# A COLLABORATIVE MODEL FOR TEACHING AND LEARNING MATHEMATICS IN SECONDARY SCHOOLS

BY

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**DECLARATION**

It is my declaration that**,** a Study on A **COLLABORATIVE MODEL FOR TEACHING AND LEARNING MATHEMATICS IN SECONDARY SCHOOLS** is my efforts, as well as all of the sources of material I have utilized in the document, are clearly identified, and recognized through the use of a comprehensive reference list.

In addition, I would like to clarify that I have submitted my thesis to the Turnitin software for verification of originality.

This thesis has not been presented for execution at any other university for any qualification than its current one.

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## DEDICATION

This endeavor would not have been possible without the social and emotional support of my wonderful boys Thembisile Praise and Loyiso, who labored relentlessly with me to inspire performance. This is a particular dedication to them. To them I say, "Boys, it's been a long time, but the benchmark has been defined; the sky is the limit for you’’.

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## THE ABSTRACT

Mathematics pass rates in South African schools, as in many developing nations, continue to be a source of concern for educators and policymakers alike. Improving mathematics performance is non-negotiable if Africa is to meet the African Union Agenda 2063 and the SADC Industrialization Strategy 2063. The study sought to corroborate the findings and provide an empirical model to improve mathematics performance in secondary schools, as research studies attest to a relationship between attitude to science and science achievement, as well as a correlation between mathematics underperformance and inadequate home and school resources and underqualified and incompetent teachers.

The research focused on creating a collaborative secondary school math model. Twenty Grade 10 mathematics students, five teachers, and two subject advisers participated in the desk review, interviews, and group discussions. The study's purpose was to create a collaborative secondary school mathematics teaching and learning approach to help educators learn more about their subject. Four contextual factors—student, educator, school, and classroom—calibrated the model. Teacher-classroom activities were examined as a way to improve classroom performance. Research data to answer the research questions was collected from mathematics teachers, subject advisors, learners, and Departmental Heads(DHs) using classroom observations, semi structured interviews, questionnaires, focus group interviews and performance tests.

The study revealed that educators lack pedagogical content expertise and reform proposals. Math teachers teach in isolation. Thus, the development of a collaborative model used learners' and educators' inherent inclination to work in groups, share viewpoints, and solve problems to develop classroom and staffroom relationships.

Establishing a community of progressive, collegial, and interdependent specialists to improve mathematics education in secondary schools will enhance interest in the subject. Due to its case study of five schools in a cluster, the research was inconclusive, but the results were enlightening. Due to university time and money constraints, the research was constrained. To improve the model, an extensive follow-up investigation is needed. To improve the notion, researchers are studying educator isolation vs. cooperation, peer assessments, and teacher and student learning.

**AMAFUSHANE**

Amazinga okuphasa kwezibalo ezikoleni zaseNingizimu Afrika, njengakwamanye amazwe asathuthuka, asaqhubeka nokuba yinkinga kothisha nabakhi benqubomgomo ngokufanayo. Ukwenza ngcono ukusebenza kwezibalo akunakuxoxiswana uma i-Afrika izohlangabezana ne-African Union Agenda 2063 kanye ne-SADC Industrialization Strategy 2063. Lolu cwaningo belufuna ukuqinisa lokho okutholakele futhi lunikeze imodeli enamandla yokuthuthukisa ukusebenza kwezibalo ezikoleni zamabanga aphezulu, njengoba ucwaningo lufakazela ukuthi ubudlelwano phakathi kwesimo sengqondo ekuphumeleleni kwesayensi nesayensi, kanye nokuhlobana phakathi kokungenzi kahle kwezibalo kanye nezinsizakusebenza zasekhaya nezesikole ezinganele kanye nothisha abangaqeqeshiwe nabangakwazi ukusebenza kahle.

Ucwaningo lugxile ekudaleni imodeli yezibalo zesikole samabanga aphakeme esebenzisanayo. Abafundi bezibalo beBanga le-10 beBanga le-10, othisha abahlanu, nabeluleki bezifundo ababili babambe iqhaza ekubuyekezweni kwedeski, ezingxoxweni nasezingxoxweni zamaqembu. Inhloso yocwaningo kwakuwukwakha indlela yokusebenzisana yokufundisa nokufunda izibalo zesikole samabanga aphezulu ukusiza othisha bafunde okwengeziwe ngesifundo sabo. Izici ezine zomongoΓÇöumfundi, uthisha, isikole, nekilasiΓÇözilinganise imodeli. Imisebenzi yasekilasini lothisha yahlolwa njengendlela yokuthuthukisa ukusebenza kwekilasi. Idatha yokuphendula imibuzo yocwaningo iqoqwe kothisha bezibalo, abeluleki bezifundo, abafundi, kanye neziNhloko zoMnyango(ama-DH) kusetshenziswa okubonwa ekilasini, izingxoxo ezihleliwe ezihleliwe, uhlu lwemibuzo, izinhlolokhono zamaqembu kanye nezivivinyo zokusebenza.

Ucwaningo luveze ukuthi othisha abanabo ubungcweti bokuqukethwe kokufundisa kanye neziphakamiso zezinguquko. Othisha bezibalo bafundisa bodwa. Ngakho-ke, ukuthuthukiswa kwemodeli yokusebenzisana kusebenzise ukuthambekela okungokwemvelo kwabafundi nothisha ekusebenzeni ngamaqembu, ukwabelana ngemibono, nokuxazulula izinkinga ukuze kuthuthukiswe ubudlelwano bekilasi nothisha.

Ukusungula umphakathi wochwepheshe abathuthukayo, abafundayo, nabancike komunye ukuze kuthuthukiswe imfundo yezibalo ezikoleni zamabanga aphezulu kuzothuthukisa intshisekelo kulesi sifundo. Ngenxa yocwaningo lwayo lwezikole ezinhlanu eziqoqweni, ucwaningo belungaphelele, kodwa imiphumela ibikhanyisa. Ngenxa yesikhathi sasenyuvesi kanye nezingqinamba zemali, ucwaningo lwaba nengcindezi. Ukuze uthuthukise imodeli, uphenyo olunzulu lokulandelela luyadingeka. Ukuze kuthuthukiswe lo mbono, abacwaningi bafunda ukuhlukaniswa kothisha ngokumelene nokubambisana, ukuhlola kontanga, nokufunda kothisha nabafundi.

## DIE OPSOMMING

Wiskunde-slaagsyfers in Suid-Afrikaanse skole, soos in baie ontwikkelende lande, bly steeds 'n bron van kommer vir opvoeders en beleidmakers. Die verbetering van wiskundeprestasie is ononderhandelbaar indien Afrika aan die Afrika-unie Agenda 2063 en die SAOG Industrialiseringstrategie 2063 wil voldoen. Die studie het gepoog om die bevindinge te staaf en 'n empiriese model te verskaf om wiskundeprestasie in sekond├¬re skole te verbeter, soos navorsingstudies getuig van 'n verband tussen houding teenoor wetenskap en wetenskapprestasie, sowel as 'n korrelasie tussen wiskunde-onderprestasie en onvoldoende huis- en skoolhulpbronne en ondergekwalifiseerde en onbevoegde onderwysers.

Die navorsing het gefokus op die skep van 'n samewerkende sekond├¬re skool-wiskundemodel. Twintig graad 10-wiskundestudente, vyf onderwysers en twee vakadviseurs het aan die lessenaarhersiening, onderhoude en groepbesprekings deelgeneem. Die doel van die studie was om 'n samewerkende sekond├¬re skool wiskunde-onderrig-en-leerbenadering te skep om opvoeders te help om meer oor hul vak te leer. Vier kontekstuele faktore - student, opvoeder, skool en klaskamer - het die model gekalibreer. Onderwyser-klaskameraktiwiteite is ondersoek as 'n manier om klaskamerprestasie te verbeter. Data om die navorsingsvrae te beantwoord is ingesamel van wiskunde-onderwysers, vakadviseurs, leerders en departementele hoofde (DH's) deur gebruik te maak van klaskamerwaarnemings, semi-gestruktureerde onderhoude, vraelyste, fokusgroeponderhoude en prestasietoetse.

