempts to invite families as one participant expresses it: '*Utitshala ugqibela engasaba fowuneli , ngoba ukuba kungomgqibelo, uphetha sowuhlala nabantwana kuphela*', which means '*You as a teacher you end up not calling them any longer because, if it's a Saturday you end up sitting there with only the children*' (# TEACHER 9). Other schools resort to very unconventional methods of coercing families to attend school meetings, which border on unlawfulness. One interviewee shared: '*siye sanenye indlela yokwenza ukuba abazali bathathe inxaxheba kwimihlangano, isikolo sigqibe ukuba sihlawulise umzali ngamnye ongakhange aphumelele kwintlanganiso*' [*We have heard as another way of improving parent attendance to meetings that the high school charges a penalty if the parent misses a meeting*] (#TEACHER 11).

In the communities where there is cooperation between the school and home, there are two discrete forms of support that emerged from the discussion with the teachers. First, school

involvement, which, in the context of the participants involves cooperation with the school in the form of responding to general and specific invitations from the school and teachers, respectively. One teacher shared: ‘abanye abazali abamenywayo malunga nenkqubela phambili yabantwana babo, baye basamkele isimemo, ukuba abazokwazi uphumelela, baye kananjalo bafowune baxolise ,babeke olunye usuku’, meaning [‘Individual parents that are invited for a specific purpose regarding the progress of their children do honour those invitations, if not able to, they call to apologise and reschedule’] (# TEACHER 10). Second, home involvement, which involves family member’s engagement with the activities that are school related at home. This comment illustrates this view:

Njengo titshala unako ukubona emsebenzini womntwana ukuba ezi zixhobo zokufunda ziyasetyenziswa ekhaya, kananjalo kune ncwadi esivunyelweyo (FM) ukuba sizinike abantwana ukuze benze kuzo umsebenzi wasekhaya, ziziphumo zalomsebenzi wase khaya ezizobonakalisa ukusetyenziswa kwezizixhobo zokufunda ekhaya’ [As a teacher you are able to see on the child’s competence that the material is being used at home. Also, there are workbooks FM has given us to allow us to give learners to do homework, it is the results of that homework that will indicate the use of the material at home.] (# TEACHER 1).

In their accounts of the events surrounding support from families, teachers during the interviews, expressed a complex combination of factors that affect such support like age (Abona baselula kunye nabazali benene babantwana abafuni kwa ukuza [The young and real parents do not want to come] (# TEACHER 1)), community background (Abazali abafani mhlawumbi ke kuxhomekeka ukuba baphuma kwesiphi isixeko. Abazali kwesam isikolo bathatha inxaxheba [Parents are not the same may be depending on the community where they come from. Parents in my school are supportive] (# TEACHER 8)), temporal variations (Impendulo yabazali kwizimemo iyohluka unyaka nonyaka. Komnye unyaka liyagcwala iholo, namanye amalungu osapho aye abekhona [Parents response to invitations differs from year to year. In one year you would fill up the hall, even other family members, other than the primary caregiver attend] (# TEACHER 9)) and literacy levels (Kukho abo bangazange bafunda, kodwa bayabaxhasa abantwana babo [There are those who are completely illiterate, but still remain supportive to the child] (# TEACHER 8)).

All the learners interviewed revealed that the support they receive from the family members is in IsiXhosa. The majority of these learners, except for 4, also stated that family

members other than biological parents assist them in their academic work. While the testimony from family members, on the other hand, indicated that they do support their children academically, there were also both concerns and appreciation. One family member's concern centred around the current approach to teaching Mathematics as opposed to what she knows, which she felt that was hampering her attempts to help the child. The participant bemoaned: 'Indlela iMaths efundiswa ngayo yohlukile kwindlela esafundiswa. Akusathethwa ngoBODMAS ngoku. Xa uqala uzama unceda umntwana njengomzali wakhe ,niye nichithe ixesha elininzi niphikisana ngokuba umntwana akayazi lendlela yomzali yokubala', ['The way Maths is taught these days is different to the way we were taught. There is no longer a talk of BODMAS now. When you try and help the child now as a parent you end up spending a lot of time arguing with the child because he/she does not agree with the parents' approach'] (#LFM2). Yet, another family member expressed view that the teachers' approach also helps them to support their children academically: 'Sinceda abantwana ngemisebenzi yabo yasekhaya nook kungelulanga ngamanye amaxesha, kodwa ulwazi abalufumana kotitshala babo luluncedo kuthi'[We assist the learners with their homework even though it is not easy at times, but the information they receive from their teacher has proved to be helpful to us] (#KFM7).

Family members expressed limited views that reflected their perceptions towards educators. The only family member who did venture into this arena was positive and had a view that encouragement as being very important in motivating children towards Mathematics education. The view is that teachers, through symbolic feedback to learners, do provide motivating encouragement to their children (Ndiyavumelana nendlela umntwana wam ahlolwa ngayo njengoko ndiyiqapheleyo into yokuba abanye otitshala benza indlela yokukhuthaza abafundi ngokuthi babeke inkwenkwezi emsebenzini womfundi noko nje bengeka makishwa kuba abafuni balahle ithemba [Yes I agree with how my child is evaluated as I have noticed that most educators offer a form of encouragement to the learners by placing stars next to their assessments even though they are not marked or correct, because they do not want to discourage them] (#LFM1)). Similarly, learners believe that they are doing well in Mathematics because, in part, of the assistance they get from their teacher ('Siqhuba kakuhle kwizibalo (chorus). uTitshala usincede nge 2-D shapes, Squares, Triangles, Cones and Rectangles' ['We are doing well in Maths (chorus). The teacher helps us with 2-D shapes, Squares, Triangles, Cones and Rectangles]. (#KG3))

7.3.1.2 SUB-THEME: FAMILIES' MOTIVATION FOR INVOLVEMENT

It is evident from the participant's views that families' expectations of the children serve as a key motivational factor in influencing them to get involved in their children's education:

Abanye abazali baphawula benjenje, ukubonakalisa kwabo ukuchulumancela in FM, 'sithetha phezu kweentloko zabo ngamacandelo afana nobu gqirha.' [Some comments from parents that show their appreciation for FM goes like this: 'We talk about careers like Medical doctor on top of their heads because we want them to take this Maths seriously](# TEACHER 11).

It is also clear from teachers' perspective that poor literacy levels do not hinder family members from harbouring these high expectations and providing academic support to the children and under their care:

'Kukho bazali abangakwaziyo ukufunda nokubhala konke konke kodwa bayamxhasa umntwana kwezemfundo, nto leyo endenza ukuba ndikholelwe ukuba abazali bannenjongo ezinkulu ngabantwana.' [There are those who are completely illiterate, but still remain supportive to the child, which makes me believe that parents have high expectations of their children's education] (# TEACHER 8).

While it was not clear what level of academic performance triggers academic support, it emerged from the interviews that the desire to be involved in the academic work of the child, at home, also serves as motivation for involvement:

Ukungqina ngenkxaso yeentsapho, mandibalise nje eli balana. Ngamanye amaxesha umzali akonqeni ukukufonela athi 'ndicela undikhumbuze malunga nalaa nto ubuthe ze siyenze kwezi ncwadi zomsebenzi, kuba ndixakiwe [Just to confirm the support from parents, let me relate scenario in my school. At times the parent does not hesitate to call you and say 'regarding what you said we must do in this workbook, please remind me because I am stuck] (# TEACHER 11).

Issues of unemployment and poverty also emerged as major barriers to family involvement in the education activities of their children. Talking about the issue of unemployment one interviewee said: 'baza kuphela ngobuninzi xa beve ukuba kukho isithuba somsebenzi, kube kuxa siba bonayo', which means [They only come in big numbers if there is a possible employment opportunity as a meal server or security personnel, that is when you see

them'] (# TEACHER 2). Another participant, talking about the issue of poverty shared: 'Ndingatsho nokuthi siye kananjalo sibathumelele izimemo sibalungiselele nokutya xa intlanganiso ihleliwe, sisazi ukuba ngekhe bachithe xesha labo esikolweni belambile. Ngalo ndlela impumelelo iye ikhuthazeke', meaning ['I would say that we also invite them through letters and provide meals for them if the meeting was a scheduled one, knowing they will not spend their precious time at a school while hungry. That encourages attendance'] (# TEACHER 5).

In corroboration of the teachers' testimony on the family member's expectations of their children, learners' testimony suggests that only not family members aspire for high paying professions for their children but are also technically aware of the centrality of mastery of the subject towards the attainment of that goal. One learner states: 'Umakhulu wam wandixelela ukuba ndifuna ukuba ngumongikazi/ugqirha,mandizazi izibalo' [My grandmother told me that if I want to be a doctor, then I need to know Maths.] (#KB1)

Family members' expectation of their children showed a deep sense of concern for the future of their children given the current socioeconomic conditions of the country. One parent stated: 'Akukho mathuba emisebenzi kwezi ntsuku,kuba nzima kakhulu ukuba umntwana akafundanga, kungoko sifuna ezintsana zifumane imfundo eluqilima ukuze sibenze bafumane imisebenzi' [there are no work opportunities these days, it is worse if one child is not educated and therefore we want these kids to get quality education that will enable them to find employment].(#CFM3)

7.3.1.3 SUB-THEME: NATURE OF ENGAGEMENT WITH FAMILIES

Beyond opportunities, barriers and motivation for family involvement, participants expressed negative experiences of the nature of engagement with the families, especially in meetings, which were downright acrimonious. Acrimony manifests itself in the form of families expressing, in meetings, comparative comments about teachers and displeasure about the treatment they receive from some of them (teachers), as this teacher puts it:

Umzekelo, Omnye wakubazali waphakama wabuza ukuba kutheni incwadi zabafundi zimakishwe ngokwahlukeneyo nje ngotitshala abohlukileyo kwibanga lesi thathu. Ngalondlela umzali lo uqhathanisa abafundisi ntsapho, okanye omnye mzali uye athi kula nyaka mntwana wam wayesenza banga le 3 zange ndayibona le' [One parent for example stood up and asked why learners' books were marked

differently by different teachers in grade 3. In this way the parent pitting one teacher against the other.' Or the other parent says 'in that year when my child was doing grade 3 I did not experience this'] (# TEACHER 11).

There were no corroborative sentiments from family members and learners' interviews, on the acrimonious nature of the meetings between family members and schools. Family members, though, did express some salient views that indicated disagreement with the way teachers communicate with them (family member) through the learners. One family member states: 'Ndiyakholwa iyokuncedisa into yoba otitshala benze umkhombandlela wezicwangciso kulonto bayifuna entwaneni, ukuze ezozicwangciso zinedisane nathi bazali ukuze sazi okudingeka kwenziwe ngumntwana' [I believe it would be helpful for the teachers to provide guidance in a form of notes on what they require from the child, to better assist us parents in understanding what needs to be done by our children] (#KFM7).

In sum, the emerging evidence from the participants' narratives on their perception of each community group's perception of the other suggests that personal circumstances influence these perceptions. This is particularly true for the family members whose support to school is influenced by employment, age, time of the year and level of education.

7.3.2 THEME 2: EFFECT OF FAMILY MATH

In this theme I unravel the effect of S4F FM programme on the family involvement in the children's education, school-home communication and strengthening the teacher's pedagogy.

7.3.2.1 SUB-THEME: FAMILY INVOLVEMENT

Teacher's perception of the effect of FM in fostering family involvement in Mathematics education of their children was abundantly positive. FM is credited with some positive constructs that contribute towards opening up of school to home cooperation channels. One teacher, for example, credits the programme for bridging the literacy divide amongst different families:

Ukuthatha inxaxheba kwabazali lolunye utshintsho oluze ne FM. Ubungqina boku bubonakala kwiimpendulo zabantwana ezibanee mpawu zeengxoxo utishala ebekhe wanayo nabazali [Involvement of parents is also another change FM brought. This is evident when you have given a child a homework, one can see that

learner responses reflect what had been discussed earlier during the parents training session. There are no longer parents who come and say I am illiterate] (# TEACHER 9).

7.3.2.2 SUB-THEME: SCHOOL-HOME COMMUNICATION

In their accounts of the modalities of how FM helped to increase the overlap between two of the learner's learning environments, home and school, teachers provided details of how ordinary household material provide learning opportunities for Mathematics:

Ukwenza unxumelwano phakathi kwesikolo nekhaya, ndiye ndiqokelele amabkokisi wobisi neziselo asebenzileyo, endaziyo ukuba ziyafumaneka phaya ekkhaya. Ziyancedisa ke ezi zinto ekufundiseni ukuqikelela ubuninzi, ubunzima nobubanzi bezinto [In so far as measurements are concerned, I collect the waste material like spent containers of long life milk and cool drink bottles and use them to create a link between school and home. I do so because these materials are also found at home and their quantities are clearly marked, which helps in involving the parent in teaching measurements'. (# TEACHER 7).

While the learners interview did not reveal any channels of school to home communication, family members did share their observations, on this aspect of S4F FM Programme. Family members believe that the school should develop differentiated age appropriate communication methods on the learner's academic work between school and home. The design of these communication methods should be such that they allow the family member who engages in the child's academic to align his/her approach to that of the teacher.

Okokuqala, into endiyiphawulileyo yeyokuba, bantwana ngakumbi abakwi banga loku-1 abakwazi kuchaza injongo zokwenziwa komsebenzi wase khaya kubazali, kuyenzeka ukuba abaqondanga kwasekuqaleni okanye balibele oko bebe kuxelelwe. Kule imeko ke ndingacebisa ngelithi, otitshala kumele babafundise abantwana emva koko babanike umsebenzi abawuqondayo ngenjongo zokuzilolonga. Okanye umsebenzi wase khaya mawuhambe nenkcazela ecacileyo okanye impendulo ezilungileyo ezichaza ekumele kwenziwe, kweliphi candela yaye yenziwe njani'. [What I have noticed is that children, especially in grade 1 are not able to relate the intentions of the homework to the parent, either they did not understand in the first place or have forgotten what they had been told. In this regard I would recommend that teachers need to teach the children then give homework on something they understand for the purposes of practice. Or at least

the homework be accompanied by an explanatory note or memo that explains what needs to be done, in what page and how.’ (#LFM1)

The view on the need for clear communication of the teachers’ expectation from the learner’s homework seems not to be limited to the lower grades of the foundation phase. A family member of a grade 4 learner laments: ‘*Ndiyakholwa iyokuncedisa into yoba otitshala benze umkhombandlela wezicwangciso kulonto bayifuna entwaneni, ukuze ezozicwangciso zinciphise nathi bazali ukuze sazi okudingeka kwenziwe ngumntwana*’, which means ‘*I believe it would be helpful for the teachers to provide guidance in a form of notes on what they require from the child, to better assist us parents in understanding what needs to be done by our children.*’ (#KFM11)

In support of the belief that diversified communication channels should be opened between the school and home, another family member invokes the temporal disconnect in teaching approaches. That is, teaching methods of Mathematics are continually changing, thus creating a potential disjointedness between school and home related to each group (teachers and family members) predisposition with different teaching methods. The family members, through their testimonies during the interview also exposed the researcher to the deleterious effects of the disjuncture between school through the teachers and home through the family members. The first of these undesirable effects include time lost in an attempt to synergise the two spheres of influence. The second effect of the disjointed school-home communication is the family member-child relationship during engagement in academic activity at home, which becomes adversarial in cases of disjointedness between the centres of influence. For instance, #LFM2 shared the following:

Indlela iMaths efundiswa ngayo yohlukile kwindlela esafundiswa. Akusathethwa ngoBODMAS ngoku. Xa uqala uzama unceda umntwana njengomzali wakhe, niye nichithe ixesha elininzi niphikisana ngokuba umntwana akayazi lindlela yomzali yokubala. [The way Maths is taught these days is different to the way we were taught. There is no longer a talk of BODMAS now. When you try and help the child now as a parent you end up spending a lot of time arguing with the child because he/she does not agree with the parent’s approach] (#LFM2).

7.3.2.3 SUBTHEME: STRENGTHENING PEDAGOGY

For some teachers, the manipulatives that the FM programme provides enriched their strategies of teaching Mathematics to the foundation phase the learners. One teacher, for

example, in expressing the personal growth she experienced as a result of practising FM shared: *izixhobo zeFM zilulutho njengoko sekutshiwo*, which means [**FM Resources are helpful as my colleagues have said**] (# TEACHER 5). Another teacher shared how her improved pedagogy translated into the Mathematics academic achievement of the learners: *'kuye kwakho kanaanjalo utshintsho olukhulu sukela kwafika UFM ngowama 2012 kwisikolo sam, kubantwana nakum. Zange ndathola inqanaba lesi-4 kwizibalo.'* [**There has been a lot of change since the introduction of FM in 2012 in my school, both on children and in me. I never get a level 4 in Mathematics**] (# TEACHER 11). As evidence of improved learning outcomes in Mathematics, through the FM programme, participants share their experiences in district competitions, for instance:

'ngokwezobalo kwi sekethe yethu, umfundi webanga lesi-3 osuka kwisikolo apho kusetyenziswa u FM uye waqubisana nomfundi wesikolo apo u FM angasetyenziswayo, olo qubiswano luyibeke yacaca into yoba ngubani oyena yena' [**With regards to Maths quiz, in our circuit, a grade 3 learner from a school with FM outcompetes a grade learner from a school that is not practicing FM. It just becomes clear as to who is who in that competition**] (# TEACHER 11).

Family members, while not mentioning the S4F FM Programme resources by name but do point out the assistive nature of manipulatives including easily obtainable stones during their academic engagement with their children. Collectively, these materials serve as the school-home link and strengthen pedagogy:

Okokuqala,into encedayo kukuba nencwadi yokuzivavanya apho ubhala phantsi amanqanaba akho ngokulandelelana kwawo ukukhupha impendulo. Ukuba umntwana ufuna uchola into ezinje ngamatye ukuze akwazi ubala,okanye asebenzise iminwe nenzwane kunye nezo zomzali makenze njalo ke [**What helps the most is to have a practice book on which to write down you're your step by step method towards the answer. If the child needs to go and pick things like stones outside to help with counting, or use fingers and toes including those of the parent, let it be so**] (#KFM1).

Figure 7-2 shows an assortment of S4F FM Programme resources that are used in the teaching of Mathematics in the Foundation Phase. The photos were taken in Kuyasa PS on the day of the interview with learners and family members, which was scheduled to coincide with the Family Math day at the school. These resources include easily obtainable

everyday materials like bottle caps (C) and stones (B and D) that teachers and family members refer to in their testimonies.

Figure 7-2: S4F FM Programme materials used in the teaching of Mathematics in the Foundation Phase.