Die studie het aan die lig gebring dat opvoeders nie pedagogiese inhoudskundigheid en hervormingsvoorstelle het nie. Wiskunde-onderwysers onderrig in isolasie. Dus het die ontwikkeling van 'n samewerkende model gebruik gemaak van leerders en opvoeders se inherente geneigdheid om in groepe te werk, standpunte te deel en probleme op te los om klaskamer- en personeelkamerverhoudings te ontwikkel.

Die vestiging van 'n gemeenskap van progressiewe, kollegiale en interafhanklike spesialiste om wiskunde-onderrig in sekond├¬re skole te verbeter, sal belangstelling in die vak verhoog. As gevolg van die gevallestudie van vyf skole in 'n groepering, was die navorsing onbeslis, maar die resultate was verhelderend. Weens universiteitstyd- en geldbeperkings was die navorsing beperk. Om die model te verbeter, is 'n uitgebreide opvolgondersoek nodig. Om die idee te verbeter, bestudeer navorsers opvoeder-isolasie vs. samewerking, portuurassesserings en onderwyser- en studenteleer.

**UMXHOLO**

Amazinga okuphumelela imathematika kwizikolo zaseMzantsi Afrika, njengakumazwe amaninzi asakhasayo, asaqhubeka engumthombo wenkxalabo kootitshala nakubaqulunqi bemigaqo-nkqubo ngokufanayo. Ukuphuculwa kwentsebenzo yemathematika akunakuxoxwa ukuba i-Afrika iza kukhawulelana ne-Ajenda yeManyano ye-Afrika ka-2063 kunye neSicwangciso soShishino soShishino lwe-SADC 2063. Uphononongo lwazama ukungqinisisa iziphumo zophando nokubonelela ngemodeli yobungqina bokuphucula indlela abaqhuba ngayo imathematika kwizikolo zasesekondari, njengoko izifundo zophando zingqina oko. Ubudlelwane phakathi kwesimo sengqondo kwimpumelelo yesayensi kunye nesayensi, kwakunye nonxulumano phakathi kokungaqhubi kakuhle kwemathematika kunye nokungonelanga kwezibonelelo zasekhaya nezesikolo kunye nootitshala abangaqeqeshwanga kakuhle nabangakwaziyo ukwenza umsebenzi wabo.

Uphando lujolise ekudaleni imodeli yezibalo yezikolo zamabanga aphakamileyo. Abafundi bemathematika beBakala 10 abangamashumi amabini, ootitshala abahlanu, nabacebisi bezifundo ababini bathathe inxaxheba kuphononongo lwedesika, kudliwano-ndlebe nakwiingxoxo zamaqela. Injongo yolu phando yayikukuyila indlela yokufundisa nokufunda yemathematika kwizikolo zasesekondari ukunceda ootitshala bafunde ngakumbi ngesifundo sabo. Iimeko ezine zomxholoΓÇöumfundi, utitshala, isikolo negumbi lokufundelaΓÇözilungelelanise imodeli. Imisebenzi katitshala-eklasini iye yavavanywa njengendlela yokuphucula ukusebenza eklasini. Idatha yokuphendula imibuzo yophando yaqokelelwa kootitshala bemathematika, kubacebisi bezifundo, kubafundi, nakwiiNtloko zamaSebe (DH) kusetyenziswa imigqaliselo eklasini, udliwano-ndlebe olucwangcisiweyo, iikhweshine, udliwano-ndlebe lwamaqela kunye neemvavanyo zentsebenzo.

Uphononongo luveze ukuba ootitshala abanabo ubungcaphephe bomxholo wokufundisa kunye nezindululo zohlaziyo. Ootitshala bezibalo bafundisa bodwa. Ngoko ke, uphuhliso lwemodeli yentsebenziswano lusebenzise utyekelo lwabafundi nootitshala lokusebenza njengamaqela, ukwabelana ngeembono, nokusombulula iingxaki ekuphuhliseni ubudlelane eklasini nootitshala.

**KEY TERMS:**

Collaborative, model, social status, supportive environment, teaching, learning, secondary schools, curriculum, corporative learning, peer learning

## LIST OF ABBREVIATIONS

APP- Appropriate Practical Practice

ANC- African National Congress

ATP – Annual Teaching Plan

CAPS- Curriculum Assessment Policy Statements

CPD-Continuous Professional Development

CD- Collaborative Model

CEER-Collaborative, Enactment, Extended, Reflection

C2005 – Curriculum 2005

DBE – Department of Basic Education

DoE – Department of Education

FP – Foundation Phase

FET – Further education and Training

IP – Intermediate Phase

JICA-Japanese International Cooperation Agency

LA – Learning Area

LTSM – Learner Teacher Support Material

MSSI-Mpumalanga Secondary Science Initiative

NDP-National Development Plan

NPC- National Planning Commission

NCS – National Curriculum Statement

OBE – Outcomes Based Education

PEEL-Project for Enhancing Effective Teaching

PISA- Programme for International Students Assessment

PCK- Pedagogical Content Knowledge

PK-Pedagogical Knowledge

RNCS – Revised National Curriculum

SADC- Southern African Development Community

STEP –Science Teacher Education Project

STEM-Science, Technology, Engineering and Mathematics

TIMSS-Trends in International Mathematics and Science Studies

TCK-Teachers Content Knowledge

UNESCO- United Nations Educational Scientific and Cultural Organization

UN-United Nations

UNISA- University of South Africa

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## CHAPTER 1: CONTEXT AND BACKGROUND OF THE STUDY: SOUTH AFRICAN EDUCATION SYSTEM

### 1.1 INTRODUCTION

*School is key in life… Education is important to me, just because I want a better life… It Hmeans a lot to me [but] my school is not 100% to learn in, just because [the] building is old so anything can happen". Ntsomi, pupil, Phillip Mtywaku Secondary School, Eastern Cape*

A depiction of the state of some of South Africa's schools particularly rural and farm contexts is shown in the Fig 1.1, which are dilapidated and unfit for the delivery of high-quality and equitable teaching and learning that would catapult the country towards internationally recognized standards.

**Figure 1.1: State of some schools in South Africa post 1994 (Adapted www.nationalachieves.com)**

South Africa has made significant financial, human, and material investments in education, which is seen as a path to national growth. However, the situation of schools described above is in direct conflict with these investments. In South Africa's national development vision, education is at the heart of the process. People's attitudes about education may be changed, and education can also aid in the fulfilment of other development goals, pursuant to the National Development Plan (2030). A key tenet of the National Development Plan 2030 (2012) is the belief that education, training, and innovation are the methods of addressing social concerns like as poverty, unemployment, and inequality, and that schools are the foundations upon which society may change and define its future. In pursuit of the National Development Agenda 2030, South Africa expects that by 2030, schooling systems will have highly motivated teachers and learners, effective principals who are competent in educational and curriculum leadership, parents who are actively involved in education, accountable schools with adequate teaching and learning resources and basic infrastructure, as per the National Development Agenda 2030 (NDA) (2012).

The prologue chapter provides information about the current status of the South African educational system, problems it is currently dealing with, educational performance, the current state of mathematics education, and factors influencing the nation's success in mathematics. The chapter served as a contextual foundation for the study on creating a collaborative approach to teaching and learning mathematics in secondary schools. In-depth expositions of the state of mathematics education in South Africa as well as the status of education in South Africa from a worldwide viewpoint were offered as a prelude to addressing the subject problem under consideration.

## 1.2 STATE OF EDUCATION IN SOUTH AFRICA: THE LAST DECADE

To begin with, the new South African Constitution, Act 196 of 1996, placed a high priority on education and established it as a Basic Human Right in Chapter 2 of the Constitution, which deals with the Bill of Rights. South Africa's inclusive education system was launched in 1996 with the introduction of an OBE (Outcome Based Education), which was introduced in Grade One the following year (Manqele, 2012). Furthermore, the government has bolstered this reform goal by prioritizing problems of education in its National Development Plan, which is part of the national vision regarding improvements in education versus the national goals. Owing to Mafukata (2016) the National Development Plan (NDP) Vision 2030 aspires to improve the quality of education for all South Africans to achieve the predicted economic growth and social development as primary outcomes of democracy. Consequently, education is now seen as the most important social concern in South Africa, and it is also considered to be a powerful source of empowerment for both people and communities.

It is well documented in the literature that South African education is a system in deep crisis, with superficial national performance against poor quality graduates post basic education, shocking statistics of poor academic performance, undertrained teachers, and teacher absences (Carte Blanche, 2012; Jansen, 2012; Metcalfe, Orkin, and Jenny, 2012; Tau. 2012; Singh, 2015; Spaull, 2015). Many students are unable to deal with the intricacy of schoolwork, and the country's performance in worldwide benchmarking examinations is abysmal, to say the least (Reddy etal, 2016; Guthrie, Evans, and Burritt 2014; Persson and Napier, 2014; Wilmot and Merino, 2015). It should be noted that the following description of the status of South Africa's education is true despite the substantial financial resources spent in education by national and provincial governments. The budgeted expenditures for education and other national departments were shown in the figure 1. 2 below.

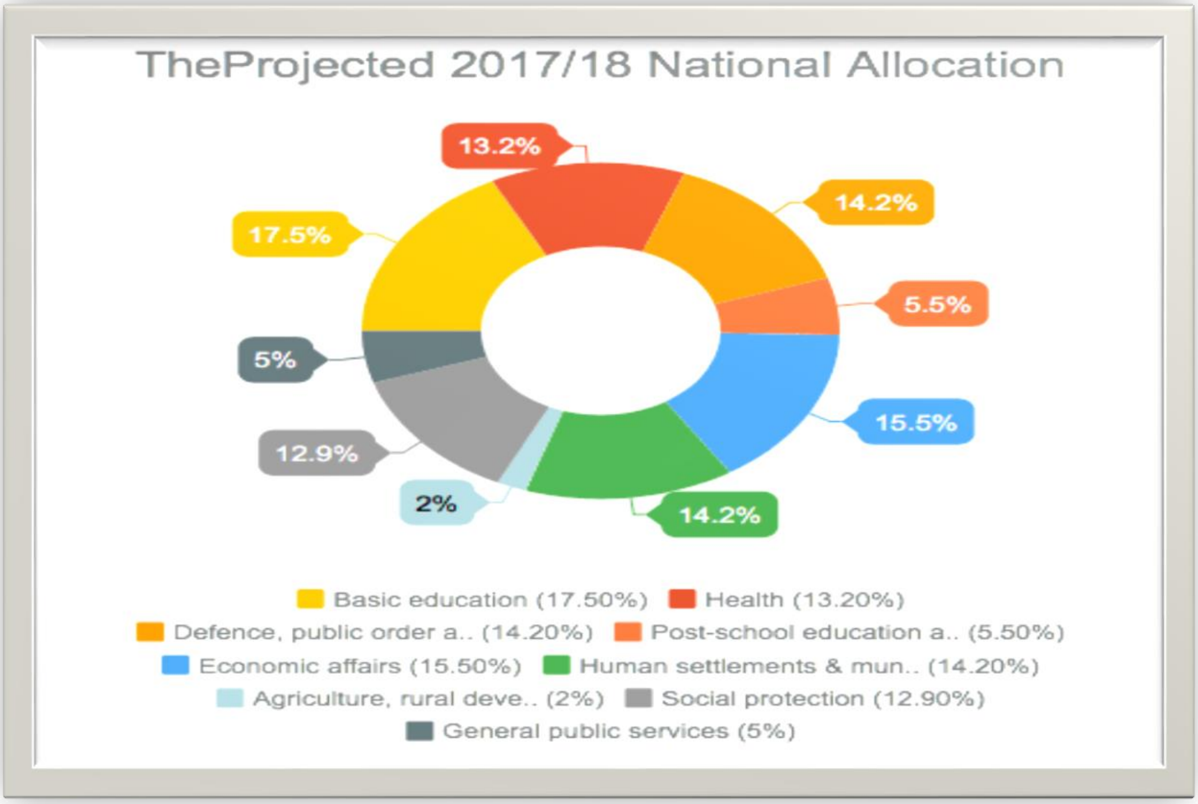


**Figure 1.2: Education Expenditures in South Africa (2017/2018)**

The Figure 1.2 illustrates how South Africa's investment on education has increased steadily over the last several decades, with the level of expenditure currently equivalent with that of rich nations and far higher than that of peer developing countries. With a budget of 230 billion Rands, education received the lion's share of overall budgetary spending for the 2017/2018 financial year, accounting for 17.5 percent of total budgetary expenditure. In the past, the apartheid regime purposefully underfunded black schools to impede the educational accomplishments of black students, according to history. Spending on white learners (formerly Model C schools) was 112 times greater than spending on black learners in urban areas in 1994, and five times higher than spending on white learners in rural regions (Branson et al. 2013). Attempts to rectify this tendency have resulted in a significant rise in government expenditure on education over the last two decades, which has been followed by several changes, including a revision of the school curriculum. When it comes to education, the South African government spent almost 20% of its budget and 6% of its GDP in 2015, outpacing several other Southern African nations and the OECD's average of 5.2 percent. In a worldwide comparison of education expenditures, South Africa had the highest ranking, accounting for 15 percent of overall education spending, placing it ahead of industrialized nations such as the United Kingdom, the United States, and Germany.

Despite significant financial investments in education, South Africa's educational spending is characterized by significant discrepancies between inputs and results. Based on research such as the World Bank (2018), the poor link between expenditure and results is also evident in many other developing nations, although South Africa is obviously an anomaly. Figure 1.3 below depicts the relationship between global nations and South Africa in terms of educational investment and results in higher education.