In conclusion, it is evident that the school community, teachers and family members in particular perceive the S4F FM programme as having a positive contributory effect on closing the gap between the school home and community. When these spheres of influence in the cognitive development of a learner, school, home and community are closer together, the child's learning opportunities are improved. The next theme



untangles the other factors the school community perceives to influence mathematics education.

7.3.3 THEME 3: MATHEMATICS EDUCATION

The factors that the school community perceives as having an effect on Mathematics education include perceptions towards the subject, education policy and teaching strategies.

7.3.3.1 SUB-THEME: PERCEPTIONS TOWARDS MATHEMATICS

While learners and family members did not express a view on how Mathematics is performed, teachers did ponder upon the reasons for poor performance. In response to a question regarding their views about Mathematics education in the country, participants expressed a view that suggested poor learner performance in the subject, especially in grades beyond foundation phase. Teachers' beliefs are that teaching and learning of Mathematics in the foundation phase are proper and the downward spiral might begin early in the intermediate phase as one expressed: 'xa befika kwibanga le-12 abasakwazi asazi ke apho ilahleka khona lamfundiso mhlambe ilahleka kwibanga le'0, ['By the time they get to grade 12 they are not coping and we don't know where it got lost maybe in grade 4'] (# TEACHER 9). Another one confirmed their uncertainty to the cause of the general poor performance in the subject: andiqinisekanga ukuba undonakele ubaphi ngokuya abantwana baye besiya phambili', ['I am not sure what the problem is as they learners progress'] (# TEACHER 6).

7.3.3.2 SUB-THEME: POLICY CONSIDERATIONS

The transition from IsiXhosa to English as the language of teaching and learning from foundation to intermediate phase, respectively, emerged as a policy imperative that posed a challenge to the learner's comprehension of mathematical concepts. One teacher said, of the language policy: 'njengoko ugxa wam ekhe wathetha ngombandela wolwimi, kubanzima kakhulu kodwa umxholo awutshintshi wona', ['Just like my colleagues have said about language, it disadvantages them but the content does not change'] (# TEACHER 5). The challenge seems to lie in the confusion brought about the words used to describe a concept in one language in grade 3 and completely new words in another language in grade 4.

'Yayikho ingxaki xa sasiqala ukufundisa ngesixhosa apho wawufumana utishala wakwa grade 4 ekhalaza ukuba abantwana abazazi ezinto abafanele ukuba bayazazi ukusuka kwa grade 3.' ['There was a problem when we started teaching in IsiXhosa wherein in the grade 4 teacher was complaining about learners lacking on the differentiation between the hundreds, tens and units, they should have learnt in grade 3'] (# TEACHER 9)

It appears from the teacher's accounts that there exists evidence suggesting that the confusion brought about by the change in language adversely affects the academic learning outcomes and those effects become apparent as early as in grade 4.

'Xa ndilandela abantwana abebeqhuba kakuhle baze bapasela ibanga 4 ndaye ndafumanisa ukuba abaqhubi kakuhle kwi term yokuqala, ze iphuchuke indlela abaqhuba ngayo ngokuhamba kwexesha' ['When I follow up on the progress of the bright sparks in grade 4 I find that the performance has declined in term 1 and it improves over time. The reason for this is that we teach them in Isixhosa and they are taught in English in grade 4'] (# TEACHER 11).

However, learners' testimonies from all those interviewed revealed that the assistance they received at home was in the home language, Isixhosa. Learners did not proffer a view on their preference of the language of Mathematics either at school or home.

Teachers expressed divergent views regarding an intervention programme called NECT, with some bemoaning its apparent inconsistency with the curriculum policy, CAPS. One teacher stated: 'ngokwenqanaba esifundisa ngalo kwibanga le-3, kukho isiphazamisi esingu NECT esiye sangenelela naso. Inani elifunekayo ngu 0-200, ngokuka CAPS, ngoku NECT 0-500 kwibakala loku-1' ['According the level we teach in grade 3, there is a confusing NECT that just came in. The number range is 0 – 200, according to CAPS, and now with NECT is 0-500 in term 1'] (# TEACHER 8). Even when NECT is contrasted against FM as another intervention programme, with regards to their compliance with the CAPS teachers demonstrate less confidence in NECT. Another teacher added: 'u FM uyavumelana no CAPS okanye uyangqamana. Ingxaki yami ilapho ke. Ndiyamvuyela yena u FM. u NECT yena akayihoyi into yoba kukho indlela ezohlukileyo zokufunda kubafundi' ['FM is agreeable with CAPS. That is where my challenge is. I'm happy with FM. NECT ignores the fact that there are learning differences among learners'] (# TEACHER 8). Despite these recurrent and disparaging views about NECT, there was evidence to suggest that some teachers understood the difference between NECT and CAPS, and what each attempts to achieve, as one teacher explained: 'UCAPS uqhathaniswa no NECT, U CAPS yena ubeka indlela ekumele kufundwe kufundiswe ngayo, ngelixa yena u NECT enika umkhombandlela ukuba mayifundiswe njani. U NECT lona ke usisixhobo esincedisana ekutheni usetyenziswa njani u CAPS' ['CAPS vs NECT, CAPS outlines what needs to be taught, while NECT guides on how it must be taught. NECT is a toolkit that deals with the how part of CAPS and helps use one as teacher'] (# TEACHER 5). However, the curriculum policy as outlined in the CAPS documents does not express itself on the classroom design where the curriculum delivery should care.

Classroom design in the foundation phase classes appears to be unsuitable for the teaching strategies teachers use in those grades. The introduction of FM, the associated teaching manipulatives and their safe keeping, when not in use, further compound the challenge of inappropriate design:

'Enenni amagumbi wokufundisela amabanga wokuqala awakulungelanga ukufundisa nokufunda kulamabanga. Kuyanyenzeleka ukuba izixhobo zokufundisa ndizigcine ezikhabhathini, ziphume xa zisosetyenziswa, endaweni yokuba zifikeleleke ngamaxesha onke nanjengoko kusenzeka e UFS' [in deed our classrooms are not designed for the kind of activities in the foundation phase. I keep the manipulatives in the cupboards and only take them out as and when I need to use them, unlike in the UFS where they are on display and easily accessible and the learner can simply pick the one she/he is interested in'] (# TEACHER 9).

Teachers have to improvise to create a physical learning environment that is suitable for their teaching and learning requirements as one teacher states: 'kukho [classrooms] indlela esulungekileyo yokuhlala kunye nohlobo olwenziweyo lwetafile kodwa senza unako nako ukulungisa iziko lezemfundo ukuze lilungele lindlela yokufunda siyifunayo' [They [classrooms] are formal seat and desk arrangement but we do our best to modify the classroom to suit the kind of learning environment we want'] (# TEACHER 7).

7.3.3.3 SUB-THEME: TEACHING STRATEGY

The value of physical artefacts in Mathematics education in the foundation phase was abundantly clear from the accounts of the participants. The artefacts form the basis of learning from practical manipulation and experiencing to the abstract learning.

'Izixhobo zokufundisa ezibambekayo zibaluleke kakhulu kuba umntwan ufunda into ayibonayo phambi kokuba aye kwiqikelelo. 'Umzekelo kukufundiswa kwe shapes' [I find the use of physical artefacts the most important thing as it allows learners to learn through seeing, and not rely on theory. One example is the teaching of shapes, wherein you do not depend on the drawings but allow them to experience the physical shapes in their hands'] (# TEACHER 7).

The evidence gathered from the interviews further suggests that the artefacts provide an opportunity to learn Mathematics through playing, which teachers perceive as challenging the stereotypes and traditional beliefs associated with playing dices:

‘Umzekelo, abantwana mabavunyelwe badlale amadayisi ngaphathi kwigumbi lokufundisa, ntoleyo echaseneyo nendlela esafundiswa ukuba sikholelwe kuyo. I dayisi laziwa njengento yabantu abangalunganga, kanti abantwana bayazifunda izibalo ngeli lixa bedlala’. [*For example, learners should be allowed to play dices [part of FM material] in class, which is a great departure from the way we were socialised to believe as we grew up. A dice was known to be a game for hooligans. But we have come to learn that as learners play with the dice they are playing with numbers and doing number operations like addition*] (# TEACHER 11).

In conclusion, teacher participants exonerate themselves from the poor learner performance in Mathematics and identify language policy and discrepancies between policy imperatives and strategies to mitigate performance. The view, as expressed by teacher participants, that learners are scholastically well prepared in the foundation is not supported by literature, which suggests that for most situations, learners begin to accumulate learning deficits from grade 1 onwards. The last theme untangles the initiation of community engagement on the children’s education requirements.

7.3.4 THEME 4: COMMUNITY ENGAGEMENT

7.3.4.1 SUB-THEME: COMMUNITY INITIATED ENGAGEMENT

School engagement with the community beyond the immediate home of the learners is largely initiated from school. The circumstances that elicit the engagement whether initiated by school or community are varied and seem to be associated with socioeconomic background of the area. One teacher, from a rural school said: *‘kwesam isikolo, asiye siphume siyo funa uncedo nokuba kusekuhlaleni, isuke ibe ngamalungu okuhlala asuke eze esikolweni ukuzo xela ngendlela umntwana aziphatha ngayo, bazibophe ngelithi ‘nantoni na edinga mzali qhakamshelani mna’* [*In the case of my school, we do not necessarily go out to ask for help from community, instead it is the community members who would at times come to school to report that certain children live by themselves without an adult person and therefore, for anything that needs a parent ‘please contact me’*] (# TEACHER 9). Adding the perspective of a relatively more affluent area near town another teacher reflects on a completely different form and trigger for community involvement: *‘isikolo sethu sime kwindawo apho kuxhaphake ubundlobongela ubungephi. abantu bokuhlala baze esikolweni bezocela ukuba banikwe nabo inxaxheba ekulweni izinto ezinje ngokuxhatshazwa kwezinyobisi, ukukhulelwa kwentsana nezinye’* [*Our school is in an area where petty crime*

is rife. Some community members have just approached the school to be given the opportunity to fight such things as drug abuse, teenage pregnancy etc.'] (# TEACHER 11).

7.3.4.2 SUB-THEME: SCHOOL INITIATED ENGAGEMENT

The absence of the immediate family members from the education life of the child triggers both the school and community initiated engagements. The concern that militates for engagement is at times more than just the presence or absence but the value that is being added to the child's education. One teacher participant said this, of the circumstances that trigger engagement of community members: 'kumbandela apho umzali womntwana naye eselula yaye nemfundo engekho kangako, kwimeko ezinjalo ndiye ndicele ummelwane othe kratya noko ngokufunda ndisondeze umntwana walakhaya apho mfundo ingekhoyo noko ukuze azoncedwa nokuba ummelwane lowo akanamntwana kwisikolo sam' ['in cases where the biological parent, who is usually younger and literate is not at home. In such cases I ask a literate neighbour and attach the learner who lives with illiterate parents to be assisted, even if the neighbour does not have a child at the school'] (# TEACHER 9). The school, at times, finds itself at the centre of the facilitation of cooperation between family and community members, especially in cases where such cooperation will benefit the academic welfare of the learner. One teachers shared: 'endiyenzayo ndiye ndicele ukuba umzali lo oselula womntwana ibe nguye ochonga umakhelwana okwiminyaka anayo ukuze amncede, indima yalo mzali mncinci ongenamfundo kukujonga indlela ekuqhutywana ngayo nommelwana lowo amkhethileyo' ['What I do is to ask the illiterate parent to come and identify a younger literate neighbour to assist, and the role of the illiterate parent is to facilitate that the contact between the learner and neighbour and siblings happens] (# TEACHER 6).

Family members' testimonies, on the other hand, revealed that there are different discourses on the engagement with their children's academic work. The discourses are about the fundamental question of whether children do need parental assistance: 'abantwana abakudingi ukuncediswa yaye ndiqaphele nto njengomzali luxanduva lwethu ukubanqwanqwada siqinisekise ukuba bayawenza msebenzi wabo' ['The children do need assistance and I have noted that as a parent it is our responsibility to guide them and ensure they are focusing on their studies'] (#CFM7). In concurrence, other family members believe that paying attention to the child's self-belief and interpersonal relationships, rather than direct involvement in the academic work, is the primary role of the caregiver:

'Umzali kumele afundise umntwana intlonipho nokuthi bakhiwa njani ubuhlobo. Uyenza ke lento nje ngezinto ezincinci, umfundise ukuba abulise xa ebona umntu wamqibela kudala, njengoba ebuyela esikolweni. Okwesi-3 mgcine umntwana wakho ecocekile ngalo lonke ixesha, ukuncedisana naye angazijongeli phantsi yaye umfundise nangococeko.' [The parent also needs to teach the child on how to respect and build relationships. You do this by teaching the child as simple things as to greet whenever he finds people that he/she had not seen in a long time, like when coming back from school. No 3. Keep the child clean, when going to school in order to boost his/her self-esteem and also teach the child about cleanliness'](#LFMN4).

The mode of engagement involves assessing the child's competency in handling the academic tasks at hand, akin to scaffolding espoused in Vygotsky's Sociocultural Theory: 'ndiyamncedisa owam umntwana ngokumlandelela ndijonge msebenzi wakhe awenzayo, ndiphawule ukuba bafuman aubunzima kulento ifunwayo' ['I assist my child by assessing their homework and noting that they are having difficulty comprehending the information requested'] (#KFM9) and trying to align the assistance provided with the interests of the child: 'ujonga ukuba yeyiphi imfundo/isabject ayithandayo umntwana wena ke njengomzali ujonge ukuba uqhuba njani kulo mfundo ayithandayo' ['You check what subject the child likes and you as a parent then check how is the child doing in the subject he/she likes'] (#KFM3). The trigger for the engagement can include, as family members stated during interviews, the child's attitude towards school: 'ngamanye abanye xesha uye uphawule ukuba abasafuni ncam ukuya esikolweni, hayi ngoba bexhatshazwa qha kuba bedontsa nzima kwizifundo zabo' ['At times you note that they sometimes do not want to go to school, not because they are being abused but because they are having difficulty with their studies'] (#LFM5). Family members also mentioned that checking on the child's expectation for the future as another modality of focusing the child's attention into the immediate homework task:

'indima emayidlalwe ngumzali emntwaneni kukwenza isiqinisekiso soba umntwana uyaliqaphela ingomso. Ndiqala ngojonga ukuba umntwana ufuna ukuba yintoni ebomini ndiye ndimkhuthaze ndimlandelele ndimxelele ngokuzimisela kwakhe emsebenzini wakhe. Ndimxelele mntwana anagaphazamiswa zizinto ezenzeka ngaphandle ezimbi nemfundiso ezimbi zotshomi angazihoyi', [The role of the parents is ensuring that the child focuses on the future. I start by finding out what the child would like to be in future and

follow up encouragement and keeping the child in focus telling him/her that she needs to master the work. Tell the child not be distracted by what is happening outside like bad influences from friends and peer pressure'](#KFM1).

Family members also raised some latent considerations which determine engagement with the child's academic work. These include time: 'kubakho amaxesha apho ubona ukuba umntwana wakho uyasokola ekwenzeni umsebenzi wesikolo ekhaya kuxa kengoku uzinika ithuba lokucela ukuba ukhe umncede', which means 'There are times where you see your child struggling to understand their homework and therefore you give your self-time to offer assistance'(#KFM8).

In conclusion, the evidence suggests that the school, as the theoretical framework for the study suggests, is at the centre of coordination of school and community engagement activities. Evidence also suggests that some family members assist the children with school work in a manner consistent with the scaffolding concept of Vygotsky's sociocultural theory. The discussion below consolidates the findings from the interaction with school community members in relation to literature and theoretical framework.

7.4 DISCUSSION

Teachers operate from the school, which lies at the centre of facilitation of school-home and school-community communication channels. In this study, they provided varied evidence of support from family members. Teachers glean evidence of engagement in academic work through learners' books, and the honouring of invitations to visit the school. Teachers' perceived support from community members regarding learners' education varies, depending on the age of the family member, the surrounding community and the available time.

Consistent with literature, evidence from family members suggests that role construction plays a role in the decision to become involved in the child's education. Role construction by family members involves considerations of what they need to do to assist their children with their academic work. In this regard, family members perceive their roles to include direct assistance in the form of engagement with the homework, on the one hand. On the other hand, family members perceive their roles in the education of their children to include motivating and focusing the child through alignment of the child's life expectations with the

immediate academic task. In the case of direct involvement, family members also consider their capabilities against the expected outcomes of the engagement activity.

Evidence suggests that the differences on how Mathematics was taught when the current caregiver was a learner, and the teaching methods of today, influence family members' perception of their self-efficacy in the subject. Learners, on the other hand, have positive perceptions about the abilities of the people who support them with their Mathematics academic work. The apparent contradiction between family members and children on the family members' self-efficacy, might be the result of the identity of the person who supports the learner at home. All except six of the interviewed learners revealed that their older siblings, rather than older family members like biological parents or grandparents, are assisting them with their academic work. Siblings are more likely to have had similar pedagogical experiences in Mathematics. This may explain the little support for negative self-efficacy perceptions from the learners' testimonies.

Teachers' testimonies regarding family members' perceptions of invitations for involvement is supported by literature, which suggests that socioeconomic background influences the decision to become involved. Poor responses from family members to general invitations from the school also exposed traces of acrimonious relationships, as reported in the literature, between family members and teachers. This was also visible in the present study. A lack of response to general invitations from the school, and unpleasant verbal exchanges between family members and teachers, were some of the manifestations of these acrimonious relationships. This study showed that teachers mainly initiate teacher-family member interaction, and not the other way round. This supports evidence from the literature that family members in South Africa view teachers as being self-sufficiently equipped to deal with children's educational needs.

Learners' perception of their ability to cope in Mathematics was generally positive in this study. Family members' narratives were in agreement with the general perception of learners. This finding is consistent with the literature, which suggests that when family members receive some form of tutoring in Mathematics education, children tend to perceive the subject favourably. The S4F FM programme provided such tutoring to family members in this study. Literature further emphasises the importance of congruency between children's perception and their family members' perception of the children's

ability in mathematic. With regard to these perceptions, there were no serious contradictions between these two groups in this study.

Teachers from countries that perform well in TIMMS, perceive family members' expectations of their children as a major contributory factor to good performance in Mathematics. Notwithstanding the high expectations learners have for themselves, along with those from their family members, there was no indication of this in the present study.

7.5 CONCLUSION

In sum, the S4F FM programme has elements that seem to encourage a greater overlap amongst the three spheres of influence in the Mathematics education of children. It is only after the evidence from analysis of learners' achievement marks in Chapter 6 that I can pronounce on the weights of these positive elements, when contrasted with the contraindications observed from the interviews with the teachers and family members. In other words, results from the empirical work reported on in Chapter 6, methodologically triangulated the results from this chapter.