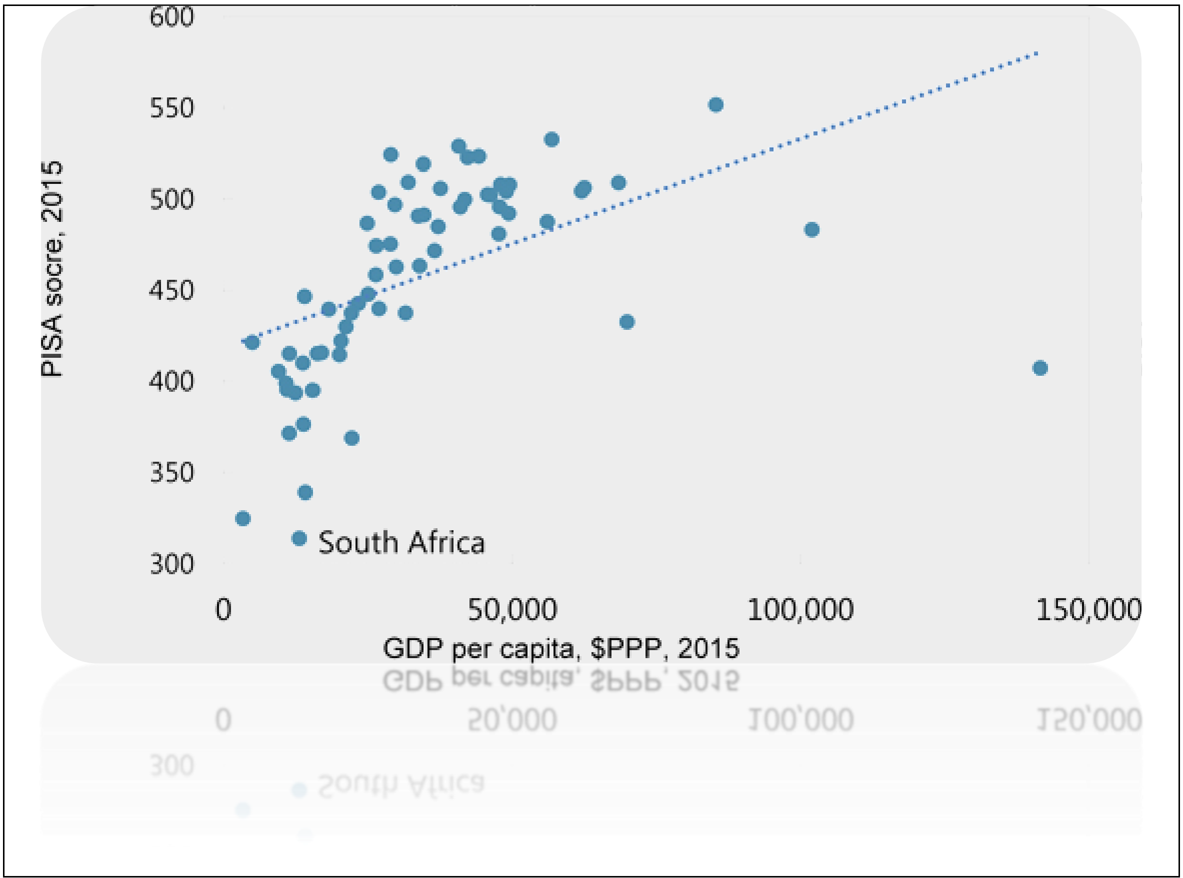


**Figure 1.3: PISA scores against GDP per capita for a group of countries**

There are two measures of the efficiency of educational inputs that have been developed. These are the efficient frontier and the line-of-best-fit. The efficient frontier depicts the ideal level of learner exam scores for a given amount of education spending in relation to that amount of education spending. South Africa, the country with the greatest distance between it and the efficient frontier curve in this PISA sample of countries, is depicted in Figure 1.3 as the nation with the greatest distance between it and the efficient frontier curve. This means that, in terms of expenditure per student, South Africa is the country with the greatest inefficiency among the countries included in the PISA study. With the help of the line of best fit method, the PISA scores are plotted against GDP per capita for a group of countries. Visual representations of the degree to which the quality of education is aligned or misaligned with the level of national wealth can be created in this manner. The issues facing the system, the performance of the education sector, and the status of mathematics education in the country are all discussed in greater depth in the following sections, which are divided into three categories.

### 1.2.1 CHALLENGES CONFRONTING EDUCATION IN SOUTH AFRICA

Scholars have highlighted a slew of issues plaguing South African education, including diminishing quality, a culture of dysfunctionality in schools, ineffective leadership and underperforming teachers, violence, a lack of community support, and corruption, among others (Spaull 2013, Mouton etal 2013, Maddock and Maroun 2018).

#### 1.2.1.1 Disruptive learners' behaviour in schools and classrooms

The school plays a significant role in the development of a learner's learning and socialization, and it is thus essential that schools create a safe environment in which genuine learning and growth may take place (Ngqela & Lewis, 2012). Increasingly, young people are growing up in a scary and hazardous environment, creating a generation whose lives are characterized by the prospect of being harmed or dying (Benjamin, 2011a). Not only do schools experience violence, but so do other places of employment. A global environment that is characterized by a catastrophic breakdown of traditional family structures, unemployment, significant drug usage rates, and widespread violence is one that is fostering the development of children all over the world. This environment can be found in the majority of developing and underdeveloped countries, particularly in Africa (Schoeman, 2010). However, as proven by the daily newspapers published in Pretoria, the country's capital, violence is still a common occurrence in many South African schools. According to research conducted by Tau (2011), pupils in QwaQwa did not attend school for many days in June 2011 because of persistent violence in the neighbourhood, and this has become a tragic trend in the setting of South African schools. The cause for the violence in that village was a general dissatisfaction with the newly elected mayor on the part of the populace. School disruptions are not unusual when unhappiness with other socioeconomic situations reaches a boiling point in a community and spills over into the schools.

In May 2011, a seven-year-old boy was receiving antiretroviral medication after being raped in his elementary school during normal school hours, like a different study done by Sifile (2011). Following the stabbing murder of a 15-year-old learner at this school following a gang battle with other students, parents started meeting outside the school each day to walk their children home in Delft (a small town in South Africa). They expressed concern that their children will be caught in the middle of deadly gang battles because of another pupil at this school being stabbed to death during a dispute with other students (Bezuidenhout, 2011). In addition, youngsters at Lavender Hill School are often forced to duck gunfire on their route to and from class. They were informed that one of their classmates had been shot and was in the hospital when they arrived at this school before their Grade 12 assessment began that day (Fredericks, 2011a). Certain of these episodes raise major concerns about the safety of learners in South African schools — and in several parts of the nation, violence has become chronic, with little hope of change in the foreseeable future.

#### 1.2.1.2 Inadequate infrastructural Resources

In response to insufficient classrooms, unsafe pit latrines, and antiquated teaching learning facilities, government authorities in all provinces have turned the backlog of school infrastructure into a song, which can be heard across the country. According to Spaull (2013), breaking down the statistics by province also shows some significant variances in the results. In Gauteng, 48 percent of respondents claimed that no schools had been refurbished, while 41 percent said that just a handful or a few schools had undergone renovations. 75 percent of respondents said that few or no schools had their own sports facilities, with just 11 percent claiming that most schools had such facilities. Half of those who answered the survey reported that there were either few or no libraries in their local schools. According to the Eastern Cape Education Department, 62 percent of schools have been renovated in the last 20 years, compared to only 12 percent who say all or most have been renovated; 47 percent of schools in their area do not have enough classrooms; 56 percent say either few or no schools have sports facilities; and 74 percent say either few or no schools do not have a library.

In an associated report on school infrastructure, the Department of Education (2018) found that, in 2018, out of 23,471 public schools, 19 percent used only illegal pit latrines for sanitation, with another 37 schools having no sanitation facilities at all; 86 percent lacked a laboratory; 77 percent lacked a library; 72 percent lacked internet access; and 42 percent lacked sports facilities. There were 239 schools that did not have access to power. According to South African head teachers, a lack of physical infrastructure (as opposed to the OECD average of 26 percent) is limiting the ability of their school to offer quality education to its students. Compared to the OECD average of 16 percent, 70 percent of respondents indicate a scarcity of library items. Department of Basic Education, (2018).

Apart from infrastructure, there are additional challenges that children in South Africa must face to not only get a high-quality education, but also to avoid being exposed to a greater risk of damage as a result of their education. The most common transportation issues had to go more than 2 kilometres to school in their neighbourhood, with a further 45 percent reporting that some students were required to do so; at the same time, 54 percent said that the PED does not offer transportation for students who need it. Sixty percent of respondents said that a lack of transportation had an impact on student attendance. When the data is split down by province, there are significant differences: When asked whether all or most of the students in the Eastern Cape must travel more than 2 kilometres to school, 76 percent said positively, compared to 58 percent in Limpopo and 27 percent in Gauteng, according to the survey. For pupils who required transportation, 59 percent of those questioned in Limpopo said they were not provided with it, while 51 percent in the Eastern Cape and 37 percent in Gauteng said they were not. 59 percent of respondents in the Eastern Cape said that a lack of mobility had a negative influence on student attendance, compared to 52 percent in Gauteng and 39 percent in Limpopo, DBE (2018).

The predicament is no better at the national level. Based on the 2013 National Household Travel Survey, approximately 11 million students walk to school, out of the 17.4 million students who attended educational institutions in the United States. Most of these children (22 percent, or more than 2.4 million children) walk between 30 minutes and an hour to their educational institution, which means they have walked more than 3 kilometres. Even though the Department of Transpor, in collaboration with the Department of Basic Education, is mandated to ensure that students in grades R through 12 who live more than three kilometres from the nearest school receive transportation. Children from low-income families are also more likely to walk to school than children from other parts of the province; over 210,000 students walk for more than an hour each day, while 659,000 students walk for between 30 minutes and an hour each way, National Household Travel Survey (2013).

#### 1.2.1.3 Underperforming and under trained teachers

Educators are often regarded as the most essential investment in the educational system. Personnel spending are by far the most significant investment in the system, accounting for about 90 percent of the budget in most provinces. One of the most important corrective decisions confronting policymakers is the distribution of educators.

The Amnesty International (2020) report states that between 1964 and 1994, teachers were distributed inequitably throughout all schools. The learner-to-educator ratio fluctuated from province to province. The learner-to-educator ratios in white children's schools were much lower than in other schools. With a 40:1 learner-to-teacher ratio in primary schools and a 35:1 learner-to-teacher ratio in secondary schools, the post-provisioning model, launched in

1998, aims to equalize educator ratios across the educational continuum. The introduction of this legislation had a significant impact on addressing some of the grossly unequal tendencies of state-paid educators.

There are still certain limitations to the human resources provision in schools. One major flaw was that there was no effort made to progressively spread educators around the system to address past disadvantages—that is, to position more educators in schools serving pupils who were dealing with more serious socioeconomic challenges. While a small pool of "redress posts" was formed, most of them have remained unfilled. Secondly, in secondary schools, there was a provision for extra teachers to be assigned to "weighted curriculum." The fact that these curricular offerings are still mostly offered at historically advantaged institutions means that these schools' benefit from higher financial resources. Third, the more experienced instructors continue to work at the more expensive educational institutions. Perhaps most importantly, local school governing bodies may be able to attract more teachers by employing locally produced school fees. School districts with more financial resources are in a better position than other districts to supplement their teaching staff with additional school governing body (SGB) posts. South Africa is also confronted with substantial challenges in terms of teaching talents and aptitude, particularly in the areas of language and mathematics, among other things, Amnesty International (2020).