Chapter 7 qualitatively attempted to answer the research sub-question: *What was the effect of the S4F FM programme on the perceptions of children's family members, teachers and the learners themselves towards mathematics?*

The theoretical framework for this study places the school at the centre of facilitating the family members' involvement in the education of their children, and promoting learners' cognitive development. Family members' involvement is mediated through the Hoover-Dempsey and Sandler, and Epstein and Sanders models, while learners' cognitive development is mediated through Vygotsky's Sociocultural theory and social constructivism. The ultimate outcome of these processes, according to the theoretical framework of the study, is a change in attitudes and perceptions, and also an improvement in Mathematics performance. In the next chapter I provide critical comments on the design and implementation of the S4F FM programme by bringing all the findings together.

CHAPTER 8: STUDY SUMMARY, CONCLUSION AND RECOMMENDATIONS

8.1 INTRODUCTION

The overall aim of this study is to *explore and describe the changes brought about through an S4F FM programme in a rural school community in South Africa*. To this end, I navigated through philosophical worldviews to frame the literature study and empirical work. I also formulated a theoretical framework to guide my thought processes during the course of the research. Through the literature study, I established the body of knowledge already in existence on family involvement interventions regarding primary school Mathematics in the rural Eastern Cape, South Africa. Lastly, I distilled all the aspects of the research, including findings from the empirical work, literature study, philosophical worldviews and theoretical framework to reflect on the entire study with respect to its overview, key findings and recommendations, proposed framework, and reflections on the value and limitations of the study.

8.2 OVERVIEW

Chapter 1 provided an outline of the study, and offered and justified the need to undertake the study. It also focused on research problem and presented the practical ways in which I would conduct the study. In justifying the research endeavour, the rationale (cf. 1.3) highlighted the paucity of research on the efficacy of the S4F FM intervention programme on the school community's perceptions and learner achievement marks in primary school Mathematics. To determine the modalities of the research actions, I formulated the main research question (cf. 1.4), which in turn identified the main objective (cf. 1.5) for the study. I also reviewed theories and models that explained family members' perceptions regarding involvement in their children's education, and the learning modalities and spheres of influence in the child's cognitive development. I distilled these theories and models into a conceptual framework (cf. 2.4) for the study, which placed the school at the centre of facilitation of family involvement and the creation of an enriched learning environment.

In Chapter 2, I considered the philosophical assumptions, and advanced an argument that all research is value-driven, and therefore possess some form of subjectivity. In advancing

this argument, I laid the foundation for the methodological choice for the study, which was mixed methods, and the theories that guided the thinking during the subsequent aspects of the research endeavour.

The models and theories that I navigated through explained three aspects of the study: first, family members' motivation for involvement in the child's education. Here I utilised the Hoover-Dempsey and Sandler model. The second aspect was the mechanisms of supporting the child's education through collaboration by schools, homes and communities - Epstein's overlapping spheres of influence was used for this. Thirdly, I investigated the processes involved in the acquisition of new Mathematics knowledge during a learning activity, making use of Vygotsky's Sociocultural theory and social constructivism. I then synthesised these models into a unified explanatory conceptual framework for the study. The resultant conceptual framework placed the school at the centre of facilitating family members' motivation for involvement, home-school-community collaboration and laying the ground for learners' acquisition of new Mathematics knowledge. The conceptual framework also guided the literature search.

Chapter 3, the literature review, provided an overview of existing the existent body of knowledge related to the facets of the family involvement in children's education, particularly as practiced in the S4F FM programme. In the literature review, I first explored South African family dynamics, resulting in the preference of the use of the concept of family rather parental involvement in the child's education. The literature review further explored the origins the Family Math programme, which is a forerunner to the S4F FM programme. The exploration of literature on the background to the S4F FM programme revealed the motivating factors behind the Family Math programme in the USA. Women and other minority groups' poor participation and competence in Mathematics, with a consequent low representation of these groups in professions that required the subject, motivated for an intervention in the form of Family Math. I was further able, through the literature review, to dissect and expose school communities' perceptions regarding Mathematics education, and family involvement in children's education. The literature is consistent with the theoretical framework, based on the Hoover-Dempsey and Sandler model, on family members' motivation to become involved in children's education. Lastly, I explored factors that affect learners'scholastic achievement to substantiate their use as predictors of selection of a school in the OR Tambo Education district into the S4F FM programme. The

exploration of these factors also laid the foundation for quasi-experimental research design in the research methodology for the study.

In Chapter 4, as the methodology chapter, I described the actual procedures and techniques that I used to identify, select, process and analyse data for the study. In this description, I also addressed threats to the study's overall validity and reliability. With justification for the choices I made in selecting these strategies and procedures, I explained the actual activities of data generation, analysis and interpretation for both the qualitative and quantitative aspects of the study. I then argumentatively expounded on the use of the two research methodologies in a single study, thereby identifying the study as a mixed method one. The first empirical chapter of this mixed method study was the exploration of the background to the S4F FM programme.

The background to S4F FM programme, as presented in Chapter 5, provided the analysis and interpretation of the narratives from UFS S4F staff members. These narratives traced the origins of the programme from the USA, and exposed its evolutionary process over time, which gave it a unique UFS character. The key drivers to this evolutionary process included the education levels of children's families, socioeconomic backgrounds, family structures, families' attitudes towards education and mathematical accommodation of the home languages (African languages) of the target communities. Literature and evidence from interaction with S4F FM programme staff, reaffirmed the modelling of the theoretical framework, that the programme facilitates in bringing the Epstein's overlapping spheres of influence closer together. This chapter preceded the quantitative analysis of the effect of the S4F FM programme on the Mathematics achievement marks in Chapter 6.

Chapter 6 statistically analysed and interpreted learners' Mathematics marks from schools that form part of the S4F FM programme in the OR Tambo Education District. The aim was to establish causal inferences between the S4F FM programme intervention and learners' Mathematics marks. To this end, I used propensity score matching and the covariates whose relevance I had established through a literature search to establish a comparison group to the schools that had been part of the intervention. Through the assistance of a statistician from the UFS department of Mathematical Statistics and Actuarial Science, I analysed data using the R software environment. The overall finding of the analysis, having controlled for the threats to validity, was that the S4F FM programme improved learners' achievement

marks in the OR Tambo Education District. This finding seems to suggest that the teaching methods predicated on social constructivism and Vygotsky's Sociocultural theory, as suggested in the theoretical framework and encouraged in S4F FM programme, bear positive results for the learners' scholastic achievement. However, to give meaning to this finding and to complete the empirical work towards the achievement of the main objective of the study, I analysed and interpreted the narratives of the school community on their perceptions towards Mathematics education.

In Chapter 7, I attempted to understand the perceptions towards Mathematics education that emanated from the lived experiences of interacting with the S4F FM programme. I gained this understanding through the analysis and interpretation of the interview narratives of the teachers, learners and family members. The results from this chapter confirmed suggestions from the conceptual framework that role construction, self-efficacy, invitations and personal context of energy and time are some of the considerations that influence the decision making-process of a family member to engage in a child's educational activities. The findings also supported literature on the effect of the community's socioeconomic background on family members' involvement in education. There was also literature on the unstable relationship between teachers and family members, and the role of family members' expectation on the motivation of children towards their educational work. It is important to make sense of how these findings feed into the overall objective of the study, and I attempt to do this in the sections below.

In this chapter, I attempt to understand the effect of the Family Maths intervention programme on a school community in the rural Eastern Cape Province, South Africa. To glean some understanding of the effect, I first reflect on and consolidate the independent findings of the different chapters. Secondly, in the light of the findings, I make recommendations for the improvement of the running of the S4F FM programme and further research. I then conclude by reflecting on the entire research endeavour for its contribution to the body of knowledge on the effect of interventions aimed at the facilitation of family involvement in children's education. I also reflect on the limitations of the study as they relate to those elements of design or methodology that influenced the interpretation of the results.

8.3 THE EFFECT OF THE FAMILY MATHS INTERVENTION PROGRAMME ON THE SCHOOL COMMUNITY

This study revealed that the activities of the S4F FM intervention programme helped the rural Eastern Cape school community to favourably perceive Mathematics education, resulting in improved learner scholastic achievements in the subject. The school community's perception that the S4F FM programme has a positive impact can be grouped into four broad concepts. The first is school-home-community collaboration, with the school serving as the coordinating centre (cf. 1.6.5; 2.3.3.1; 7.3.2.2). Secondly, family members' perceptions for involvement, which are largely personal and uniquely contextual to each family member (cf. 1.6.1, 2.3.1, 7.3.2.1). Thirdly, the varied engagement activities that are closely intertwined with perceptions of involvement (Cf. 7.3.4.1). The last is Mathematics-linked aspirations for the future of children (cf. 2.3.1, 7.3.1.2), which literature identifies as the single most important factor that determines the performance in the subject (cf. 3.4.3). The cumulative effect of these factors, as the results suggest, is improvement in Mathematics achievement outcomes.

The model in the theoretical framework for the study positions learners' Mathematics outcomes as the ultimate outcome of all the activities of the S4F FM programme (cf. 2.4). It is important, though, to state that the background to the S4F FM programme highlights these results regarding the philosophical reasoning behind engaging in programme activities, and the desired outcome for those for whom the intervention is meant. I therefore first discuss the insights from the exploration of the background to the programme.

8.3.1 BACKGROUND TO S4F FM

The evidence provided gives an insider's perspective of the progression from the EQUALS and Family Math programmes, introduced from the Edinboro University of Pennsylvania in 1998, to the current S4F at UFS. This progression involves the adaptation of the programme design, the approach to training and the support materials, while maintaining the founding values as espoused by the first proponents of the concept of Family Math. The founding values are to change attitudes, increase performance and participation in

Mathematics at school, and also in Mathematics-based careers of marginalised communities.

The South African social ecology, as the UFS S4F practitioners experienced it, is different from that of the USA. This necessitated the adaptation of the programme design, approach to training and the support materials. The components of the social ecology that set South Africa apart from the epicentre of the FM programme (Lawrence Hall of Science, University of California, Berkeley, USA), include predominantly low levels of education amongst children's families, poor socioeconomic backgrounds, family structures that are predominantly devoid of nucleus family settings, families' attitudes of apathy towards education, and the inherent mathematical deficiency of the home languages (African languages) of the participating communities in the S4F FM programmes. These social-ecological factors, combined with the linguistic and dialectical differences between the USA and South Africa, precipitated the evolution of a uniquely UFS Family Math programme that forms an integral part of the current S4F FM programme.

The growth of the UFS iteration of the Family Math programme was accompanied by an increase in reach over the approximately two-decade history of the S4F FM programme at the UFS. Currently, the programme has a footprint in five provinces, an increase from a few original localities in the Free State during the early 2000s. Evidence suggests that this expansion can be attributed to a combination of factors like support from sponsors and the training model, which includes the use of manipulatives.

In sum, the description of the origins of the S4F FM programme depicts a background of a dynamic and adaptive programme, which has developed into a uniquely UFS product, while still pursuing the basic tenets as the first proponents of EQUALS had envisaged. The first proponents had observed an imbalance and sought to achieve gender equity in access, participation and performance in Mathematics, with female learners being the most disadvantaged. However, to situate the results for this study in context, it is important that I remind the reader about the postulations of the theoretical framework for this research.

In regard to the theoretical perspectives, the study was based on multiple theories which I integrated to form a unified guiding lens. The theories include the Hoover-Dempsey and Sandler, Epstein and Sanders models, Vygotsky's Sociocultural theory, and social

constructivism. The integrated theoretical framework, as described in Chapter 2, places the school in the centre of the family involvement concept. This position emanates from the schools' strategic positioning, both academically and socially, with an expectant role to facilitate family involvement and learners' cognitive development. This should lead to the outcomes of changed attitudes, improved perceptions, and enhanced performance. In this regard, as evidence suggests, schools continue to be loci of convergence for S4F FM facilitator-teacher, facilitator-family member and teacher-learner social interactions to enhance children's cognitive development. These interactions, as gleaned from the evidence, also draw the home environment as one sphere of influence closer to school (another sphere of influence), thereby creating a continuous and congruent learning environment between the home and the school for the child.

In this regard, the study reveals an interplay between socioeconomic background and levels of literacy, with the effect of determining the level of family involvement in the child's education. This research further revealed that African languages are inherently deficient in Mathematical language, which serves as an obstacle to learning Mathematics among the speakers of these languages. This finding has implications for language policy considerations in the transition from the foundation to the intermediate phases and learners' scholastic performance in the subject during that transition.

8.3.2 EFFECT OF S4F FM ON LEARNERS' SCHOLASTIC ACHIEVEMENT

This study revealed that, controlling for other factors like the grade and other community and school-based covariates, the achievement marks of learners from schools that were part of the S4F FM programme were significantly higher than the schools outside the intervention. This finding confirms the modelling proposed in the conceptual framework for the study (cf. 1.7.5), which views the S4F FM activities as mediating learning and family involvement in children's education. Learning, according to the conceptual framework, is facilitated through Vygotsky's Sociocultural theory (cf. 2.3.3) and social constructivism (cf. 2.3.4). It is important to note that this study was methodologically triangulated to confirm or disconfirm the findings obtained through one methodology with those obtained with another methodology. In this regard, the positive perceptions of the school community towards Mathematics education explain the improved scholastic achievement in Mathematics. The results also reflect the achievement of the goals of the founding

proponents of the Family Math programme, which was to change attitudes and improve performance in Mathematics.

The study further revealed that exposure of the school community to the S4F FM programme in the foundation phase (Grades 1 - 3) has a positive cascading effect beyond the actual grade of intervention. For example, statistically significant improvements resulting from exposure to the intervention were observed to not only significantly improve learner achievement marks in Mathematics in the foundation phase, but also in the intermediate phase (Grades 4 - 6). The improvements are markedly more pronounced in the phase of intervention, namely the foundation phase. The study showed an average of 5% higher marks for the foundation phase when compared to the intermediate phase. Findings from the exploration of the school community's perceptions may explain the differentiated performance in Mathematics in this learning phase. Teachers expressed their disapproval of the Department of Basic Education's language policy, which dictates that learners in the foundation phase must be taught in their home language in all subjects. The teachers' disapproval emanates from their observation of learners' difficulty in transitioning from learning in IsiXhosa (or other home languages) during the foundation phase, to English in the intermediate phase. To further compound the learning difficulties resulting from the Language Policy, this study also found that the S4F FM staff members perceive African languages as lacking Mathematics terms.

Contrary to suggestions from literature on the effect of class size (cf. 3.6.3), this study found that larger Grade 3 class sizes had positive and significant effect on learners' Mathematics marks. Literature from South Africa, however, is not definitive on the effect of class size on achievement, opting to acknowledge its insignificance and its ever-evolving role. Results from the qualitative empirical work of this study did not confirm or negate the finding on the effect of class size on performance. Instead, literature also suggests a causal link between the combination of a low socioeconomic background and class size, on the one hand, and learners' academic achievement on the other (cf. 3.6.3).

The study also revealed that an improved community socioeconomic background, as indicated by the levels of education of community members, access to electricity and family income, positively and significantly affects learners' achievement marks. Linked to the socioeconomic status was the type of access to water by the community, which this study

showed to have an effect on the learners' achievement marks. Learners from communities who access their water from the municipality, had relatively better Mathematics marks when compared to those who source their water from the river.

These findings underline the relevance of socioeconomic background in the mitigation of family involvement, and the resultant quantitative improvements of learners' achievement. The rigorous mixed methods I used in this study were able to illuminate the role of socioeconomic background, both from the view of affective aspects and quantitative analysis. Results from the exploration of the literature, the background to the S4F FM programme and school community perceptions, seem to corroborate the findings from the quantitative analysis of learners' marks.

The literature reveals that the community's socioeconomic background, including service delivery matters, affects learners' academic achievement much more than school-bound social factors (cf. 3.7). One observation advanced by the literature is that family members, women in particular, from low socioeconomic backgrounds tend to be the ones who frequently attend teacher-family meetings. Teachers believe that this background defines these family members' attitudes and the often acrimonious family-teacher interactions (Cf. 3.4.5). Findings from the exploration of the perceptions of the school community, and the teachers in particular, corroborate literature on the association between socioeconomic backgrounds and beliefs about involvement in children's education (cf. 7.3.4.1). Stemming from these family attitudes are negative learner attitudes, with ultimate poor academic performance. Literature also associates socioeconomic background with a reciprocal negative feedback loop between the family members and teachers. Negative family attitudes towards the school and teachers elicit the same negative attitudes from the teachers.

The socioeconomic background of families, as seen from the exploration of the background to the S4F FM programme, is part of the South African social ecology that set the programme apart from its progenitor in the USA. According to this history, one of the targeted group of the Family Math intervention were marginalised communities characterised by low socioeconomic backgrounds.

Interestingly, the study found that the higher the number of learners who fall pregnant in a school, the more learner achievement marks in Mathematics increase. There was no confirmatory finding from other empirical explorations of this study for this observation. One possible explanation for the better achievement in Mathematics by learners from schools with a high pregnancy rate, as suggested by the literature is that the learners are older and repeating grades (cf. 3.6.4). It is my contention, however, that this observation on the association between learner pregnancies and increase in learner achievement marks, should be interpreted within a wider scope of other support systems around such learners. As evidence suggests, perceptions by family members on aspects such as role construction, self-efficacy and invitations to become involved, all lead to scholastic improvement.

8.3.3 EFFECT OF S4F FM ON PERCEPTIONS

This study identified role-construction as a serious consideration in the rural Eastern Cape communities (cf. 7.3.4.1). According to the literature (cf. 3.4.3), it is one of the factors influencing the decision to become involved in a child's education. Over and above direct involvement, these role-construction considerations include boosting the child's self-esteem, building relationships, motivation and keeping the child focused on the aspirations for the future (cf. 7.3.4.2). The improvement in learners' achievement marks from schools taking part in the S4F FM programme may underline the role-construction beliefs that this study exposed.

Regarding self-efficacy as another factor influencing family members' decision to become involved in the child's education, this study found that family members do not believe that their efforts will lead to the desired educational outcomes (cf. 7.3.1.1). In contrast, children have confidence in the ability of their family members to help them cope in Mathematics. The asymmetry in self-efficacy beliefs between the children and their family members may suggest that it is the child's belief that matters more in this regard. This assertion is borne out in the resultant improvement in the learner achievement marks that I observed in the quantitative analysis of this study.

Teachers' testimonies regarding family members' perceptions of invitations for involvement (cf. 7.3.1.1) support the literature, which suggests that socioeconomic background influences the decision to become involved (cf. 3.4.3). This study revealed that the teachers are always the ones who initiate contact with family members. Responses to

these invitations are generally poor, especially from communities with low socioeconomic backgrounds. Similar to self-efficacy beliefs, the effect of responses to invitations may not account much for the eventual learner performance. Alternatively, S4F FM programme activities compensate for the harmful effect of non-responsiveness of family members to invitations.