Like the findings of another study done by Stellenbosch University, mathematics teachers in Grades 4 to 7 (Intermediate Phase) in under-resourced schools in the Eastern Cape had an excellent mastery of the subject. Teachers who were questioned by Amnesty International expressed concern about a wide range of topics. Among them were many curricular revisions as well as a trend toward more content, which resulted in less time for preparation and a less original educational contribution than in the past. Further, they said that, as the world has become more complicated, instructors have shifted from being educators to becoming facilitators instead. It was while they obtained information from curricular subject advisers. Consequently, many educators have experienced heightened stress, which has a severe impact on their kids' right to an education, Amnesty International (2020).

One further obstacle is the amount of genuine teaching time that is spent during class sessions. During a typical session, teachers devote an average of 66 percent of their classroom time on real teaching and learning, compared to an OECD average of 78 percent. Teachers and students at schools with a high proportion of students from low-income households spend less time on real teaching and learning, with each 60-minute class spending more than 3 minutes on actual teaching and learning. To no surprise, this implies that more classroom management techniques are being used in South Africa, with 84 percent of instructors reporting that they regularly deal with disruptive students (compared to a global average of 65 percent), according to the Organisation for Economic Co-operation and Development (OECD) (2016).

On research on the South African education crisis, Spaull (2013) indicates that educators failed in worldwide benchmarking exams. SACMEQ III (2007) examined Grade Six instructors in addition to Grade Six students. According to the analysis of this data, many South African mathematics educators s have below-basic levels of topic understanding, with many teachers failing to answer questions directed at their students. The subject knowledge levels of grade six mathematics teachers in quintiles one, two, and three were equivalent to those of the typical teacher in Mozambique, Zambia, and Malawi, but much lower than those of teachers in Kenya, Zimbabwe, Uganda, and Tanzania. In a similar vein, rural mathematics educators in South Africa exhibited much lower levels of subject mastery than rural mathematics educators in Swaziland, Tanzania, Uganda, and Kenya. As a result, it is surprising that the top 5 percent of Grade Six students in South Africa (565 students) performed better on the same mathematics test than the poorest 20% of Grade Six mathematics instructors in the sample. Given that both the teacher and child exams are scaled to be equivalent, this is a significant finding (80 teachers). Considering the fact that educators cannot teach what they do not know, these findings have significant implications for the educational quality in South Africa. It will be very difficult to increase student achievement in these areas unless the subject expertise (and eventually the pedagogical content knowledge) of mathematics educators in disadvantaged and rural locations is enhanced significantly.

Based on a study by Carnoy et al. (2011), Grade 6 mathematics educators in the Northwest received an average score of 40 percent on a test that was mostly consisted of Grade 6 level questions (see Taylor & Reddi, 2013 and Taylor & Taylor, 2013). All the studies that have looked at teacher topic knowledge in South Africa to far have been limited, isolated project-based inquiries into teacher content knowledge in a given place up until this point. While they are very instructive and, when considered together, provide a strong indication that teacher subject knowledge is badly lacking (at least in certain areas of the educational system), they are not representative of the whole country's educational system. Only the SACMEQ III study, which was completed in 2007, seems to represent an exception to this pattern. Participants in the SACMEQ III study included 392 primary schools, 498 Grade Six reading teachers, and 498 Grade Six mathematics teachers, among others. The survey was done in South Africa and was designed to be nationally representative. Since the tests were not completed by every educator, we were only able to evaluate the maths-teacher scores for 401 Grade Six math teachers and the reading-teacher scores for 415 Grade Six reading teachers.

An investigation by the country's universities into the reasons for African school leavers' reluctance to teach primary school learners investigated why African school leavers did not want to teach children between the ages of five and nine. Govender (2011) reports that African trainee teachers preferred to teach high school learners rather than their younger counterparts, which is consistent with the findings of the study. Only 15 out of 324 teachers who graduated with a teaching degree with a specialization in the Foundation Phase were Africans, according to brief research done at four universities (Govender, 2011). The findings of the TIMSS examinations also revealed that instructors who had strong mathematics pedagogical views were more likely to have students who achieved lower scores (Howie, 2004). Constant curriculum change, as well as extra training sessions designed to "teach the new curriculum," may be contributing to teachers' underperformance (Bertram, 2011).

There were dismal outcomes in the Eastern Cape Province in 2010 for grades K-12. Most students in grades one through seven were only able to pass, and only half of those students made it to high school (Editorial comment, 2011). Schooling in South Africa's system is incredibly inefficient, as the country can claim nearly 100% enrolment in Grade 1 with less than one-quarter of these learners expected to complete Grade 12 (Motala in Gernetzky, 2011a)—wastage that the country cannot afford to have, especially when it comes to supplying the economy with well-trained laborers.

Regarding the South African education system, the morale and productivity of educators are important factors in determining the overall quality of teaching delivered. Researchers

Matoti (2010) discovered that the majority of educators are concerned about their own futures in education as well as the long-term survival of South African institutions of higher learning. Along with the lack of accountability, they are worried about a range of topics, including the present political and economic environment, changes in policies and curriculum, and the future of the educational system. They are also concerned about excessive teacher turnover, hazardous school settings, and inadequate working circumstances, among other things. Teachers are also worried about a variety of issues, including role conflict, low teacher morale, and unprofessional behaviour by educators, among others (Matoti, 2010). It is commonly acknowledged that school administrators have a vital role to play in the educational process.

#### 1.2.1.4 Prevalence of poverty and inequality within education system

Despite South Africa's wealth and success, poverty, unemployment, and systemic inequality continue to plague the country. There is a great deal of variation in economic and social rights among different ethnic groups in this nation, including those relating to health, housing, food security, and education. Despite a little growth in skilled and semi-skilled jobs since 1994, black employment continues to be dominated by low-wage sectors like as mining and agriculture. However, despite the fact that the government's own poverty statistics indicate that just a tiny proportion of the population is impoverished, some estimates place the loss of public funds to malfeasance at R700 billion (US$ 48.6 billion). Additionally, poverty rates decreased from 66.6 percent in 2006 to 53.2 percent in 2011, although the number of people living below the national upper-bound poverty line (R992 – about US$69 – per person per month) climbed to 55.5 percent by 2018. From 1996 to 2011, access to clean water and electricity increased from 57 percent to 75 percent for all South Africans, despite the fact that more than half a million black South Africans lived below the poverty line, compared to less than one percent of the white population over the same period, Spaull (2013).

Compared to the early 1990s, infant mortality has fallen from as high as 71 deaths per 1,000 live births to 26 deaths per 1,000 live births by 2020, which is directly related to improved quality of life for mothers and their children. There have been several increases in the 659 index, which is a measure of inequality, throughout the years, with the most recent surge being between 1996 and 2015. According to World Bank estimates, the richest 10% of the population held around 71 percent of net wealth in 2015, while the poorest 60% of the population controlled just 7% of net wealth. Given that intergenerational mobility remains low, inequities are passed down from generation to generation, and the amount of inequality does not vary much with the passage of time. There is a significant link between race and economic disparity in South Africa, with black South African families earning on average less than 20% of the average salaries of white South African households. Education has the ability to make a significant and positive contribution to the decrease of inequalities in society.

Even while South Africa has done an admirable job in the preceding two decades of increasing access to education for black children at all levels, this has not always been followed with high-quality education for everyone. As a result, the educational system continues to reflect the socio-economic differences that present across the country. Pursuant to the results of a recent research of school principals from across the OECD, 71 percent of South African teachers work in schools with more than 30 percent of socio-economically disadvantaged students, which is more than three times the OECD average of 20 percent, according to the report. Another indicator of deprivation is the fact that 77.3 percent of OECD countries are in poverty, OECD (2015).

Regarding educational quality, South Africa has one of the most disparate school systems in the world. The discrepancy between test results obtained by students in the top 20% of schools and the remainder is particularly enormous. Similarly, the quality of South Africa's educational system has been criticized in many research reports. As shown in a 2015 assessment conducted by the Organization for Economic Co-operation and Development (OECD), South Africa's overall education system was placed 75th out of 76 nations. Based on the results of a 2017 worldwide study, South African Grade 4 children (aged 8-9) performed worse than any other country on a reading and literacy exam, with 78 percent of pupils unable to comprehend what they were reading for meaning. In 2018, the top 200 high schools in the nation (3 percent of all schools) had more students who received distinctions in Mathematics matric (80 percent or above) than the other 6,600 high schools put together (97 percent).

South Africa's public-school systems are effectively categorized into two, as per an examination of every educational success record that is available in the country. The smaller, higher-performing system serves the wealthiest 20-25 percent of students, who achieve significantly higher test scores than the larger system, which serves the impoverished 75-80 percent of students, and thus serves the vast majority of students in the country. Nevertheless, the outcomes in this latter, more crucial area can only be described as disappointing. When students are divided into groups based on their income, socioeconomic level, geographic location, and language, it is possible to distinguish between the two types of educational systems. However, while there are minor differences depending on which dimension of the dissemination is used to separate the distributions, the overall picture of two vastly distinct educational systems is quite clear. TIMSS (2011) revealed that the average Grade Nine pupil in KwaZulu-Natal was 2,5 years behind the average Grade Nine pupil in the Western Cape when it came to science, and that the average Grade Nine pupil in the Eastern Cape was 1,8 years behind the average pupil in Gauteng when it came to Maths and Science, according to the most recent findings.

In a similar study, PrePIRLS (2011) revealed that rural and township Grade Four students are two to two and a half years behind their urban counterparts in terms of reading proficiency. Several studies, including the National School Effectiveness Study (2007/08/09), have found that children in Grade Three who attended former-white schools performed significantly better on the same test than children in Grade Five who attended former-black schools, illustrating that large inequalities in educational outcomes exist even before the age of eight, according to the study. It has substantial economic repercussions for individuals who are touched by the low quality of education provided to the majority of young people in South Africa, according to the World Bank (2016). The economic prospects of young individuals, on the other hand, seem to be deteriorating with the passage of time, as seen in the graph below. When comparing 1995 and 2011, the number of 18–24-year-olds who are not in education, employment, or training (NEET) has climbed from around 30% to 45 percent, but the percentage of those engaged in school has declined from 50% to 36% over the same time. The young unemployment rate has also climbed, rising from 36 percent in 1995 to 50 percent in 2011, more than double the national unemployment rate at the time of publication.

Any conversation concerning South African education would be hopelessly insufficient unless the tremendous levels of inequality that affect the country and permeate every element of the educational system were addressed. One of the most visible manifestations of this is in educational outcomes, which range from a small number of schools that achieve at or above globally comparable levels of success to a large number of schools that are unable to transmit even the most basic numeracy and reading skills to their students. There is widespread agreement that a few of children (about 25 percent) do far better than the overwhelming majority of students (roughly 75 percent) who perform very poorly on these assessments when looking at child performance in South Africa (Van der Berg, 2007; Fleisch, 2008; Spaull, 2013). To understand the bimodality of performance, it's crucial to first understand that the better performing group of affluent schools is still failing when compared to global standards for educational attainment.

Similarly, when comparing achievement levels across provinces or geographical locations, similarly large degrees of discrepancy may be discovered. According to the most recent TIMSS (2011) study, the average Grade Nine pupil in KwaZulu-Natal was 2,5 years behind the average Grade Nine pupil in the Western Cape when it came to science, and the average Grade Nine pupil in the Eastern Cape was 1,8 years behind the average pupil in Gauteng when it came to Maths and Science, respectively. Furthermore, according to the prePIRLS (2011) survey, rural and township kids in Grade Four are 2 to 2 and a half years behind their urban counterparts in terms of reading ability (Howie & van Staden, 2012). There are large differences in functional literacy rates among provinces and across areas, according to the SACMEQ (2007). Students in Limpopo and the Eastern Cape were classified as functionally illiterate, but just 5 percent of students in the Western Cape were classified in this manner, compared to 49 percent of students in the Western Cape, according to the study.

#### 1.2.1.5 Poor educational outcomes

The school system in South Africa is the lowest among the middle-income nations that engage in cross-national evaluations of educational success when it comes to outcomes in education. We also do lower than several low-income African nations, which is a concern. The numbers from the National Senior Certificate (NSC) test in Grade 12, which is released on a yearly basis, are especially deceptive since they do not take into account those students who never make it to that stage. Only 50 out of every 100 students who begin school will make it to Grade 12, 40 will pass, and only 12 will be eligible to attend university. A lack of post-secondary education puts those between the ages of 18 and 24 at a considerable disadvantage in terms of finding full-time work, as well as having the largest risk of being jobless for a lengthy period, if not permanently. However, despite recent gains in student outcomes as well as policy innovations that have improved the situation for many, the picture that emerges is both dire and consistent: regardless of how one measures learner performance, and regardless of which grade one chooses to test, the vast majority of South African pupils are significantly below where they should be in terms of the curriculum and more generally, have not reached their potential. The current state of the South African education system is marked by great inefficiency, significant underperformance, and grotesque inequalities, Spaull (2013).

Participation in international tests is part of a broad variety of initiatives in South Africa to assess the quality of education, including the National Education Quality Initiative, which is part of the global community. It is possible to assess the level of achievement of different student populations using these tests since they are based on what students know rather than what they don't know. The findings of each research, as well as the most important ones, are discussed in detail in the following section.

- **Systemic Evaluations (2001 and 2007; Grade Three)**

About 54 000 third graders in more than 2 000 primary schools were studied over the course of two decades by the Systemic Evaluations (DoE, 2008a). There has been a 5-percentage point gain in numeracy and a 6-percentage point increase for literacy since 2001, according to the findings of the 2007 Systemic Evaluation, which found that the average score for literacy was 36 percent (30 percent in 2001). For literacy, the Free State gained 16 percentage points and the Western Cape 13 percentage points; for numeracy, the Free State gained 13 percentage points (15 percentage points for literacy, 17 percentage points for numeracy). When the Department of Education decided that "immediate improvement in these essential foundational abilities" was needed, it was consistent with the prior demand for "rapid action to address the issue" that appeared in the Systemic Evaluation report five years earlier. " (DoE, 2003: 66). Despite the foregoing, the equivalence of these tests is very dubious, and hence they should not be used as the primary source for reporting changes over time.

**Western Cape Learner Assessment Study (2003; Grade Six)**

The findings of the Western Cape Learner Assessment Study were revealed in 2004 for all primary schools in the Western Cape in 2003. Nearly 35 percent of the pupils tested were performing at or above the acceptable level of Grade Six reading comprehension, and an even smaller percentage were performing at or above the required level of Grade Six numeracy comprehension (15,6 percent). As cited in Taylor (et al., 2008: 43). For example, four out of every five Grade Six students at former white schools were able to read proficiently, but just four out of every hundred students in former Department of Education and Training (black) schools were able to read proficiently, a substantial gap. School effectiveness is examined in the National School Effectiveness Study (NSES; 2007-2009; Grades Three to Five).

South Africa's National School Effectiveness Study is the country's first panel dataset on educational achievement. This study investigated the reading and numeracy abilities of students in grades three through five in 266 schools in 2007 (grade three), 2008 (grade four), and 2009 (grade five) (Taylor, 2011). Since 2007 to 2008, youngsters aged three and four were tested on a scale that was calibrated at that level. Among students in Grade Three [Grade Four], just 19 percent [27 percent] of pupils passed reading examinations and 28 percent [35 percent] of children passed numeracy assessments.

**Annual National Assessments (ANA; 2011 and 2012; Grades One-Six and Nine)**

The Department of Basic Education's Annual National Assessments (ANAs) in 2011 and 2012 were a crowning success in the department's history. The ANAs are a collection of nationally standardised exams for numeracy and literacy in grades one through six and nine that are administered by a single organization. They were carried out in February 2011 (to test the 2010 material) and September 2012 (to test the 2012 content) (testing 2012 content). Apart from the two censuses, these two exams are the most comprehensive data-gathering exercises in the country since they examined every single student from Grades One through Six and Nine, respectively.