The positive relationship between attitudes towards Mathematics and scholastic success has long since been established in literature (Akay & Boz, 2010: 1; Pajares, 1996: 546) (cf. 1.2.2). Learners' positive attitudes towards the subject, as confirmed by this study, may directly be linked to the observed improvement in the achievement marks in Mathematics in this study (cf. 6.3.5). Although I did not explore the comparisons of attitudes of the school community between those exposed to the p4F FM Programme and those outside the programme, it is still my contention that the programme influenced these attitudes. If this contention holds, then this study confirms the importance of attitudes in addressing participation and performance in Mathematics, as the original proponents of the Family Math programme had envisaged (cf. 5.1.2).

Thus, regarding the motivation for family members to become involved in children's education, role-construction, self-efficacy and specific and general invitations for involvement, do influence that decision. Participation in the S4F FM programme may have improved the family members' motivation, leading to positive perceptions as suggested by the Hoover-Dempsey and Sandler model of the theoretical framework for this research.

The results of this study support the predictions of the model of the theoretical framework, which places perceptions about Mathematics and educational achievement as the outcomes of all the input activities inspired by the Hoover-Dempsey and Sandler model, Epstein's overlapping spheres of influence, Vygotsky's Sociocultural theory and social constructivism. The recommendations for sustained improvements in educational outcomes would have to take the postulations of the theoretical framework into account. Next, I outline the recommendations that emanate from this study.

8.4 RECOMMENDATIONS

Through navigation of worldview philosophies, theoretical frameworks, a literature search, a triangulated and rigorous methodological disposition, and detailed empirical search, this

study revealed that an intervention into Mathematics education is conceptually complex, multi-stakeholder based, multitasked and functionally dynamic. The recommendations advanced in this study are therefore aimed at embracing these different elements of the intervention, to maximise efficacy and sustainability.

Interventions regarding Mathematics education must, from the outset, be clear as to whether they are a community outreach programme, corporate social responsibility programme, or a programme driven by a clearly identified desire to foster social change through targeting the academic needs of the target community. When the rationale is clearly defined, and conceptually clarified in terms of why there is family involvement in Mathematics education, then some assemblage of sustainability and academic benefit are achievable. This conceptual clarity by all stakeholders in the intervention programme, must be agreed upon before the programme commences. Failure to foster a common understanding in this regard may lead to sponsors reprioritising funding, even if this means that the main aim of social change through academic improvement is not realised. I strongly recommend that the conceptualisation of these intervention programmes must be premised on social change that seeks to address social exclusion in both participation and performance in Mathematics. This also affects job opportunities that flow from the subject later in one's life. Because of the multifaceted nature of the stakeholders, both in personae and differing roles in the intervention programme, roles and responsibility need to be clearly defined

The communities that constitute the stakeholders in family involvement in the Mathematics education of children include the school staff, family members and the learners themselves. The education management establishment outside the school itself, which includes district officials, operating agents, S4F FM staff in the case of the present study and funders, are other stakeholders of the programme. Operating agents must be given legitimate leverage to lead and coordinate the activities of any intervention programme. This will minimise disruptive episodes of confusion about the roles and responsibilities of the functioning of the intervention programme. Such role definition will allow that state to carry out its core mandate of delivering education services to the entire citizenry, while allowing the intervention operatives, who have assumed a specialist role on the activities of family involvement, to provide the strategic direction of the partnership. This recommendation is informed by the inherently bureaucratic and rather static nature of government operations.

The effect is that in the case of family involvement in children's education, the state may not promptly respond to the needs of a functional dynamic family involvement project.

Functional dynamism of family involvement in children's education involves family members who must actively participate in involvement activities, and schools who must facilitate family members' participation, both at school and at home. This will lead to the creation of a rich continuous learning environment. The state must therefore support the programme through deliberate resource allocation to enable school staff to reach out to communities, even outside of regulated working hours. A deliberate programme, by the state, needs to be established to work on family members' perceptions regarding their role construction, self-efficacy and responsiveness to invitations to become involved in children's education. This recommendation emanates from the empirical observation in this study that parents are not necessarily the primary caregivers. This task is often performed by other family members such as grandparents, with an obvious generation gap, and a plethora of other socio-economic challenges that affect the voluntary and spontaneous involvement in children's education.

In sum, I distilled and crystallised my conceptualisation of the recommendations into a proposed framework for operationalising the activities of the intervention programme.

8.4.1 PROPOSED FRAMEWORK

In Chapter 1 of this study, I stated what the value of the research endeavour would be (cf. 1.11). Through this study, I had hoped to expand the existing body of knowledge related to family involvement in the primary Mathematics education of the child. The study would also suggest practical solutions to the approach and design of intervention programmes in Mathematics education to help streamline, focus and efficate the activities of the stakeholders in the intervention programme.

Through independent evaluation of learners' scholastic outcomes in Mathematics, I hoped to give insight into the value for investment by sponsors, the S4F FM programme managers' motivation for adaptation and/or rescaling, and also provide an intervention prototype to the Eastern Cape Department of Basic Education. As in the rest of this country, the province is experiencing a Mathematics crisis.

In the following passages I reflect on my research endeavour, to determine whether it lives up to what I expected the value of Mathematics education through the mediational effects of family involvement would be. To drive this point home, I propose a framework that guides the activities of the stakeholders in primary Mathematics education. The proposed framework within the realms of logic programme evaluation model. I encapsulate the idea of the proposed framework in an illustrative diagram, figure 8-1, to highlight some nuances of the entire intervention programme. I then describe the framework by starting with the motivation for initiating an intervention programme. However, I first need to situate the proposed framework within the theoretical framework for the study.

8.4.1.1 SITUATING THE OPERATIONAL FRAMEWORK IN THE THEORETICAL FRAMEWORK

The proposed framework is meant to be an operational model for interventions in Mathematics education in communities. In essence, the proposed operational framework is built from the integration of the foundations of the theoretical framework (cf. 2.4), and the findings from this study. It incorporates the four singular models, namely the Hoover-Dempsey & Sandler model, Epstein & Sanders model, Vygotsky's Sociocultural theory, and social constructivism. These constitute the theoretical framework into the two main conceptions of the intervention: family members' involvement and cognitive developmental activities.

The S4F FM programme intervention is an input variable in both the operational and theoretical frameworks. The proposed operational framework unpacks the mediation role of the singular models through paying attention to relevance and other influencing factors. The school and associated activities are symbolically placed at the centre of both frameworks. The school occupies the same central role in the practical process of the intervention. Lastly, the operational framework untangles the final outcome of the theoretical framework into an intermediate and final outcome, which are affective educational issues and scholastic achievement. Below I explain the different components of the operational framework.

8.4.1.2 MOTIVATION FOR INTERVENTION

Figure 8-1 shows that the process of Mathematics is structurally organised to have two foci of origin as rationales for the starting point of the programme. These are either at A, in the top left corner, ending up at Z in the bottom right corner, or and vice versa. The two origins

are not always mutually exclusive. In other words, an intervention in Mathematics might be based on the desire of an interest party who wants to engage in an act of Corporate Social Responsibility. A often becomes the driving force for the initiative. Alternatively, as observed with the origins of Family Math in the USA during the 1970s, the idea for an intervention might be the realisation of poor scholastic performance in the subject, leading to meagre participation in Mathematics, which in turn affects later career opportunities. In this case, Z becomes the key driving force for the intervention.

At the start, the intervention works with a portion of or the whole school community, usually made up of teachers, learners and family members (cf. figure 8-1). In this regard, this study proposes that for the purposes of sustainability and maximal scholastic achievement in Mathematics, the intervention must always keep sight of the medium and ultimate outcomes. Seven guiding principles must always focus the activities of the intervention. These seven principles are: focus on medium term and ultimate outcomes, values anchored in community features, responsiveness, theory-based; adaptability, consistent cognisance of mediating and influencing factors, and be context driven (cf. figure 8-1). Next, I describe the technical structure of the framework as depicted in figure 8-1.

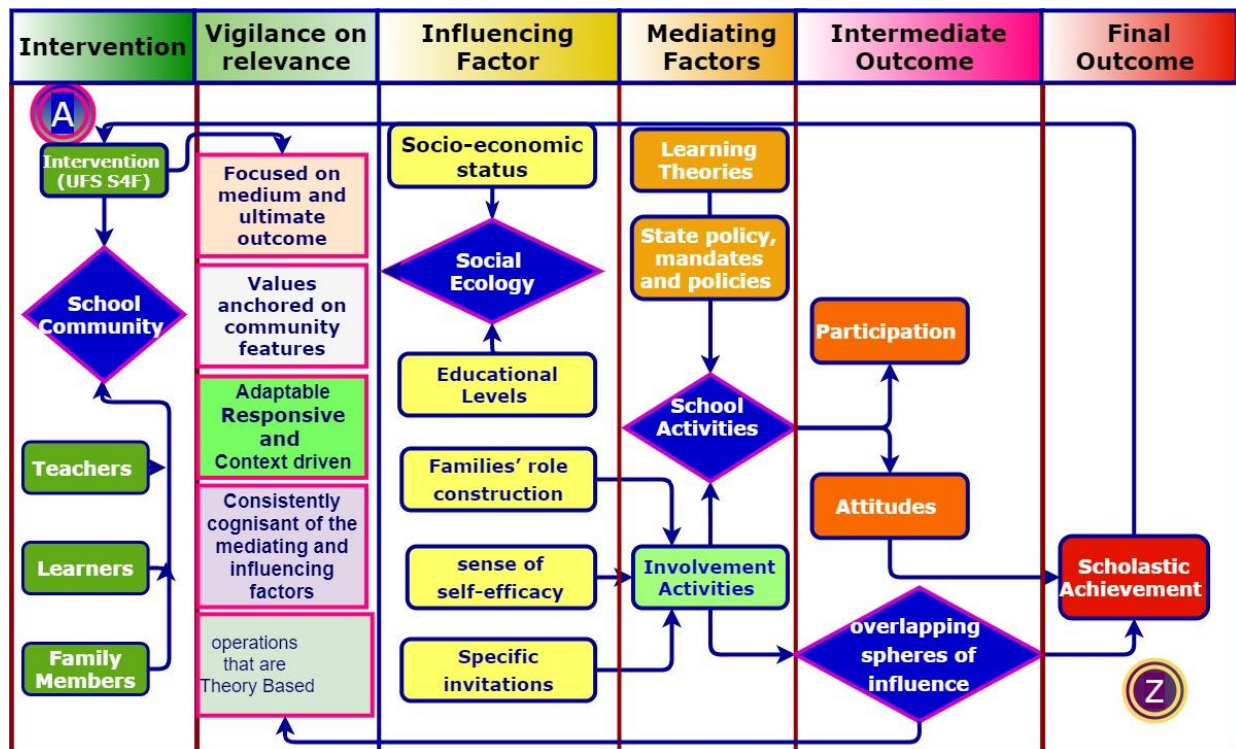


Figure 8-1: Diagrammatic representation of the contribution of the study towards Mathematics education through mediational effects of family involvement

8.4.1.3 TECHNICAL DESCRIPTION OF THE FRAMEWORK

Once the intervention programme into primary school Mathematics is running, this study proposes five interlinked components that are articulated by processing for the optimal outcomes. The components as arranged from left to right at the top of figure 8-1, are vigilance on relevance, influencing factors, mediating factors, intermediate outcomes and final outcomes. The blue colour and diamond shapes represent the indispensable broad themes that harbour the richness of the intervention. The arrows depict the considerations for the thought process and the directions for the activities during the running of the intervention. Below I describe the conceptual tenets of the framework.

8.4.1.4 CONCEPTUAL DESCRIPTION OF THE FRAMEWORK

In the second last column of Figure 8-1 are affective issues in education, such as the beliefs, feelings, attitudes and perceptions of learners towards their education, which his framework considers as intermediate outcomes of the intervention. To mediate these intermediate outcomes in relation to the children's home environments, the utilisation of makeshift artefacts and common recyclable household materials to enhance learning Mathematics, as mediated by family members' and teachers' involvement are invaluable in this regard, as they demystify the subject. The elements of the learning theories of Vygotsky's Sociocultural theory and social constructivism (cf. 2.4) play a key role in the mediation of the intermediate outcomes.

An additional benefit of activities of mediated learning is that the overlapping spheres of influence are brought closer together, thus optimising learning opportunities for the learners. The bold phrases below represent the broad themes that encompass and conceptually categorise the processes of intervention in Mathematics education. I expand on these concepts below.

Intermediate and final outcomes: It must be remembered that the main thrust of the first proponents of the Family Math programme was as an intervention to improve levels of affective emotions to Mathematics education. The ultimate outcome of improved Mathematics performance was envisaged. Emboldened by the empirical findings of this research, I therefore reaffirm and wish to expand this body knowledge, and approach in the context and space of the rural Eastern Cape province of South Africa. The attitudes and levels of participation in children's education, in the second last column of Figure 8-1, as

impacted on by school activities, ultimately lead to improved scholastic outcomes, in the last column.

Mediating factors: The school activities influencing participation and attitudes, involve theory-mediated teaching and learning in the context of certain policies, mandates and departmental priorities, and family involvement activities, such as invitations.

Closely linked to the community features, which this study highlights as an indispensable consideration in any Mathematics education intervention, are what I commonly refer to as family involvement activities. Models of family involvement in education, as corroborated by empirical evidence from this study, predicate all forms of family involvement in children's education. This is often influenced by the perceptions of family members about such involvement. Families' role construction, sense of self-efficacy and focused to become involved form the basic tenets of the decision for family involvement. These perceptions differ from one individual to the next, and sometimes need to be overcome in order to become involved, and the type of involvement. As the derived conceptual framework for this study suggested earlier, I therefore add to the practical knowledge regarding the practice of family involvement in primary education. The school, as sphere of influence in a child's learning, must deliberately engage in activities that seek to improve the perceptions of the family in order to lay the foundation for involvement. These efforts need to be engendered in a continually dynamic manner that is both responsive and adaptable to the ever-changing education landscape.

Influencing factors: The collective community features that anchor the values of the intervention are called the social ecology of the targeted community. Empirical evidence from this study, and perspectives from the background to the S4F FM programme in particular, suggests that community features such as the working hours of family members, security concerns in training venues, differing educational backgrounds of participating family members and the broader socio-economic background of the community, consistently informed and helped to adjust the training approach. In other words, the project practitioners transcended the notion of obligatory participation on the part of the trainees because of the envisaged benefit to themselves. Instead, the practitioners embedded themselves in the community and embraced the nuances of its social ecology. I

therefore add this practical approach as an integral feature of future interventions into Mathematics education, if relevance and success are to be realised.

Vigilance on relevance: The responsiveness and adaptability of the intervention operation were best exposed when I explored the background to the S4F FM programme. Evidence suggests that when the S4F FM programme first landed in South Africa in 2000, the operational curriculum delivery mode was Curriculum 2005, also known as the 'Outcomes Based Education' (OBE) curriculum. OBE was replaced by the National Curriculum Statement (NCS) in 2002 (NCS). This was later adjusted to the Revised National Curriculum. From 2012 onwards, the Curriculum Assessment and Policy Statement (CAPS) was to drive curriculum delivery in the classroom. Throughout these changes on the national education management front, the operatives of the S4F FM programme consistently responded and adapted their training manuals to stay relevant to the teachers' and learners' classroom needs. Additionally, to keep family involvement in children's education relevant and adaptable, the practitioners established enterprises to manufacture and modify South African training materials. This included adaptations to workbooks, the recalibration and replacing of units of measurement, and adaptations to the lingo used in materials for teaching and learning, to better suit the South African context. I therefore added the practicality of consistent vigilance to policy developments, and materialistic and conceptual developments that might occur during the course of a family involvement intervention in Mathematics education.

To sum up the proposed framework for the operationalisation of a family involvement intervention programme into primary Mathematics education, I conclude by unpacking the relevant school activities. School activities are predicated on the theoretical framework (cf. 2.4) for the study, which places the school at the centre of coordination of two main activities of family involvement into children's education, namely facilitation of family participation, and mediation of the learning process. In this proposed framework, I offer a practical and operational dimension to this theoretical proposition. In this regard, the Epstein and Sanders model (2006: 87) provides a step-by-step guide on how the school must create an environment in which school-based learning, home-based learning and community-based learning can be functionally synergised for an optimal learning experience. These are collectively called the spheres of influence.

In addition, the conceptual framework for this study advanced two learning theories best situated for the issue of family involvement in children's education: Vygotsky's Sociocultural theory and constructivism. Again, these theories provide practical steps that a person must undertake to facilitate the learning process, notably through scaffolding and the utilisation of the proximal zone of development.

In this proposed framework, I therefore advance a view that the operatives of the intervention programme must deliberately design integrated programmes, specifically for the empowerment of school management teams, SGBs, teachers subject advisors and other district officials to engender the theoretical basis for the facilitation of family involvement in the learning process.

8.5 REFLECTIONS ON THE STUDY

I have been able, through this research, to establish a clear association between the deliberate actions of fostering family involvement in children's Mathematics education, and positive scholastic achievement. The statistical dimension that was part of this research added to the robustness of the enquiry. It also empowered me to make causal inference claims on the relationship between the S4F FM programme intervention activities and the learners' achievement marks in Mathematics. Exposure to S4F FM programme intervention activities improved the academic performance of primary school Mathematics learners. This observation occurred within the context of a wide range of other factors, both school and community-based, which this study also interrogated.

I have also been able to demonstrate that service delivery issues in communities have a direct impact on learners' actual Mathematics marks. This observation suggests that learning challenges observed in the classroom situation have a source and possible solution outside the classroom. Such a solution might come from an integrated social endeavour to provide adequate education opportunities for young people. In fact, as I have shown in this research, there are indefensible milestones, serving as intermediaries between the activities of the intervention programme and achievement marks, and those are affective aspects of the learning process.

With regard to the affective aspects of learning, I exposed children's attitudes towards their teachers and family members helping them at home with schoolwork, coupled with a

synchronisation in expectations between family members and children, to be necessary building blocks towards the realisation of improvement in learners' academic achievement.

8.5.1 LIMITATIONS OF THE STUDY

This study was a cross-sectional view of the effect of family involvement on primary Mathematics education in the rural Eastern Cape province. As such, the insights that I gained were not able to unravel the long-term effects and the choices between Mathematics and Mathematical Literacy as elective subjects made by learners in Grade 10 of their studies.

While robust statistical analysis was undertaken to understand the effects of exposure into the S4F FM programme, the initial selection of schools and their participation inherently compromised the results, when compared to the ideal of randomised controlled designs, devoid of selection biases.

The scope of the study was limited to a specific education district in the province of the Eastern Cape, and therefore the findings are not generalisable to areas that fall outside similar contexts.

While the list of covariates that determined selection affected the variable of interest, namely achievement in Mathematics, was exhaustive as gleaned from the literature, the challenge of maintaining all the assumptions of linear and multiple regression during the analysis was a factor, mainly because of unobserved and irrelevant covariates.

8.6 SUGGESTIONS FOR FURTHER STUDY

The depth of the crisis of Mathematics education in South Africa is well documented. It is my contention that the promising positive results I exposed in this study in primary Mathematics education need to be explored further to secondary levels of the education of the subject. A similar study, targeting the same cohort of learners later in their secondary education, could be conducted to ascertain the following three features of the observations made in the present study: -

- Do the benefits of family involvement intervention into primary Mathematics education accrue further into secondary school, even when the intervention has ceased?

- What subject choices do learners that had been through the intervention programme make in their secondary education careers, when Mathematics and Mathematical Literacy become electives?
- To what extent do the activities of family involvement in Mathematics education affect other subjects with respect to attitudes and scholastic achievement in the same school and classrooms?

8.7 CONCLUSIONS

Intervention into primary Mathematics education utilising family involvement is beneficial in addressing the immediate challenge of the gap between families and schools. These benefits evidently lead to improvement in the intervening mediating factors of perceptions and socioeconomic background. Ultimately, the composite interaction between these different assemblies of mistrust, attitudes and mediating the effects of socioeconomic background, do positively address the ultimate goal of improving learners' scholastic achievement in Mathematics.

However, it must be borne in mind that these observed benefits eventually impact on that subject based career opportunities regarding participation. Beneficial interventions are important in the context of South Africa with a Mathematics education challenge, on one hand, and the resultant exclusionary nature of poor education in the subject. Thus, an emancipatory ethos that seek eliminate exclusion and expand opportunities must be the driving force for a long lasting social change.

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ADDENDA

Attached hereunder are the addenda for the researcher endeavour undertaken in this study.

The addenda are organised as follows: -

- A. Consent form for parents as a sample of all consent forms from other participants, teachers, learners and UFS S4F staff
- B. Informed assent for learners
- C. Sample of learners achievement marks
- D. Confounding factors used as a baseline data
- E. Interview questions for teachers
- F. Interview questions for UFS S4F Staff
- G. Interview questions for learners
- H. Application to conduct research from Dean of Education Faculty as a sample of all applications made to the University.
- I. Eastern Cape Education Department approval to conduct research
- J. Summary code output from R programming software

**ADDENDUM A: CONSENT FORM FOR PARENTS AS A SAMPLE OF ALL
CONSENT FORMS FROM OTHER PARTICIPANTS, TEACHERS, LEARNERS AND
UFS S4F STAFF**

DATE: 2 May 2018

TITLE OF THE RESEARCH PROJECT

The effect of a S4F FM programme on a school community in rural South Africa

PRINCIPAL RESEARCHER'S NAMES AND CONTACT NUMBER:

Sibongile Beje Student No.:2015336783 Contact No. :0825691133

FACULTY AND DEPARTMENT:

Faculty of Education

School of Education Studies

STUDY LEADER(S) NAME AND CONTACT NUMBER:

Dr. Lynette Jacobs (UFS staff member)

Contact number: 051 5051289, AND

Dr. Cobus Van Breda (UFS staff member)

Contact number: 051 4013640

WHAT IS THE AIM / PURPOSE OF THE STUDY?

The University of the Free state is rolling out the S4F FM programme in the OR Tambo Inland District as an intervention to improve learner performance. The overall aim of this study is to *explore and describe the changes that were brought about through an S4F FM programme in a rural school community in South Africa*. Role players in the school community include family members, learners and teachers.

WHO IS DOING THE RESEARCH?

I am Sibongile Beje working as the Deputy Education Specialist in the Joe Gqabi Education District. Part of my job is to analyse learners term results for the District. In the process

of doing this job I observed that learners' performance in Mathematics decreased as learners progressed from grade 1 to 9. I then became interested in the effect of the intervention programmes that are aimed at improving learner performance in the subject. S4F FM in OR Tambo Inland is such programme.

HAS THE STUDY RECEIVED ETHICAL APPROVAL?

This study has received approval from the Research Ethics Committee of UFS. A copy of the approval letter can be obtained from the researcher.

Approval number: UFS-HSD2017/1007

WHY ARE YOU INVITED TO TAKE PART IN THIS RESEARCH PROJECT?

I have chosen you based on the fact that your child attends a school that is participating in the S4F FM programme that is being rolled out by the University of the Free State. The reason for interviewing you, together with other family members is understand from your point of view, how the Family Math programme taking place in the school affected you, regarding the education of your child, particularly in Mathematics. Dr. Cobus Van Breda, the S4F FM programme coordinator from the university informed and introduced me to District coordinators of the programme, including the one from OR Tambo Inland. Other participants to this research project will be, learners and teachers from schools that are participating in the project S4F FM programme. Approximately, there will be 25 learners, 25 family members and 10 teachers that will be interviewed for this research projects.

WHAT IS THE NATURE OF PARTICIPATION IN THIS STUDY?

To understand the perceptions of the school community, I will conduct focus group interviews with parents and other caregivers, teachers and learners. You will therefore participate in this study in your personal capacity as a family member of a child who attends a participating school. In group interviews, a few open-ended questions will be asked. These interviews will be aimed at eliciting responses that bring to the fore, views and opinions and experiences that family members have on the effect of the S4F FM programme. The interviews are not expected to last longer than one hour for each category of interviewees. I foresee no risk from participating in the study, except that

which may possible come from other family members who may think that you stand to benefit from participating in the study. Such suspicions will be dealt with through distribution of information leaflets, detailing the conditions of participation in the research project.

CAN THE PARTICIPANT WITHDRAW FROM THE STUDY?

Please be informed that participation in this research project is voluntary and that there is no penalty or loss of benefit for non-participation. Being in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason. It will, however not be possible to withdraw non-identifiable contributions made during the interview sessions.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

There may not be direct benefits emanating from this research project to the current cohort of learners, that will be part of the interviewees. Benefits may accrue to the community and teachers in that the ways S4F FM is practiced might change for the better. Therefore, as a family member you might be better empowered to engage with the education of your child at home, especially Mathematics. Also, messaging from the classroom to home may be better communicated and understood, resulting in less confusion to the child, more parental involvement in Mathematics education and possibly improved performance in Mathematics.

WHAT IS THE ANTICIPATED INCONVENIENCE OF TAKING PART IN THIS STUDY?

Participation in the study may come with some degree of inconvenience for you as a family member in that you may miss out on your daily housekeeping chores or income generating activities. It is not possible for the principal researcher to eliminate all possible inconvenience, however, every arrangement permissible will be done to minimize potential inconveniences, including the choice of place and time for the interviews.

WILL WHAT I SAY BE KEPT CONFIDENTIAL?

I will keep all information obtained from you, through the interviews, confidential and your identity will also not be identified and recorded anywhere and at any stage of the research project. Instead, each interviewee's answers, including yours will be given a

fictitious code number or a pseudonym and the interviewee will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings. Please be aware that your answers, and those of others, may be reviewed by people responsible for making sure that research is done properly, including the research supervisors, transcriber, external coder, members of the Research Ethics Committee. All third parties that will have access to the data generated from the interaction with you and other teachers will be made to sign a confidentiality agreement. For the results of this research project to be of benefit to others, the anonymous data generated from interviewees may be used or feature in research reports, thesis, journal articles and conference presentations. I must state that focus group interviews will be used in this research project. Focus group are individuals connected by a common background, e.g. teacher or learners, who are intercommunicating under the guidance of a moderator for the purpose of gaining some insight about their views, experiences, attitudes or perceptions. Consequently, it may not be impossible, under group interview circumstances, to guarantee absolute privacy and therefore, I cannot guarantee that other participants in the focus group will treat information confidentially. I shall, however, encourage all participants to do so.

HOW WILL THE INFORMATION BE STORED AND ULTIMATELY DESTROYED?

Hard copies of their answers will be stored by the researcher for a period of five years in a locked cupboard at home for future research or academic purposes. Electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. Once the designated time of keeping the data lapses, all hard copies will be shredded as a way of destroying it. Electronic information will be destroyed through deletion of the files from all forms of storage including cloud. I foresee no physical injury that could be attributable to the study, however, should such occur, that principal researcher will take full responsibility of the medical attention that participants may require. Participation in the study is voluntary, as such, the principal researcher is indemnified of against claims of any nature that occurs before, during or after the study

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

There will be no financial reward for participation in the study. I envisage no costs that participants may incur as a result of participation in this study. This is because I plan to hold group interviews in places where participants live, work or study. Participation in the study may come with some degree of inconvenience for family members who may miss out on their daily housekeeping chores or income generating activities or who may have to travel to the place of interviews. However, the time and place of interviews will be arranged in a way that mitigates against these potential inconveniences.

HOW WILL THE PARTICIPANT BE INFORMED OF THE FINDINGS / RESULTS OF THE STUDY?

If you would like to be informed of the final research findings, please contact Sibongile Beje on Tel0392570024 or Cell-0825691133 or fax-0865588483. The findings are accessible for September 2020 – December 2020. Should you require any further information or want to contact the researcher about any aspect of this study, please contact the principle researcher at the contact details provided here, including using email at bejeboss@yahoo.com. Should you have concerns about the way in which the research has been conducted, you may contact Lynette Jacobs at 051 5051289 or jacobsl@ufs.ac.za.

Thank you for taking time to read this information sheet and for participating in this study

ADDENDUM B: INFORMED ASSENT FOR LEARNERS

Researcher

Sibongile Beje
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Maclear
Contact Details: +2782 569 1133
Email: bejeboss@gmail.com

Study Leader

Dr. Jacobs L.
Winkie Direko Building
School of Education
University of the Free State
P.O. Box 339
Bloemfontein, South Africa
Contact Details: +27 (0) 51 3651
Email: jacobsl@ufs.ac.za

Date: 02.05.17

Dear Participant: InterSen Pupil

Please accept my request for your participation in this research study: **The effect of a S4F FM programme on a school community in rural South Africa.** The current study seeks to understand how does the S4F FM programme by UFS affect the way children view mathematics and the way it is taught. My study will focus on parents, teachers and children. The following question will guide the study: **What changes were brought about through a Family Math programme in a rural school community in South Africa?** Research into family involvement in children's Mathematics education is necessary in South Africa. The necessity for such research comes from the fact that learners are not doing well in Mathematics when compared with learners from other countries and also pass percentages in the senior and FET phases of education in the subject are low.

Your participation in the study is voluntary and basic rights will be respected and protected at all times. We will maintain confidentiality, non-disclosure of personal information and identity, inform you at all times of the processes involved in the research study. You also have the right to leave or discontinue participation should you feel uncomfortable at any stage.

Your participation will add great value to this study.

Yours Faithfully

Sibongile Beje

DATE

2 May 2018 2 May 2018 2 May 2018

TITLE OF THE RESEARCH PROJECT

The effect of a S4F FM programme on a school community in rural South Africa
 The effect of a S4F FM programme on a school community in rural South Africa
 The effect of a S4F FM programme on a school community in rural South Africa

PRINCIPAL RESEARCHER'S NAMES AND CONTACT NUMBER:

Sibongile Beje Sibongile Beje Sibongile Beje *Student No.:2015336783*
Student No.:2015336783 *Contact No. :0825691133*
Contact No. :0825691133

FACULTY AND DEPARTMENT:

Faculty of Education Faculty of Education Faculty of Education
School of Education Studies School of Education Studies School of Education Studies

STUDY LEADER(S) NAME AND CONTACT NUMBER:

Dr. Lynette Jacobs (UFS staff member)
Contact number: 051 5051289, AND

Dr.Cobus Van Breda (UFS staff member)
Contact number: 051 4013640

QUESTIONS

- a) How has the way you communicate with family members of the learners developed over time?
- b) How has your participation in S4F FM influenced your teaching of Mathematics or any other subject, if at all?
- c) What is your belief about the role of parents in their children's education
- d) What do you believe to be your role in keeping family members actively involved in their children's education, especially at home?
- e) Have the parents, and family members responded to the contents of the S4F FM programme? If yes, how and what is the effect?
- f) What is your opinion about the clarity of messages from parents and children's family members to specific teachers and from teachers to home?
- g) What is your belief about the efficacy of parents and children's family members volunteering to support education in whatever form, including tutoring to learners?
- h) Is there a way, in your opinion, by which you can structure the learner's homework activity such that it encourages parents and children's family members involvement?
- i) How would you go about involving community leaders in the decision making regarding the education of the learners?
- j) Is there value, in your opinion, in informing the community about learner activities like academic field excursions, career exhibitions, if so what are the benefits?
- k) In your opinion, is there anything that needs to be changed in the way S4F FM programme is run. If yes, what, how and by whom?

ADDENDUM C: SAMPLE OF LEARNERS ACHIEVEMENT MARKS

Institution	Learner	Treatment	SubjectGrade	Data Year	Term	Learner Average
School -1	1	C	Mathematics (Gr R)	2016	4	81
School -1	2	C	Mathematics (Gr R)	2016	4	39
School -1	3	C	Mathematics (Gr R)	2016	4	78
School -1	4	C	Mathematics (Gr R)	2016	4	73
School -1	5	C	Mathematics (Gr R)	2016	4	72
School -1	6	C	Mathematics (Gr R)	2016	4	66
School -1	7	C	Mathematics (Gr R)	2016	4	49
School -1	8	C	Mathematics (Gr R)	2016	4	21
School -1	9	C	Mathematics (Gr R)	2016	4	75
School -1	10	C	Mathematics (Gr R)	2016	4	78
School -1	11	C	Mathematics (Gr R)	2016	4	75
School -1	12	C	Mathematics (Gr R)	2016	4	69
School -1	13	C	Mathematics (Gr R)	2016	4	59
School -1	14	C	Mathematics (Gr R)	2016	4	66
School -1	15	C	Mathematics (Gr R)	2016	4	68
School -1	16	C	Mathematics (Gr R)	2016	4	72
School -1	17	C	Mathematics (Gr R)	2016	4	65
School -1	18	C	Mathematics (Gr R)	2016	4	74
School -1	19	C	Mathematics (Gr R)	2016	4	77
School -1	20	C	Mathematics (Gr R)	2016	4	71
School -1	21	C	Mathematics (Gr R)	2016	4	57
School -1	22	C	Mathematics (Gr R)	2016	4	25
School -1	23	C	Mathematics (Gr R)	2016	4	54
School -1	24	C	Mathematics (Gr R)	2016	4	28
School -1	25	C	Mathematics (Gr R)	2016	4	22
School -1	26	C	Mathematics (Gr R)	2016	4	30
School -1	27	C	Mathematics (Gr R)	2016	4	19
School -1	28	C	Mathematics (Gr R)	2016	4	17
School -1	29	C	Mathematics (Gr R)	2016	4	54
School -1	30	C	Mathematics (Gr R)	2016	4	76
School -1	31	C	Mathematics (Gr R)	2016	4	69
School -1	32	C	Mathematics (Gr R)	2016	4	30
School -1	33	C	Mathematics (Gr R)	2016	4	69
School -1	34	C	Mathematics (Gr R)	2016	4	48
School -1	35	C	Mathematics (Gr R)	2016	4	41
School -1	36	C	Mathematics (Gr R)	2016	4	49
School -1	37	C	Mathematics (Gr R)	2016	4	37
School -1	38	C	Mathematics (Gr R)	2017	4	64
School -1	39	C	Mathematics (Gr R)	2017	4	70
School -1	40	C	Mathematics (Gr R)	2017	4	48
School -1	41	C	Mathematics (Gr R)	2017	4	65

School -1	42	C	Mathematics (Gr R)	2017	4	71
School -1	43	C	Mathematics (Gr R)	2017	4	53
School -1	44	C	Mathematics (Gr R)	2017	4	90
School -1	45	C	Mathematics (Gr R)	2017	4	90
School -1	46	C	Mathematics (Gr R)	2017	4	17
School -1	47	C	Mathematics (Gr R)	2017	4	51
School -1	48	C	Mathematics (Gr R)	2017	4	62
School -1	49	C	Mathematics (Gr R)	2017	4	21
School -1	50	C	Mathematics (Gr R)	2017	4	27
School -1	51	C	Mathematics (Gr R)	2017	4	74
School -1	52	C	Mathematics (Gr R)	2017	4	51
School -1	53	C	Mathematics (Gr R)	2017	4	80
School -1	54	C	Mathematics (Gr R)	2017	4	25
School -1	55	C	Mathematics (Gr R)	2017	4	19
School -1	56	C	Mathematics (Gr 01)	2016	4	65
School -1	57	C	Mathematics (Gr 01)	2016	4	63
School -1	58	C	Mathematics (Gr 01)	2016	4	67
School -1	59	C	Mathematics (Gr 01)	2016	4	40
School -1	60	C	Mathematics (Gr 01)	2016	4	75
School -1	61	C	Mathematics (Gr 01)	2016	4	71
School -1	62	C	Mathematics (Gr 01)	2016	4	48
School -1	63	C	Mathematics (Gr 01)	2016	4	36
School -1	64	C	Mathematics (Gr 01)	2016	4	50
School -1	65	C	Mathematics (Gr 01)	2016	4	64
School -1	66	C	Mathematics (Gr 01)	2016	4	45
School -1	67	C	Mathematics (Gr 01)	2016	4	44
School -1	68	C	Mathematics (Gr 01)	2016	4	72
School -1	69	C	Mathematics (Gr 01)	2016	4	72
School -1	70	C	Mathematics (Gr 01)	2016	4	59
School -1	71	C	Mathematics (Gr 01)	2016	4	36
School -1	72	C	Mathematics (Gr 01)	2016	4	55
School -1	73	C	Mathematics (Gr 01)	2016	4	69
School -1	74	C	Mathematics (Gr 01)	2016	4	66
School -1	75	C	Mathematics (Gr 01)	2016	4	44
School -1	76	C	Mathematics (Gr 01)	2016	4	52
School -1	77	C	Mathematics (Gr 01)	2016	4	34
School -1	78	C	Mathematics (Gr 01)	2016	4	62
School -1	79	C	Mathematics (Gr 01)	2016	4	34
School -1	80	C	Mathematics (Gr 01)	2016	4	34
School -1	81	C	Mathematics (Gr 01)	2017	4	48
School -1	82	C	Mathematics (Gr 01)	2017	4	63
School -1	83	C	Mathematics (Gr 01)	2017	4	58
School -1	84	C	Mathematics (Gr 01)	2017	4	40
School -1	85	C	Mathematics (Gr 01)	2017	4	56