In the United States, the only standardised national tests that existed were at the end of the educational system, which was until 2011. (NSC). Everything else was either provincial (Systemic Evaluations in the Western Cape and Gauteng), confined to a nationally representative sample (Systemic Evaluations, TIMSS, PIRLS SACMEQ), or, more typically, chosen at the school or classroom level. Systemic Evaluations in the Western Cape and Gauteng the absence of a nationally comparable (standardised) test at the primary school level made it impossible to compare schools across different provincial or district jurisdictions, or even over time. Therefore, policymakers and parents were unable to decide whether a particular elementary school was failing or not, at least not with any degree of confidence. Furthermore, since child learning was inaccurately assessed and therefore of low comparative value, it was not feasible to hold schools responsible for pupil learning or to focus help to those in the greatest need.

The Department of Basic Education has produced a report outlining the rationale, methodology, methods, and outcomes for both the ANA 2011 (DBE, 2011b) and the ANA 2012 (DBE, 2012). The HSRC certified a sample of 1 800 schools in 2011 by commenting 50 test scripts (25 for numeracy and 25 for literacy) for each of Grades Three and Six (DBE, 2011b). There was no external verification by an outside authority in 2012, but the DBE undertook its own sort of verification by centrally commenting a sample of scripts from Grades Three, Six, and Nine (DBE, 2012:17).

The comparison between ANA 2011 and 2012 presents several significant challenges, notwithstanding the fact that this technique of testing is still in its infancy and as such certain flaws are to be expected. The following are the most serious: Within their own schools, teachers assessed exams and kept classrooms safe throughout ANA 2011 and 2012. the fact that teachers and administrators must reveal the results of a national standard exam may push them to behave strategically even if the ANA isn't high stakes (guiding pupils during the exam or marking leniently for example). It's not apparent whether the current verification techniques (in 2011 but particularly in 2012) can discover, fix, or avoid these mistakes.

In their comments on the ANA findings, Berg and Spaull (2012), John (2012), and Naidoo (2012) said that the results were a complete catastrophe and were not believable owing to differences in providing a thorough explanation for why the ANAs of 2011 and 2012 are not comparable. To begin with, the outcomes were not comparable, which harmed the system. According to Naidoo (2012), the fact that the ANA's findings from 2011 and 2012 are incomparable is very regrettable. This implies that schools, instructors, and parents are receiving incorrect information. Consequently, the 2012 ANA results, when compared to those of 2011, give the appearance of a significant increase in school performance that did not exist. This would make it much more difficult to really induce change in classroom behaviour, which is critical to actual breakthroughs in learning outcomes.

Minister A Motshekga, on the other hand, concluded to the conclusion in 2012 that "ANA child performance in the Foundation Phase (Grades One, Two, and Three) is adequate, (Motshekga, 2012). Statements like these are dishonest and dismiss all the available statistics demonstrating Foundation Phase achievement for most South African children is low, as detailed in this study. Owing to the DBE's comparison of the conclusions of the ANA 2011 and ANA 2012 when the results are not comparable, the genuine advancements in the system during this period have been skewed. It has done so at the risk of its own technical credibility as well as the integrity of the entire ANA process going forward.

The Trends in International Mathematics and Science Study (TIMSS), which is administered every two years, is another major global benchmarking test (TIMSS; 1995, 1999, 2002, 2011; Grades Eight and Nine) Students in grades 8 and 9 from a variety of countries participate in the International Mathematical and Scientific Survey (TIMSS). Every four years, the International Association for the Evaluation of Educational Achievement (IEA) works with local educational research organizations to assure the quality of the TIMSS studies. In addition to assuring the quality of the TIMSS investigations, the IEA scales the findings to make them comparable between nations and across time (Mullis, Martin, Foy, & Arora, 2012). All four of those years occurred when South Africa participated. International grade 8 tests had been found by previous TIMSS rounds to be excessively tough for South African students, resulting in a high number of guesses on multiple-choice problems in 2002 TIMSS. Grade 9 pupils were also assessed because of these findings (that is no better than random). In 2011, only Grade Nine South African students completed the TIMSS Grade Eight exam, which influences the test's reliability and accuracy, as per Foy et al. (2010).

Referencing TIMSS' legitimacy, Reddy etal, (2013) point out that the survey gave the finest chance to evaluate educational results between 1995 and 2011. In South Africa, there was no obvious progress in either mathematics or science at the Grade Eight level between the TIMSS surveys conducted in 1995, 1999, and 2002. Over this time, the average exam scores in South Africa did fluctuate a little bit, but none of these fluctuations were statistically significant in nature.

Pursuant to TIMSS 2002 and 2011, the average performance of Grade Nine children in mathematics and science grew by 67 and 64 points, respectively, from the previous year's TIMSS. For each topic, this equates to one and a half grade levels of learning growth (Reddy, et al., 2012: 3). This is an unusually substantial improvement in performance and offers compelling evidence that learning outcomes for Grade Nine students in mathematics and science have improved during the period 2002-2011. However, it should be highlighted that, despite the improvement, South Africa's overall score remains the poorest of among middle-income nations that took part in the TIMSS assessments.

#### 1.2.1.6 Learner Dropouts

The high dropout rate in the educational system is another problem. School dropout rates vary widely throughout South Africa, with two in ten students leaving after Grade 3, four after Grade 9, five after Grade 9, and so on and so forth. In other words, just around a quarter of students who begin school in first grade complete it, Pather, 2011; Badat in Pather. The fact that 10% of the nation's 7,002 secondary schools (including independent and Model C schools) produce 60% of all pupils eligible for college is noteworthy. Additional 20% of students from historically disadvantaged schools, while the remaining 20% of students from other schools are eligible for university entrance (Badat in Pather, 2011). A total of 1,2 million (11.1 percent) of the 11 063 399 students enrolled in South African schools in 2011 were required to repeat grades in 2012, according to the research by Rademeyer (2012), resulting in 11 063 399 students repeating classes in 2011. Repeaters outnumber new students in Mpumalanga (963 193) and the Western Cape (963 193), two provinces in South Africa (920 097). Another issue was the need to repeat the current school year in 2010 for 146 000 students in Grade 9, as well as this year for 155 394 pupils in Grade 9. There is a high dropout rate among kids in grades 2 through 7, although it decreases as students go through grades 10 and 12. Repetition rates for grades 11 and 12 grow from an overall rate of 11.1% to 24.7 and 22.9 percent, respectively, (Rademeyer, 2012; Kruger, 2012).

Some of these learners are required to repeat Grades 11 and 12 for a third or fourth time (Rademeyer, 2012), and therefore, the percentage of learners in these grades who are over-age in comparison to the class average has increased significantly. For example, Gernetzky (2011a) claims that in certain circumstances, 80 percent of graduates came from 10-20 percent of schools, and that 40 percent of schools generated no university graduates.

#### 1.2.1.7 Lack of proper school governance

A democratic education system includes the traits of inclusiveness, transparency, and adaptation that are demonstrated by all relevant players, and more specifically, the characteristics displayed by the governing bodies of schools (Naong & Morolong, 2011). Governing councils with considerable responsibilities are required in all public schools in line with the South African Schools Act Act 84 of 1996 (Department of Education, 1996). Attendees would include the principal, elected parent representatives, teachers, and other members of the school staff. Additionally, the Act (DoE, 1996) delegated several functions, including the maintenance and improvement of school property, the selection of extra-mural curriculum options, purchasing textbooks and educational materials, making payments to school employees as well as other duties consistent with Act 84 of 1996 (DoE, 1996) and any applicable provincial law, among other things.

Due to the lack of training of School Governing Bodies (SGBs) in areas where SGBs have never existed before beginning their work, SGBs face insurmountable challenges such as unfamiliarity with meeting procedures, difficulties in managing large volumes of administrative work, and lack of knowledge of relevant legislation (Xaba, 2011). The absence of financial management skills and the lack of cooperation between the SGB members and the principal are both major concerns (Mestry, 2004). Parents who are unemployed are less likely to participate in their children's education, based on Steyn, Steyn, and De Waal (2011). Educators, on the other hand, blame SGB members' lack of knowledge and training for their poor performance. In the real world, this means that members of SGBs are unable to fulfill their duties and responsibilities, which has disastrous consequences for the schools over which they have governance and supervisory responsibilities. As a result, they are prone to corruption and nepotism, and they are frequently absent from meetings and workshops, among other qualities. It should go without saying that historically underserved institutions are a prime example of this tendency (Xaba, 2011).