School -1	86	C	Mathematics (Gr 01)	2017	4	61
School -1	87	C	Mathematics (Gr 01)	2017	4	55
School -1	88	C	Mathematics (Gr 01)	2017	4	59
School -1	89	C	Mathematics (Gr 01)	2017	4	67
School -1	90	C	Mathematics (Gr 01)	2017	4	70
School -1	91	C	Mathematics (Gr 01)	2017	4	56
School -1	92	C	Mathematics (Gr 01)	2017	4	54
School -1	93	C	Mathematics (Gr 01)	2017	4	48
School -1	94	C	Mathematics (Gr 01)	2017	4	41
School -1	95	C	Mathematics (Gr 01)	2017	4	43
School -1	96	C	Mathematics (Gr 01)	2017	4	42
School -1	97	C	Mathematics (Gr 01)	2017	4	62
School -1	98	C	Mathematics (Gr 01)	2017	4	55
School -1	99	C	Mathematics (Gr 01)	2017	4	28
School -1	100	C	Mathematics (Gr 01)	2017	4	59
School -1	101	C	Mathematics (Gr 01)	2017	4	56
School -1	102	C	Mathematics (Gr 01)	2017	4	53
School -1	103	C	Mathematics (Gr 01)	2017	4	44
School -1	104	C	Mathematics (Gr 02)	2016	4	56
School -1	105	C	Mathematics (Gr 02)	2016	4	35
School -1	106	C	Mathematics (Gr 02)	2016	4	38
School -1	107	C	Mathematics (Gr 02)	2016	4	52
School -1	108	C	Mathematics (Gr 02)	2016	4	50
School -1	109	C	Mathematics (Gr 02)	2016	4	38
School -1	110	C	Mathematics (Gr 02)	2016	4	44
School -1	111	C	Mathematics (Gr 02)	2016	4	58
School -1	112	C	Mathematics (Gr 02)	2016	4	57
School -1	113	C	Mathematics (Gr 02)	2016	4	56
School -1	114	C	Mathematics (Gr 02)	2016	4	40
School -1	115	C	Mathematics (Gr 02)	2016	4	49
School -1	116	C	Mathematics (Gr 02)	2016	4	61
School -1	117	C	Mathematics (Gr 02)	2016	4	58
School -1	118	C	Mathematics (Gr 02)	2016	4	40
School -1	119	C	Mathematics (Gr 02)	2016	4	58
School -1	120	C	Mathematics (Gr 02)	2016	4	58
School -1	121	C	Mathematics (Gr 02)	2016	4	35
School -1	122	C	Mathematics (Gr 02)	2016	4	65
School -1	123	C	Mathematics (Gr 02)	2016	4	53
School -1	124	C	Mathematics (Gr 02)	2016	4	55
School -1	125	C	Mathematics (Gr 02)	2016	4	48
School -1	126	C	Mathematics (Gr 02)	2016	4	52
School -1	127	C	Mathematics (Gr 02)	2017	4	52
School -1	128	C	Mathematics (Gr 02)	2017	4	57
School -1	129	C	Mathematics (Gr 02)	2017	4	32

School -1	130	C	Mathematics (Gr 02)	2017	4	30
School -1	131	C	Mathematics (Gr 02)	2017	4	57
School -1	132	C	Mathematics (Gr 02)	2017	4	55
School -1	133	C	Mathematics (Gr 02)	2017	4	55
School -1	134	C	Mathematics (Gr 02)	2017	4	62
School -1	135	C	Mathematics (Gr 02)	2017	4	61
School -1	136	C	Mathematics (Gr 02)	2017	4	53
School -1	137	C	Mathematics (Gr 02)	2017	4	32
School -1	138	C	Mathematics (Gr 02)	2017	4	53
School -1	139	C	Mathematics (Gr 02)	2017	4	29
School -1	140	C	Mathematics (Gr 02)	2017	4	53
School -1	141	C	Mathematics (Gr 02)	2017	4	52
School -1	142	C	Mathematics (Gr 03)	2016	4	35
School -1	143	C	Mathematics (Gr 03)	2016	4	55
School -1	144	C	Mathematics (Gr 03)	2016	4	56
School -1	145	C	Mathematics (Gr 03)	2016	4	51
School -1	146	C	Mathematics (Gr 03)	2016	4	34
School -1	147	C	Mathematics (Gr 03)	2016	4	28
School -1	148	C	Mathematics (Gr 03)	2016	4	54
School -1	149	C	Mathematics (Gr 03)	2016	4	34
School -1	150	C	Mathematics (Gr 03)	2016	4	55
School -1	151	C	Mathematics (Gr 03)	2016	4	45
School -1	152	C	Mathematics (Gr 03)	2016	4	48
School -1	153	C	Mathematics (Gr 03)	2016	4	60
School -1	154	C	Mathematics (Gr 03)	2016	4	51
School -1	155	C	Mathematics (Gr 03)	2016	4	53
School -1	156	C	Mathematics (Gr 03)	2016	4	45
School -1	157	C	Mathematics (Gr 03)	2016	4	34
School -1	158	C	Mathematics (Gr 03)	2016	4	49
School -1	159	C	Mathematics (Gr 03)	2016	4	46
School -1	160	C	Mathematics (Gr 03)	2016	4	47
School -1	161	C	Mathematics (Gr 03)	2016	4	51
School -1	162	C	Mathematics (Gr 03)	2016	4	35
School -1	163	C	Mathematics (Gr 03)	2016	4	29
School -1	164	C	Mathematics (Gr 03)	2016	4	62
School -1	165	C	Mathematics (Gr 03)	2016	4	64
School -1	166	C	Mathematics (Gr 03)	2016	4	58
School -1	167	C	Mathematics (Gr 03)	2017	4	55
School -1	168	C	Mathematics (Gr 03)	2017	4	56
School -1	169	C	Mathematics (Gr 03)	2017	4	46
School -1	170	C	Mathematics (Gr 03)	2017	4	52
School -1	171	C	Mathematics (Gr 03)	2017	4	42
School -1	172	C	Mathematics (Gr 03)	2017	4	59
School -1	173	C	Mathematics (Gr 03)	2017	4	54

School -1	174	C	Mathematics (Gr 03)	2017	4	49
School -1	175	C	Mathematics (Gr 03)	2017	4	70
School -1	176	C	Mathematics (Gr 03)	2017	4	67
School -1	177	C	Mathematics (Gr 03)	2017	4	61
School -1	178	C	Mathematics (Gr 03)	2017	4	62
School -1	179	C	Mathematics (Gr 03)	2017	4	70
School -1	180	C	Mathematics (Gr 03)	2017	4	23
School -1	181	C	Mathematics (Gr 03)	2017	4	50
School -1	182	C	Mathematics (Gr 03)	2017	4	49
School -1	183	C	Mathematics (Gr 04)	2016	4	35
School -1	184	C	Mathematics (Gr 04)	2016	4	44
School -1	185	C	Mathematics (Gr 04)	2016	4	35
School -1	186	C	Mathematics (Gr 04)	2016	4	32
School -1	187	C	Mathematics (Gr 04)	2016	4	37
School -1	188	C	Mathematics (Gr 04)	2016	4	47
School -1	189	C	Mathematics (Gr 04)	2016	4	49
School -1	190	C	Mathematics (Gr 04)	2016	4	53
School -1	191	C	Mathematics (Gr 04)	2016	4	47
School -1	192	C	Mathematics (Gr 04)	2016	4	53
School -1	193	C	Mathematics (Gr 04)	2016	4	50
School -1	194	C	Mathematics (Gr 04)	2016	4	50
School -1	195	C	Mathematics (Gr 04)	2016	4	33
School -1	196	C	Mathematics (Gr 04)	2016	4	40
School -1	197	C	Mathematics (Gr 04)	2016	4	48
School -1	198	C	Mathematics (Gr 04)	2016	4	45
School -1	199	C	Mathematics (Gr 04)	2016	4	42
School -1	200	C	Mathematics (Gr 04)	2016	4	38
School -1	201	C	Mathematics (Gr 04)	2016	4	46
School -1	202	C	Mathematics (Gr 04)	2016	4	46
School -1	203	C	Mathematics (Gr 04)	2016	4	44
School -1	204	C	Mathematics (Gr 04)	2016	4	51
School -1	205	C	Mathematics (Gr 04)	2016	4	48
School -1	206	C	Mathematics (Gr 04)	2016	4	38
School -1	207	C	Mathematics (Gr 04)	2017	4	36
School -1	208	C	Mathematics (Gr 04)	2017	4	45
School -1	209	C	Mathematics (Gr 04)	2017	4	30
School -1	210	C	Mathematics (Gr 04)	2017	4	47
School -1	211	C	Mathematics (Gr 04)	2017	4	49
School -1	212	C	Mathematics (Gr 04)	2017	4	51
School -1	213	C	Mathematics (Gr 04)	2017	4	33
School -1	214	C	Mathematics (Gr 04)	2017	4	33
School -1	215	C	Mathematics (Gr 04)	2017	4	46
School -1	216	C	Mathematics (Gr 04)	2017	4	52
School -1	217	C	Mathematics (Gr 04)	2017	4	44

School -1	218	C	Mathematics (Gr 04)	2017	4	33
School -1	219	C	Mathematics (Gr 04)	2017	4	41
School -1	220	C	Mathematics (Gr 04)	2017	4	47
School -1	221	C	Mathematics (Gr 04)	2017	4	52
School -1	222	C	Mathematics (Gr 04)	2017	4	28
School -1	223	C	Mathematics (Gr 04)	2017	4	39
School -1	224	C	Mathematics (Gr 04)	2017	4	46
School -1	225	C	Mathematics (Gr 04)	2017	4	51
School -1	226	C	Mathematics (Gr 04)	2017	4	56
School -1	227	C	Mathematics (Gr 05)	2016	4	37
School -1	228	C	Mathematics (Gr 05)	2016	4	45
School -1	229	C	Mathematics (Gr 05)	2016	4	42
School -1	230	C	Mathematics (Gr 05)	2016	4	39
School -1	231	C	Mathematics (Gr 05)	2016	4	44
School -1	232	C	Mathematics (Gr 05)	2016	4	50
School -1	233	C	Mathematics (Gr 05)	2016	4	46
School -1	234	C	Mathematics (Gr 05)	2016	4	38
School -1	235	C	Mathematics (Gr 05)	2016	4	49
School -1	236	C	Mathematics (Gr 05)	2016	4	24
School -1	237	C	Mathematics (Gr 05)	2016	4	36
School -1	238	C	Mathematics (Gr 05)	2016	4	43
School -1	239	C	Mathematics (Gr 05)	2016	4	39
School -1	240	C	Mathematics (Gr 05)	2016	4	44
School -1	241	C	Mathematics (Gr 05)	2016	4	42
School -1	242	C	Mathematics (Gr 05)	2016	4	51
School -1	243	C	Mathematics (Gr 05)	2016	4	46
School -1	244	C	Mathematics (Gr 05)	2017	4	47
School -1	245	C	Mathematics (Gr 05)	2017	4	47
School -1	246	C	Mathematics (Gr 05)	2017	4	36
School -1	247	C	Mathematics (Gr 05)	2017	4	52
School -1	248	C	Mathematics (Gr 05)	2017	4	53
School -1	249	C	Mathematics (Gr 05)	2017	4	43
School -1	250	C	Mathematics (Gr 05)	2017	4	48
School -1	251	C	Mathematics (Gr 05)	2017	4	52
School -1	252	C	Mathematics (Gr 05)	2017	4	49
School -1	253	C	Mathematics (Gr 05)	2017	4	50
School -1	254	C	Mathematics (Gr 05)	2017	4	45
School -1	255	C	Mathematics (Gr 05)	2017	4	40
School -1	256	C	Mathematics (Gr 06)	2016	4	46
School -1	257	C	Mathematics (Gr 06)	2016	4	41
School -1	258	C	Mathematics (Gr 06)	2016	4	44
School -1	259	C	Mathematics (Gr 06)	2016	4	43
School -1	260	C	Mathematics (Gr 06)	2016	4	41
School -1	261	C	Mathematics (Gr 06)	2016	4	48

ADDENDUM D: EXAMPLE FROM 1ST 100 SCHOOLS CONFOUNDING FACTORS USED AS A BASELINE DATA

Municipal_Ward	Schools	Treatment	LearnersPerClassroom_2017	LearnersPerEd	Pregnancies_2	LearnerToilet_2017	Enrlmnt_Grade_R	Enrlmnt_Grade_1	Enrlmnt_Grade_2	Enrlmnt_Grade_3	Enrlmnt_Grade_4	Enrlmnt_Grade_5	Enrlmnt_Grade_6	PropElectricity	MedIncome	Education	PropEmployed	AreaType	WaterSource	Toilet
Ward A1	Schl 1	C	15	15	7	21.83	5.41	3.94	4.00	4.15	3.85	5.07	4.16	0.07	1460 0.00	1.00	0.11	Traditional	River/ other	Pit toilet without ventilation
Ward A2	Schl 2	C	59	36	0	28.10	13.33	6.89	6.91	4.64	7.01	4.88	6.43	0.86	1460 0.00	2.00	0.11	Traditional	Muni cipal	Pit toilet with ventilation (VIP)
Ward A1	Schl 3	C	45	37	12	28.19	3.74	4.82	4.45	7.12	5.43	6.87	7.16	0.07	1460 0.00	1.00	0.11	Traditional	River/ other	Pit toilet without ventilation
Ward A3	Schl 4	C	29	39	20	28.25	7.63	3.00	6.30	9.60	8.70	4.55	8.07	0.81	1460 0.00	2.00	0.14	Traditional	River/ other	Pit toilet without ventilation
Ward A4	Schl 5	C	195	36	2	54.75	41.27	36.67	29.6 9	27.3 6	19.9 1	20.0 8	22.0 2	0.84	1460 0.00	2.00	0.42	Formal	Muni cipal	Pit toilet with ventilation (VIP)
Ward A5	Schl 6	C	30	27	4	26.60	10.28	9.04	8.79	6.76	5.93	9.07	7.78	0.81	1460 0.00	2.00	0.19	Traditional	River/ other	Pit toilet with ventilation (VIP)
Ward A6	Schl 7	C	28	31	12	17.44	3.35	8.37	6.04	5.15	8.44	4.32	4.09	0.85	1460 0.00	2.00	0.33	Traditional	River/ other	Pit toilet without ventilation
Ward A7	Schl 8	C	23	27	2	46.50	4.56	6.27	10.7 1	4.39	7.37	5.24	11.6 1	0.39	1460 0.00	2.00	0.11	Traditional	River/ other	None
Ward A8	Schl 9	C	26	30	1	14.79	16.20	3.63	2.97	14.1 0	13.4 0	12.0 6	13.0 8	0.88	1460 0.00	2.00	0.12	Traditional	River/ other	Pit toilet without ventilation
Ward A9	Schl 10	C	86	40	5	24.85	5.93	20.06	12.1 3	5.41	8.14	6.69	9.45	0.01	1460 0.00	1.00	0.07	Traditional	River/ other	Pit toilet with ventilation (VIP)
Ward A10	Schl 11	C	19	26	24	28.38	5.41	8.85	5.15	3.70	8.07	3.21	7.66	0.83	1460 0.00	2.00	0.08	Traditional	River/ other	Pit toilet without ventilation
Ward A11	Schl 12	C	43	30	2	11.44	9.44	17.81	6.66	8.17	11.2 2	9.29	8.98	0.76	1460 0.00	2.00	0.09	Traditional	River/ other	None
Ward A12	Schl 13	C	66	33	2	31.50	3.56	5.81	4.34	6.40	3.94	5.32	4.15	0.89	1460 0.00	2.00	0.04	Traditional	River/ other	None
Ward A2	Schl 14	C	28	42	0	26.17	6.28	6.98	5.67	3.42	4.49	2.51	2.39	0.86	1460 0.00	2.00	0.11	Traditional	Muni cipal	Pit toilet with ventilation (VIP)
Ward A13	Schl 15	C	32	32	15	60.50	19.27	14.21	4.93	7.66	10.0 6	8.26	11.8 9	0.87	1460 0.00	2.00	0.10	Traditional	River/ other	Pit toilet without ventilation

Addenda

Ward A3	Schl 16	C	21	30	0	0.93	7.37	8.68	11.09	10.83	8.32	8.81	9.61	0.81	1460.00	2.00	0.14	Traditional	River/other	Pit toilet without ventilation
Ward A12	Schl 17	C	37	27	0	21.00	10.06	2.59	4.62	6.27	7.82	5.89	4.24	0.89	1460.00	2.00	0.04	Traditional	River/other	None
Ward A12	Schl 18	C	38	27	7	278.00	3.71	4.32	4.98	3.42	6.14	8.35	2.24	0.89	1460.00	2.00	0.04	Traditional	River/other	None
Ward A14	Schl 19	T	29	36	13	87.00	9.90	6.98	7.50	16.87	12.79	16.05	14.11	0.09	1460.00	1.00	0.14	Traditional	River/other	None
Ward A7	Schl 20	C	23	27	11	17.75	9.51	6.07	4.36	7.80	3.21	5.89	6.77	0.39	1460.00	2.00	0.11	Traditional	River/other	None
Ward A10	Schl 21	C	17	19	0	12.60	6.18	5.13	2.30	2.19	3.27	4.95	5.40	0.83	1460.00	2.00	0.08	Traditional	River/other	Pit toilet without ventilation
Ward A15	Schl 22	C	74	46	37	36.30	13.61	8.38	8.47	10.71	4.38	9.91	16.05	0.93	1460.00	3.00	0.53	Formal	Municipal	Pit toilet with ventilation (VIP)
Ward A16	Schl 23	C	41	28	27	30.25	5.32	8.92	7.27	8.29	7.05	4.36	4.66	0.69	1460.00	2.00	0.17	Traditional	River/other	Pit toilet with ventilation (VIP)
Ward A2	Schl 24	C	60	31	16	54.00	15.79	14.43	15.19	18.30	28.86	9.66	9.36	0.86	1460.00	2.00	0.11	Traditional	Municipal	Pit toilet with ventilation (VIP)
Ward A5	Schl 25	C	35	32	13	25.07	9.26	10.45	10.13	7.89	9.91	5.61	4.39	0.81	1460.00	2.00	0.19	Traditional	River/other	Pit toilet with ventilation (VIP)
Ward A1	Schl 26	C	78	39	24	296.00	9.88	7.82	6.44	5.08	8.44	5.24	4.04	0.07	1460.00	1.00	0.11	Traditional	River/other	Pit toilet without ventilation
Ward A17	Schl 27	C	25	16	9	27.17	2.68	7.89	9.83	8.23	5.85	9.18	11.56	0.35	1460.00	2.00	0.09	Traditional	River/other	None
Ward A18	Schl 28	C	43	27	12	32.17	5.37	11.07	8.17	7.64	10.59	8.56	2.17	0.85	1460.00	2.00	0.12	Traditional	River/other	Pit toilet without ventilation
Ward A3	Schl 29	C	20	20	9	31.40	4.36	3.27	2.86	3.00	5.07	3.27	1.64	0.81	1460.00	2.00	0.14	Traditional	River/other	Pit toilet without ventilation
Ward A11	Schl 30	C	3	6	0	1.88	5.94	7.21	5.89	5.24	3.05	4.02	0.00	0.76	1460.00	2.00	0.09	Traditional	River/other	None
Ward A19	Schl 31	C	33	30	10	64.75	8.76	14.71	17.85	11.63	13.22	6.50	3.81	0.78	1460.00	2.00	0.55	Formal	Municipal	Flush toilet (connected to sewerage system)
Ward A20	Schl 32	C	55	35	7	45.70	22.50	26.62	27.03	15.58	19.69	19.94	14.43	0.78	1460.00	2.00	0.30	Traditional	Municipal	Pit toilet without ventilation
Ward A13	Schl 33	C	28	28	15	36.33	7.26	9.57	9.92	12.25	6.71	5.98	4.67	0.87	1460.00	2.00	0.10	Traditional	River/other	Pit toilet without ventilation

Addenda

Ward A21	Schl 34	C	16	21	3	16.78	7.50	3.11	3.78	3.51	6.61	3.11	2.83	0.86	1460 0.00	2.00	0.28	Traditional	River/ other	Pit toilet without ventilation
Ward A22	Schl 35	C	56	33	12	42.62	7.86	8.47	8.56	10.1 8	5.27	6.35	7.75	0.84	1460 0.00	2.00	0.10	Traditional	River/ other	None
Ward A13	Schl 36	C	19	24	9	26.29	8.82	4.21	4.64	3.96	3.56	7.84	5.68	0.87	1460 0.00	2.00	0.10	Traditional	River/ other	Pit toilet without ventilation
Ward A23	Schl 37	C	47	27	6	46.62	14.72	14.64	9.07	7.46	17.5 3	2.79	4.04	0.84	2890 0.00	3.00	0.56	Formal	Muni cipal	Flush toilet (connected to sewerage system)
Ward A4	Schl 38	C	43	35	10	39.20	11.39	13.83	27.2 5	4.44	16.6 9	15.1 0	13.4 6	0.84	1460 0.00	2.00	0.42	Formal	Muni cipal	Pit toilet with ventilation (VIP)
Ward A12	Schl 39	C	102	34	2	23.92	9.88	7.31	6.27	7.56	7.95	6.30	2.86	0.89	1460 0.00	2.00	0.04	Traditional	River/ other	None
Ward A17	Schl 40	C	55	34	0	31.75	9.02	5.41	8.77	7.98	3.58	5.81	2.70	0.35	1460 0.00	2.00	0.09	Traditional	River/ other	None
Ward A1	Schl 41	C	20	22	4	32.50	15.22	16.87	9.50	11.9 9	7.75	10.2 8	7.96	0.07	1460 0.00	1.00	0.11	Traditional	River/ other	Pit toilet without ventilation
Ward A2	Schl 42	C	27	27	1	29.13	2.41	3.83	2.28	1.82	0.71	5.20	5.50	0.86	1460 0.00	2.00	0.11	Traditional	Muni cipal	Pit toilet with ventilation (VIP)
Ward A3	Schl 43	C	36	30	6	55.00	12.38	6.88	5.46	2.07	4.98	11.2 6	7.83	0.81	1460 0.00	2.00	0.14	Traditional	River/ other	Pit toilet without ventilation
Ward A16	Schl 44	C	57	38	15	68.13	6.31	14.83	6.36	9.15	13.3 1	9.24	6.47	0.69	1460 0.00	2.00	0.17	Traditional	River/ other	Pit toilet with ventilation (VIP)
Ward A9	Schl 45	C	131	40	0	55.00	6.52	7.36	11.7 3	16.4 7	6.80	8.79	15.6 3	0.01	1460 0.00	1.00	0.07	Traditional	River/ other	Pit toilet with ventilation (VIP)
Ward A24	Schl 46	C	77	22	0	71.50	5.81	5.94	4.16	4.66	6.14	5.36	3.51	0.78	1460 0.00	2.00	0.19	Traditional	River/ other	Pit toilet without ventilation
Ward A25	Schl 47	C	45	38	9	56.58	6.61	11.97	12.1 3	8.96	6.99	5.26	6.38	0.21	1460 0.00	1.00	0.08	Traditional	River/ other	None
Ward A16	Schl 48	C	32	25	0	118.0 0	4.77	3.11	3.13	2.59	4.92	5.15	5.24	0.69	1460 0.00	2.00	0.17	Traditional	River/ other	Pit toilet with ventilation (VIP)
Ward A25	Schl 49	C	85	51	7	40.83	7.95	6.11	11.0 3	14.4 3	11.3 4	3.13	3.94	0.21	1460 0.00	1.00	0.08	Traditional	River/ other	None
Ward A10	Schl 50	C	19	14	1	10.63	6.96	4.93	5.15	2.12	3.00	2.12	2.07	0.83	1460 0.00	2.00	0.08	Traditional	River/ other	Pit toilet without ventilation
Ward A3	Schl 51	C	31	28	1	60.40	8.29	4.09	2.59	4.39	6.22	8.47	5.89	0.81	1460 0.00	2.00	0.14	Traditional	River/ other	Pit toilet without ventilation

Addenda

Ward A5	Schl 52	C	32	36	3	40.17	10.92	4.98	7.98	8.53	3.49	1.30	3.05	0.81	1460 0.00	2.00	0.19	Traditional	River/ other	Pit toilet with ventilation (VIP)
Ward A24	Schl 53	C	41	35	20	43.90	9.10	8.91	6.22	8.56	6.54	7.36	5.36	0.78	1460 0.00	2.00	0.19	Traditional	River/ other	Pit toilet without ventilation
Ward A10	Schl 54	C	17	19	3	0.87	2.17	2.35	8.50	4.09	2.35	4.71	4.21	0.83	1460 0.00	2.00	0.08	Traditional	River/ other	Pit toilet without ventilation
Ward A25	Schl 55	C	15	26	2	70.00	17.71	6.91	5.59	2.59	2.59	4.44	2.77	0.21	1460 0.00	1.00	0.08	Traditional	River/ other	None
Ward A1	Schl 56	C	47	27	0	23.88	4.39	4.97	3.35	3.21	3.03	3.91	4.97	0.07	1460 0.00	1.00	0.11	Traditional	River/ other	Pit toilet without ventilation
Ward A23	Schl 57	C	17	21	9	36.25	1.30	4.42	3.81	4.28	4.42	4.77	4.56	0.84	2890 0.00	3.00	0.56	Formal	Muni cipal	Flush toilet (connected to sewerage system)
Ward A17	Schl 58	C	21	26	8	11.69	8.50	5.76	5.70	11.2 2	7.69	6.46	3.44	0.35	1460 0.00	2.00	0.09	Traditional	River/ other	None
Ward A26	Schl 59	C	39	35	3	44.38	14.89	5.26	14.8 4	5.43	17.2 1	15.6 9	14.0 4	0.88	1460 0.00	2.00	0.45	Formal	Muni cipal	Flush toilet (connected to sewerage system)
Ward A23	Schl 60	C	32	30	0	44.88	6.32	17.43	14.9 4	13.7 2	27.9 7	28.6 4	23.1 9	0.84	2890 0.00	3.00	0.56	Formal	Muni cipal	Flush toilet (connected to sewerage system)
Ward A15	Schl 61	T	39	34	12	59.30	15.40	22.86	17.5 0	27.0 6	21.5 6	10.5 0	11.2 2	0.93	1460 0.00	3.00	0.53	Formal	Muni cipal	Pit toilet with ventilation (VIP)
Ward A13	Schl 62	C	45	38	25	43.10	6.83	15.39	6.77	7.89	7.84	5.76	7.40	0.87	1460 0.00	2.00	0.10	Traditional	River/ other	Pit toilet without ventilation
Ward A22	Schl 63	C	22	29	0	83.50	4.32	1.64	1.79	5.68	3.05	1.79	1.92	0.84	1460 0.00	2.00	0.10	Traditional	River/ other	None
Ward A20	Schl 64	C	88	35	0	13.00	2.05	5.59	1.95	2.68	2.95	2.28	5.41	0.78	1460 0.00	2.00	0.30	Traditional	Muni cipal	Pit toilet without ventilation
Ward A27	Schl 65	C	13	32	8	13.17	3.91	8.00	7.64	4.51	4.32	6.16	8.04	0.88	1460 0.00	2.00	0.36	Traditional	Muni cipal	Pit toilet with ventilation (VIP)
Ward A28	Schl 66	C	68	35	62	64.35	33.34	16.95	33.4 5	32.8 4	38.6 9	37.8 8	28.5 4	0.92	1460 0.00	3.00	0.53	Formal	Muni cipal	Flush toilet (connected to sewerage system)
Ward A10	Schl 67	C	16	36	12	21.88	5.07	3.27	2.45	3.29	2.17	1.48	4.22	0.83	1460 0.00	2.00	0.08	Traditional	River/ other	Pit toilet without ventilation
Ward A1	Schl 68	C	41	28	30	28.08	10.60	14.17	4.98	6.04	5.31	9.60	14.7 1	0.07	1460 0.00	1.00	0.11	Traditional	River/ other	Pit toilet without ventilation

Addenda

Ward A2	Schl 69	C	21	29	24	32.00	7.47	8.44	4.32	1.67	6.76	4.64	4.32	0.86	1460 0.00	2.00	0.11	Traditional	Municipal	Pit toilet with ventilation (VIP)
Ward A7	Schl 70	C	45	32	10	21.25	13.26	13.40	14.6 0	9.98	12.0 5	11.7 2	9.34	0.39	1460 0.00	2.00	0.11	Traditional	River/ other	None
Ward A18	Schl 71	C	66	30	1	31.33	15.06	7.50	7.77	4.64	6.66	5.41	5.05	0.85	1460 0.00	2.00	0.12	Traditional	River/ other	Pit toilet without ventilation
Ward A12	Schl 72	C	39	34	24	76.00	6.87	4.82	8.19	8.56	4.44	8.17	8.71	0.89	1460 0.00	2.00	0.04	Traditional	River/ other	None
Ward A8	Schl 73	C	10	18	1	9.20	3.96	5.76	4.39	4.76	2.49	4.16	1.92	0.88	1460 0.00	2.00	0.12	Traditional	River/ other	Pit toilet without ventilation
Ward A25	Schl 74	C	58	31	17	106.6 7	5.27	18.06	11.5 9	10.5 5	5.22	10.2 4	9.03	0.21	1460 0.00	1.00	0.08	Traditional	River/ other	None
Ward A20	Schl 75	C	66	36	3	1.90	10.99	13.68	10.4 7	7.54	9.06	14.9 8	5.77	0.78	1460 0.00	2.00	0.30	Traditional	Municipal	Pit toilet without ventilation
Ward A3	Schl 76	C	62	41	12	40.67	4.22	7.80	7.01	4.69	4.04	6.89	5.59	0.81	1460 0.00	2.00	0.14	Traditional	River/ other	Pit toilet without ventilation
Ward A1	Schl 77	C	36	28	0	17.75	3.67	4.76	8.91	8.35	3.27	3.19	5.15	0.07	1460 0.00	1.00	0.11	Traditional	River/ other	Pit toilet without ventilation
Ward A12	Schl 78	C	33	33	0	11.71	3.42	7.40	3.63	4.44	7.60	1.92	6.73	0.89	1460 0.00	2.00	0.04	Traditional	River/ other	None
Ward A3	Schl 79	C	32	36	5	19.36	2.70	9.79	7.69	6.30	5.54	6.35	2.79	0.81	1460 0.00	2.00	0.14	Traditional	River/ other	Pit toilet without ventilation
Ward A8	Schl 80	C	333	41	0	307.5 0	15.12	17.74	19.2 2	29.4 8	12.8 6	19.9 2	18.0 1	0.88	1460 0.00	2.00	0.12	Traditional	River/ other	Pit toilet without ventilation
Ward A1	Schl 81	C	23	35	4	12.30	3.39	12.30	8.22	10.6 2	5.76	6.69	5.05	0.07	1460 0.00	1.00	0.11	Traditional	River/ other	Pit toilet without ventilation
Ward A22	Schl 82	C	31	28	14	38.50	5.12	10.56	9.81	6.14	4.09	2.45	3.11	0.84	1460 0.00	2.00	0.10	Traditional	River/ other	None
Ward A14	Schl 83	C	88	36	0	41.70	11.70	10.57	7.60	11.3 4	5.86	6.95	6.83	0.09	1460 0.00	1.00	0.14	Traditional	River/ other	None
Ward A7	Schl 84	C	33	30	5	330.0 0	10.55	6.28	3.35	2.68	4.87	5.55	4.44	0.39	1460 0.00	2.00	0.11	Traditional	River/ other	None
Ward A6	Schl 85	C	26	30	16	82.50	7.19	9.56	7.23	8.87	9.51	9.40	6.69	0.85	1460 0.00	2.00	0.33	Traditional	River/ other	Pit toilet without ventilation
Ward A29	Schl 86	T	26	38	3	59.67	16.01	6.84	7.09	11.8 9	9.19	6.98	17.5 7	0.77	5730 0.00	2.00	0.71	Formal	Municipal	Flush toilet (connected to sewerage system)

Addenda

Ward A18	Schl 87	C	50	36	14	56.88	5.59	5.46	3.39	5.50	9.04	2.86	4.82	0.85	1460 0.00	2.00	0.12	Traditional	River/ other	Pit toilet without ventilation
Ward A18	Schl 88	C	38	31	4	25.08	11.17	8.38	4.87	3.63	4.09	5.22	5.17	0.85	1460 0.00	2.00	0.12	Traditional	River/ other	Pit toilet without ventilation
Ward A5	Schl 89	C	11	19	8	16.14	7.66	13.41	4.98	13.4 4	13.2 9	7.45	7.95	0.81	1460 0.00	2.00	0.19	Traditional	River/ other	Pit toilet with ventilation (VIP)
Ward A13	Schl 90	C	82	54	0	80.50	4.32	9.76	5.22	5.10	5.55	4.49	3.56	0.87	1460 0.00	2.00	0.10	Traditional	River/ other	Pit toilet without ventilation
Ward A13	Schl 91	C	35	31	14	19.50	9.52	3.96	12.0 7	9.23	6.78	2.51	5.72	0.87	1460 0.00	2.00	0.10	Traditional	River/ other	Pit toilet without ventilation
Ward A2	Schl 92	C	162	32	0	51.50	6.60	5.22	5.13	3.90	5.81	7.46	4.22	0.86	1460 0.00	2.00	0.11	Traditional	Muni cipal	Pit toilet with ventilation (VIP)
Ward A15	Schl 93	C	55	34	3	28.90	24.01	6.69	7.98	8.46	25.3 7	25.2 1	20.8 9	0.93	1460 0.00	3.00	0.53	Formal	Muni cipal	Pit toilet with ventilation (VIP)
Ward A9	Schl 94	C	73	41	16	46.07	8.91	16.80	20.5 7	9.15	8.03	9.32	9.51	0.01	1460 0.00	1.00	0.07	Traditional	River/ other	Pit toilet with ventilation (VIP)
Ward A9	Schl 95	C	72	41	5	40.00	10.14	14.24	7.89	7.09	3.49	5.70	2.24	0.01	1460 0.00	1.00	0.07	Traditional	River/ other	Pit toilet with ventilation (VIP)
Ward A5	Schl 96	C	22	20	9	9.68	16.29	3.61	6.50	3.27	6.53	9.84	11.0 7	0.81	1460 0.00	2.00	0.19	Traditional	River/ other	Pit toilet with ventilation (VIP)
Ward A3	Schl 97	C	27	25	12	29.63	14.67	12.86	8.32	9.13	4.55	12.7 2	18.9 3	0.81	1460 0.00	2.00	0.14	Traditional	River/ other	Pit toilet without ventilation
Ward A14	Schl 98	T	62	33	10	24.30	16.60	13.24	10.9 2	7.26	5.59	7.83	10.1 1	0.09	1460 0.00	1.00	0.14	Traditional	River/ other	None
Ward A22	Schl 99	C	30	30	17	32.00	5.87	4.22	4.02	5.83	14.5 5	9.45	4.62	0.84	1460 0.00	2.00	0.10	Traditional	River/ other	None
Ward A17	Schl 100	C	30	24	15	229.0 0	12.10	7.44	4.83	3.90	4.38	5.54	5.97	0.35	1460 0.00	2.00	0.09	Traditional	River/ other	None

ADDENDUM E: INTERVIEW QUESTIONS FOR TEACHERS

DATE 2 May 2018 2 May 2018 2 May 2018

TITLE OF THE RESEARCH PROJECT

The effect of a S4F FM programme on a Schl community in rural South Africa The effect of a S4F FM programme on a Schl community in rural South Africa The effect of a S4F FM programme on a Schl community in rural South Africa

PRINCIPAL RESEARCHER'S NAMES AND CONTACT NUMBER:

Sibongile Beje Sibongile Beje Sibongile Beje Student No.:2015336783Student No.:2015336783Student No.:2015336783
 Contact No. :0825691133Contact No. :0825691133Contact No. :0825691133

FACULTY AND DEPARTMENT:

Faculty of Education Faculty of Education Faculty of Education
Schl of Education StudiesSchl of Education StudiesSchl of Education Studies

STUDY LEADER(S) NAME AND CONTACT NUMBER:

Dr. Lynette Jacobs (UFS staff member)Dr. Lynette Jacobs (UFS staff member)Dr. Lynette Jacobs (UFS staff member)
 Contact number: 051 5051289, AND Contact number: 051 5051289, AND Contact number: 051 5051289, AND

Dr.Cobus Van Breda (UFS staff member)Dr.Cobus Van Breda (UFS staff member)Dr.Cobus Van Breda (UFS staff member)
 Contact number: 051 4013640Contact number: 051 4013640Contact number: 051 4013640

QUESTIONS

1. Do you like Maths for your child?
 2. Do you help the child with Maths homework at home?
 3. What prompts you to help your child with homework, if you do?
 4. What challenges do you encounter when helping your child with Maths homework, if you do?
 5. What do you consider to be your role in your child's education?
 6. Are teachers giving homework in a way that makes it easier for you to help the child?
 7. Do you agree with the way the Schl evaluate your child?
 8. Do you believe you're your assistance with home helps your child to do better in Mathematics?
-

ADDENDUM F: INTERVIEW QUESTIONS FOR S4F FM STAFF

DATE : 2 May 2018 2 May 2018 2 May 2018

TITLE OF THE RESEARCH PROJECT

The effect of a S4F FM programme on a Schl community in rural South Africa
 The effect of a S4F FM programme on a Schl community in rural South Africa
 The effect of a S4F FM programme on a Schl community in rural South Africa

PRINCIPAL RESEARCHER'S NAMES AND CONTACT NUMBER:

Sibongile Beje Sibongile Beje Sibongile Beje *Student* *No.:2015336783*
Student No.:2015336783 *Contact* *No. :0825691133*
Contact No. :0825691133

FACULTY AND DEPARTMENT:

Faculty of Education Faculty of Education Faculty of Education
Schl of Education Studies Schl of Education Studies Schl of Education Studies

STUDY LEADER(S) NAME AND CONTACT NUMBER:

Dr. Lynette Jacobs (UFS staff member)
Contact number: 051 5051289, AND

Dr.Cobus Van Breda (UFS staff member)
Contact number: 051 4013640

QUESTIONS

1. How did the S4F FM programmes start in SA?
2. How widespread is S4F in South Africa?
3. Which communities are a primary target of S4F FM programme and why?
4. In what way has the original EQUALS and FM programmes been adapted to suite SA conditions?
5. What is your belief about the impact of S4F FM on learner academic achievement and perceptions of Schl community towards Maths education?
6. What is your belief about the future of S4F FM programme in the country, regarding sponsorship, uptake by communities and participation by stakeholders like education department?
7. What challenges, if any, that hinder effective implementation of S4F FM programmes and how can these be addressed?

ADDENDUM G: INTERVIEW QUESTIONS FOR LEARNERS

DATE: 2 May 2018 2 May 2018 2 May 2018

TITLE OF THE RESEARCH PROJECT

The effect of a S4F FM programme on a Schl community in rural South Africa
The effect of a S4F FM programme on a Schl community in rural South Africa
The effect of a S4F FM programme on a Schl community in rural South Africa

PRINCIPAL RESEARCHER'S NAMES AND CONTACT NUMBER:

Sibongile Beje Sibongile Beje Sibongile Beje Student No.:2015336783
Student No.:2015336783 Student No.:2015336783 Contact No. :0825691133
Contact No. :0825691133 Contact No. :0825691133

FACULTY AND DEPARTMENT:

Faculty of Education Faculty of Education Faculty of Education
Schl of Education Studies Schl of Education Studies Schl of Education Studies

STUDY LEADER(S) NAME AND CONTACT NUMBER:

Dr. Lynette Jacobs (UFS staff member) Dr. Lynette Jacobs (UFS staff member) Dr. Lynette Jacobs (UFS staff member)
Contact number: 051 5051289, AND Contact number: 051 5051289, AND Contact number: 051 5051289, AND

Dr.Cobus Van Breda (UFS staff member) Dr.Cobus Van Breda (UFS staff member) Dr.Cobus Van Breda (UFS staff member)
Contact number: 051 4013640 Contact number: 051 4013640 Contact number: 051 4013640

QUESTIONS

- a. Who assists you at home with your homework?
- b. Is the assistance you get at home helping you?
- c. How is your performance on the subject?
- d. How easy or difficult is to understand Mathematics in the classroom
- e. How do you believe you fare in Mathematics compared to other Schl subjects?
- f. Do you believe that Mathematics is among the subjects you have strength on?
- g. Do you think knowing Mathematics does help you in your daily life?
- h. Will you later in life want to work in a job that requires you to know Mathematics?
- i. Do you enjoy or dislike doing Mathematics homework?
- j. What is the opinion of the way you get assisted with Mathematics homework, at home?
 - a. Do you think the way you get assisted in mathematics at home complements or is aligned to the way the subject is taught at Schl?
 - b. Do you think people in the home should voluntarily assist you with Mathematics or wait for you to request help from them?

ADDENDUM H: APPLICATION TO CONDUCT RESEARCH FROM DEAN OF
EDUCATION FACULTY AS A SAMPLE OF ALL APPLICATIONS MADE TO THE
UNIVERSITY.

15 Ultsig Street
Maclear
5480
+27(0) 82 5691133
Student Number:
2015336783

Dean of Education Faculty
University of the Free State
Date: 27/03/2018

Dean of Education Faculty: Prof. Loyiso Jita

Request to conduct research

I am Sibongile Beje, a University of the Free State (UFS) PhD student in Curriculum studies of the Faculty of Education. I am doing research and would like to request permission to conduct my research at UFS. My research work is being supervised and co-supervised by Dr. Lynette Jacobs and Dr. Cobus Van Breda (both UFS staff members), respectively. The title of my research is: The effect of a S4F FM programme on a Schl community in rural South Africa. I hope to commence with actual research once I have obtained ethical clearance, until end of 2018. I work as the Deputy Education Specialist in the Joe Gqabi Education District of the Eastern Cape. Part of my job is to analyse learners' term results for the District. In the course of doing this job, I observed that learners' performance in Mathematics decreased as learners progressed from grade 1 to 9. Further insights from literature revealed that Mathematics education, in the primary phase, in the country is failing to equip learners with the required skills to cope with the subject. I then became

interested in the effect of the intervention programmes that are aimed at improving learner performance in the subject.

The University of the Free State is rolling out a S4F FM programme, called Science 4 the Future, in the OR Tambo Inland District of the Eastern Cape, amongst others, as one such intervention programmes to improve learner performance in Mathematics. The overall aim of this study is *explore and describe the changes that were brought about through an S4F FM programme in a rural Schl community in South Africa*. Role players include family members, learners and teachers.

The S4F FM programmes has its origins in the United States of America with specific goals and philosophical underpinnings. Part of my research is to understand the background of the programme in South Africa in general and UFS in particular. UFS staff members who are currently working in the programme or previously worked in it will assist me as interviewees. I hope to get insight, from interviewing UFS staff, into the rationale, mission and operational rollout of the programme in the rural areas of South Africa.

Person to person interviews will be held with three out of a total of ten permanent UFS staff working in the Science 4 the Future programme. A few open-ended questions will be asked. The interviews are not expected to last longer than one hour for each of interviewee. I foresee no potential risk to the interviewees. I, however, will conduct the interviews in a manner, time and place that will cause the least inconvenience possible. While there may be no direct benefit to individual UFS staff members that will be interviewed, some benefit may accrue to the programme itself. The study may bring to the fore salient experiences of the targeted communities, which may help in the evaluation process of the rollout strategies.

I will keep all information obtained from the interviewees confidential and the identity of each interviewee, will also not be identified and recorded anywhere and at any stage of the research project. Instead, each interviewee's answers will be given a fictitious code number or a pseudonym, and the interviewee will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings. Answers from interviewees may be reviewed by people responsible for making sure that research is done correctly, including the research supervisors, transcriber, external

coder, members of the Research Ethics Committee. No third party that will have access to the raw data generated from the interaction with the UFS staff.

For the results of this research project to be of benefit to others, the anonymous data generated from interviewees may be used or feature in research reports, thesis, journal articles and conference presentations. Consequently, it may be impossible, under group interview circumstances, to guarantee absolute privacy and therefore, I cannot guarantee that other participants in the focus group will treat information confidentially. I shall, however, encourage all participants to do so. I will also explain to all participants that they can stop being in the study at any time without getting in trouble.

Yours sincerely

Sibongile Beje Student No.:2015336783

Contact No. :0825691133

ADDENDUM I: EASTERN CAPE EDUCATION DEPARTMENT APPROVAL TO CONDUCT RESEARCH



STRATEGIC PLANNING POLICY RESEARCH AND SECRETARIAT SERVICES

Steve Vukile Tshwete Complex • Zone 6 • Zweifelshe • Eastern Cape
Private Bag X0032 • Bisho • 5606 • REPUBLIC OF SOUTH AFRICA
Tel: +27 (0)40 608 4773/4035/4537 • Fax: +27 (0)40 608 4574 • Website: www.ecedoe.gov.za

Enquiries: B Pamla Email: babalwa.pamla@ecedoe.gov.za Date: 11 June 2018

Mr. Sibongile Beje

A104 Administration Block

P.O. Box 339

Bloemfontein

9300

Dear Mr. Beje

PERMISSION TO UNDERTAKE A DOCTORAL STUDY: THE EFFECT OF THE FAMILY MATHEMATICS PROGRAMME ON THE PERCEPTIONS OF A SCHOOL COMMUNITY TOWARDS MATHEMATICS

1. Thank you for your application to conduct research.
2. Your application to conduct the above mentioned research involving 75 learners, 12 educators from five (5) selected schools in OR Tambo Inland District under the jurisdiction 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;

- g. your research will be limited to those 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;
 - h. 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.
 - i. you present the findings to the Research Committee and/or Senior Management of the Department when and/or where necessary.
 - j. you are requested to provide the above to the Chief Director: Strategic Management Monitoring and Evaluation upon completion of your research.
 - k. you comply with all the requirements as completed in the Terms and Conditions to conduct Research in the ECDoE document duly completed by you.
 - l. you comply with your ethical undertaking (commitment form).
 - m. 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 nelisa.kanjana@ecdod.gov.za should you need any assistance.



NY KANJANA

**DIRECTOR: STRATEGIC PLANNING POLICY RESEARCH & SECRETARIAT SERVICES
FOR SUPERINTENDENT-GENERAL: EDUCATION**



ADDENDUM J: SUMMARY CODE OUTPUT FROM R PROGRAMMING SOFTWARE

Model 1

```

summary (model1 <- glm (Treatment ~ Enrlmnt_Grade3 + MedIncome + PropElectr
icity, data=Schls, family = binomial ()))
##
## Call:
## glm(formula = Treatment ~ Enrlmnt_Grade3 + MedIncome + PropElectricity,
##      family = binomial(), data = Schls)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.2458  -0.3428  -0.2000  -0.1518   2.9162
##
## Coefficients:
##              Estimate Std. Error z value      Pr(>|z|)
## (Intercept)   -3.4004     0.3990  -8.523 < 0.0000000e+000 ***
## Enrlmnt_Grade3  0.7057     0.2009   3.512   0.000445 ***
## MedIncome      0.7730     0.2230   3.465   0.000529 ***
## PropElectricity -0.6678     0.2699  -2.474   0.013355 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 121.214  on 267  degrees of freedom
## Residual deviance:  98.158  on 264  degrees of freedom
## AIC: 106.16
##
## Number of Fisher Scoring iterations: 6

pred1 <- predict(model1, type='response')
Schls$Propensity <- pred1

```

Model 2

Regression modelling using the more balanced sample

Library(Lme4)

```
## Loading required package: Matrix

POdata <- mergedSchls1
POdata$Treatment <- POdata$Treatment=="T"
summary(model2 <- lm(LearnerAverage ~ Treatment + DataYear + SubjectGrade +
  LearnersPerEducator_2017 + Pregnancies_2017 + LearnerToilet_2017 +
  Education + PropEmployed + WaterSource + Enrlmnt_Grade3 + MedIncome +
  PropElectricity + Propensity, data=POdata))

##
## Call:
## lm(formula = LearnerAverage ~ Treatment + DataYear + SubjectGrade +
##     LearnersPerEducator_2017 + Pregnancies_2017 + LearnerToilet_2017 +
##     Education + PropEmployed + WaterSource + Enrlmnt_Grade3 +
##     MedIncome + PropElectricity + Propensity, data = POdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -51.815  -6.372   0.298   7.215  39.890
##
## Coefficients:
##              Estimate Std. Error t value
## (Intercept)      65.86123     0.63849 103.152
## TreatmentTRUE       3.47967     0.21914  15.879
## DataYear           0.03369     0.06213   0.542
## SubjectGradeMathematics (Gr 01) -1.78585     0.23754  -7.518
## SubjectGradeMathematics (Gr 02) -1.46441     0.23756  -6.164
## SubjectGradeMathematics (Gr 03) -1.91836     0.23665  -8.106
## SubjectGradeMathematics (Gr 04) -7.92907     0.23818 -33.290
## SubjectGradeMathematics (Gr 05) -7.34225     0.24248 -30.279
## SubjectGradeMathematics (Gr 06) -6.24643     0.24719 -25.270
## LearnersPerEducator_2017      -0.84671     0.09126  -9.278
## Pregnancies_2017              1.08358     0.06559  16.521
## LearnerToilet_2017           -0.19638     0.10892  -1.803
## Education                   0.69700     0.14562   4.786
## PropEmployed                 -6.17730     0.59822 -10.326
## WaterSourceRiver/other       -8.93449     0.93417  -9.564
## Enrlmnt_Grade3                1.14345     0.13850   8.256
## MedIncome                    4.05360     0.30562  13.264
## PropElectricity              0.12730     0.16816   0.757
## Propensity                   -7.28155     1.24898  -5.830
##
##              Pr(>|t|)
## (Intercept) < 0.0000000000000002 ***
## TreatmentTRUE < 0.0000000000000002 ***
## DataYear      0.5877
## SubjectGradeMathematics (Gr 01) 0.00000000000056810 ***
## SubjectGradeMathematics (Gr 02) 0.000000000715344634 ***
## SubjectGradeMathematics (Gr 03) 0.000000000000000538 ***
## SubjectGradeMathematics (Gr 04) < 0.0000000000000002 ***
## SubjectGradeMathematics (Gr 05) < 0.0000000000000002 ***
## SubjectGradeMathematics (Gr 06) < 0.0000000000000002 ***
## LearnersPerEducator_2017 < 0.0000000000000002 ***
## Pregnancies_2017 < 0.0000000000000002 ***
## LearnerToilet_2017      0.0714 .
```

```
## Education 0.000001705245981013 ***
## PropEmployed < 0.00000000000000002 ***
## WaterSourceRiver/other < 0.00000000000000002 ***
## Enrlmnt_Grade3 < 0.00000000000000002 ***
## MedIncome < 0.00000000000000002 ***
## PropElectricity 0.4490
## Propensity 0.000000005588535161 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 11.99 on 37301 degrees of freedom
## Multiple R-squared: 0.1154, Adjusted R-squared: 0.115
## F-statistic: 270.5 on 18 and 37301 DF, p-value: < 0.00000000000000022
```

Model 3

```
summary (model3 <- Lm (LearnerAverage ~ Treatment + DataYear + Subject
Grade, data=POdata))
```

```
##
## Call:
## lm(formula = LearnerAverage ~ Treatment + DataYear + SubjectGrade,
## data = POdata)
##
## Residuals:
## Min 1Q Median 3Q Max
## -53.735 -6.901 -0.146 7.350 40.107
##
## Coefficients:
## Estimate Std. Error t value
## (Intercept) 59.80819 0.19234 310.957
## TreatmentTRUE 2.33515 0.12859 18.160
## DataYear 0.06900 0.06403 1.078
## SubjectGradeMathematics (Gr 01) -1.57734 0.24438 -6.454
## SubjectGradeMathematics (Gr 02) -1.15756 0.24437 -4.737
## SubjectGradeMathematics (Gr 03) -1.67434 0.24354 -6.875
## SubjectGradeMathematics (Gr 04) -7.66292 0.24520 -31.251
## SubjectGradeMathematics (Gr 05) -6.95002 0.24961 -27.843
## SubjectGradeMathematics (Gr 06) -5.81573 0.25445 -22.857
## Pr(>|t|)
## (Intercept) < 0.00000000000000002 ***
## TreatmentTRUE < 0.00000000000000002 ***
## DataYear 0.281
## SubjectGradeMathematics (Gr 01) 0.0000000001099 ***
## SubjectGradeMathematics (Gr 02) 0.0000021786009 ***
## SubjectGradeMathematics (Gr 03) 0.0000000000063 ***
## SubjectGradeMathematics (Gr 04) < 0.00000000000000002 ***
## SubjectGradeMathematics (Gr 05) < 0.00000000000000002 ***
## SubjectGradeMathematics (Gr 06) < 0.00000000000000002 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 12.37 on 37311 degrees of freedom
## Multiple R-squared: 0.05911, Adjusted R-squared: 0.05891
## F-statistic: 293 on 8 and 37311 DF, p-value: < 0.00000000000000022
```

Model 4

```
summary(model4 <- lmer(LearnerAverage ~ (1|EmisCode) + (1|DataYear)
+ SubjectGrade + Treatment, data=POdata))
## Linear mixed model fit by REML ['lmerMod']
## Formula:
## LearnerAverage ~ (1 | EmisCode) + (1 | DataYear) + SubjectGrade +
##   Treatment
##   Data: POdata
##
## REML criterion at convergence: 289438.6
##
## Scaled residuals:
##   Min       1Q   Median       3Q      Max
## -4.4871 -0.5376  0.0232  0.6014  3.4228
##
## Random effects:
##   Groups   Name                Variance Std.Dev.
##   EmisCode (Intercept)  15.1308  3.8898
##   DataYear (Intercept)   0.1292  0.3595
##   Residual                136.1575 11.6687
## Number of obs: 37320, groups: EmisCode, 30; DataYear, 3
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept)      58.8038     1.0769  54.606
## SubjectGradeMathematics (Gr 01) -1.7905     0.2314  -7.739
## SubjectGradeMathematics (Gr 02) -1.5391     0.2315  -6.648
## SubjectGradeMathematics (Gr 03) -2.0390     0.2307  -8.837
## SubjectGradeMathematics (Gr 04) -8.0252     0.2323 -34.545
## SubjectGradeMathematics (Gr 05) -7.4805     0.2364 -31.644
## SubjectGradeMathematics (Gr 06) -6.3719     0.2410 -26.439
## TreatmentTRUE         3.2193     1.4305   2.250
##
## Correlation of Fixed Effects:
##              (Intr) SGM(G01) SGM(G02) SGM(G03) SGM(G04) SGM(G05) SGM(G06)
## SbjcGM(G01) -0.116
## SbjcGM(G02) -0.116  0.551
## SbjcGM(G03) -0.116  0.553  0.553
## SbjcGM(G04) -0.116  0.548  0.549  0.552
## SbjcGM(G05) -0.113  0.538  0.539  0.542  0.539
## SbjcGM(G06) -0.111  0.529  0.529  0.532  0.529  0.519
## TretmntTRUE -0.708 -0.001 -0.002 -0.001 -0.002 -0.002 -0.002
```

Model 5

Impact by grade

```
impactbygrade <- diff(coef(model5 <- lm(LearnerAverage ~ SubjectGrade:
Treatment-1, data=POdata)),7)
impact <- data.frame(Grade=c('R', '1', '2', '3', '4', '5', '6'), TreatmentEf
fect=impactbygrade, row.names = 1:7)
kable(impact)
```