**1.2.1.8 Endemic Corruption**

There has been a recent increase in corruption in both economic and social realms. Between 2011 and 2012, a slew of curricular reforms were designed and put into effect, resulting in a sea shift. The Minister of Basic Education is being held accountable for the lack of timely purchases of educational necessities and the resulting lack of educational opportunities (Greenshields, 2012). Due to this change in policy in January 2012, textbook production and distribution became imperative (Mpofu, 2012; Jika, 2012). Corruption seems to be to blame for the Limpopo textbook crisis, since textbooks were not delivered on time (Jika, 2012). As per reports, EduSolutions has reportedly received R27 million in contracts for educational toys aimed at third graders that are in violation of the company's own policies (Jika, 2012; Anon, 2012b). As a result of a lack of interest, a R700 million textbook contract that was set to run for two years was terminated (Jika, 2012). However, despite this tragedy, it does not seem that the education minister will be dismissed anytime soon (Mpofu, 2012).

A task force will be formed to investigate the challenges that led to the notorious Limpopo textbook incident (Mpofu, 2012; Jika, 2012).

As a result of the outflow caused by the non-delivery of textbooks in the Limpopo province, 70 percent of Grade 10 students across 25 schools failed their examinations in June 2012. This equates to 3 174 out of 4 529 students, with administrators admitting that this might be the situation throughout the whole province of Ontario (Govender & Shoba, 2012). The evidence clearly demonstrates that the Limpopo Education Department is completely responsible for the failure to provide books on time, despite the fact that the department is blaming contractors for not delivering the books or providing erroneous books to the schools (Louw-Carstens & Van den Berg, 2012). In this respect, 1 371 schools were impacted, and the Minister of Basic Education, Min. Motshekga, issued several assurances that books would be provided on schedule in this regard (Govender, 2012b).

Uneven distribution of textbook availability in South Africa's education system is leading to variances in educational results, despite the fact that textbook availability has grown dramatically (Reddy et al., (2016). According to international study, the number of reading books accessible at home is positively connected with reading test outcomes, whereas Isdale et al. (2017a) shown that access to textbooks is positively associated with test scores. A school's average reading score was 525 points higher in schools with large or no central libraries, compared to 494 to 501 points higher in schools with smaller or no central libraries. In South Africa's education system, textbooks provide huge and considerable returns, according to van der Berg and Louw (2006). When it comes to the educational function in South Africa, textbooks have a substantial and important impact, according to Van der Berg (2008). A study by Spaull (2011) found that students who had their own textbook or shared a textbook with one or two other students did better on literacy assessments, but not on mathematics tests.

As a result, the availability of textbooks is another another way via which socioeconomic status and geographic location influence academic attainment. It is estimated that one in three kids in the lowest 20% have no textbooks or must share one with at least two others. To put it another way, the wealthiest 20% of students only have to share a textbook with 15% of their peers, according to Spaull (2016). A school library's availability to students in

Gauteng is on par with access to independent schools in terms of geographical diversity, according to Reddy etal (2016).

#### 1.2.1.9 Incompetent teachers

The success of any curriculum reform initiative is dependent on the participation of educators (Fullan, 1993; 1999). Teachers' preparation has experienced significant changes since 1994, with the goal of educating educators to work in an increasingly democratic and diverse pedagogical environment. The reform of teacher-training curriculum, on the other hand, is still in its early stages and is not complete. Furthermore, the vast majority of instructors in the system were educated during the previous administration (Crouch and Lewin, 2000). Educators have gotten only sporadic help in their efforts to implement the new curriculum in this environment. The majority of in-service training has been devoted mostly to the introduction of new and sophisticated terminology and methodologies. Many educators, however, lack the necessary expertise and training to make the more subtle and profound modifications in education that are required. According to the Department of Education's Systemic Evaluation Report, approximately two-thirds of those polled expressed a lack of confidence in their ability to implement OBE. The new curriculum was only covered in 15 hours of in-service training per instructor on average by 2001, according to the National Education Association (DoE, 2003c).

Pursuant to a survey performed by HSRC in Modisaotsile (2012), about 20% of educators are missing on Mondays and Fridays. At the conclusion of the month, absenteeism increases to one-third of the workforce. Compared to prior white schools, teachers at black schools work an average of 3,5 hours per day, while they worked around 6,5 hours per day in former white schools. This equates to a total of three years of education difference. Owing to the closing of the country's teaching colleges in the mid-1990s, explains Mathew Prew of the Centre for Education Policy Development (CEPD), 'we haven't had a teacher development system that allows instructors to employ their methods.' That decision was made in response to a government determination that university training might give a higher grade of teaching. Universities, on the other hand, have proven unable to create adequate numbers of professors, as well as too many neurons. In order for South Africa to enhance its educational achievements, it must start with teachers, who as the primary curriculum implementers must be informed, have good professional attitudes, and be committed to serving the country.

To sum up, more than just attending courses and having objectively tested skills, education is a far broader concept than just that. Conventional international discourse tends to underestimate the complexity of education's inputs and results. For example, the appropriate pupil-to-teacher ratio and availability of chalk and textbooks are defined using technical terms. An additional year of education is related with an increase in wages, which is often described in economic terms. The inputs and outputs of an educational system may be better understood as a collection of ideas on how a society is structured and should be built in the future, given that education is mainly used to replicate civilizations. The value of school leaders in fostering transformative leadership in their institutions cannot be overstated. Participation in leadership, decision-making, policymaking, problem-solving, and general school governance should be facilitated.

## 1.3 STATE OF MATHEMATICS EDUCATION IN SOUTH AFRICA

Fig 1.4 depicts an appreciation of the beauty of mathematics as a functional discipline in daily life and society. Mathematics is one of the most significant subjects since it serves as a link between all other subjects of study.


**Fig 1.4 Beauty of Mathematics (Source: Dirac, P.AM)**

In today's changing world of competitiveness, there is an increasing need for mathematical knowledge. There is an unquestionable need for mathematics in any individual's lifetime planning as well as day-to-day planning. Umameh (2011) and Nyaumwe (2013) argue that mathematic education is a basic and crucial tool for the scientific and economic development of a person, as well as the advancement of a nation. Human cognition and reasoning are vital to his efforts to comprehend the worldview of the environment in which he lives, and it is a crucial aspect of that effort (Lynn & Bracado, 2009). As a result, mathematics is very important in human existence. The findings of Skemp (2008), who claims that mathematics is a useful tool for developing mental discipline and encouraging logical thinking, agree. Mathematics helps one prepare for the world of the future.

As a result, many countries require mathematics to be taught as a compulsory subject in secondary school since it is such an important topic in human existence. A quantitative approach is required for any kind of advancement. Any strategy that does not take mathematical concerns into account is doomed to failure. Anyone who wants to be successful in life must have a strong grasp of mathematics as a resource. Mathematics is a tool that may be used in a variety of different areas, and we can see another extension of the subject's utilitarian nature. The application of mathematics is the most important aspect of any utilitarian mathematics. Every step of every person's life is intricately intertwined with mathematics. It has been a steadfast friend from the beginning of human life on our planet. To promote extensive knowledge and accurate understanding of selected areas in mathematics, according to Educating our Future (MoE, 1996), one of the goals and objectives of the Ministry of Education (MoE) on high school education is to promote extensive knowledge and accurate understanding of selected areas. The Ministry of Education is concerned about the low performance in mathematics that is evident in the results of the Grade Twelve examinations that are held at the conclusion of each year. To provide an example, in research done in Zambia, one-third (13/3) of boys and two-thirds (2/3) of girls reported complete failure in „O level Mathematics" in the years following 1987 (Ministry of Education 1996), Kafata, and Mtetwa (2016).

### 1.3.1 STATE OF MATHEMATICS EDUCATION PERFORMANCE IN THE RECENT FIVE YEARS (2016-2020)

Figure 1.6 presented South Africa's global comparativeness in mathematics which was 139th position in terms of mathematics quality, which is pitiful and incomparable to the country's economic and social status. Few would dispute that South Africa's mathematics education system is anything other than hopeless, Spaull, 2013**).**

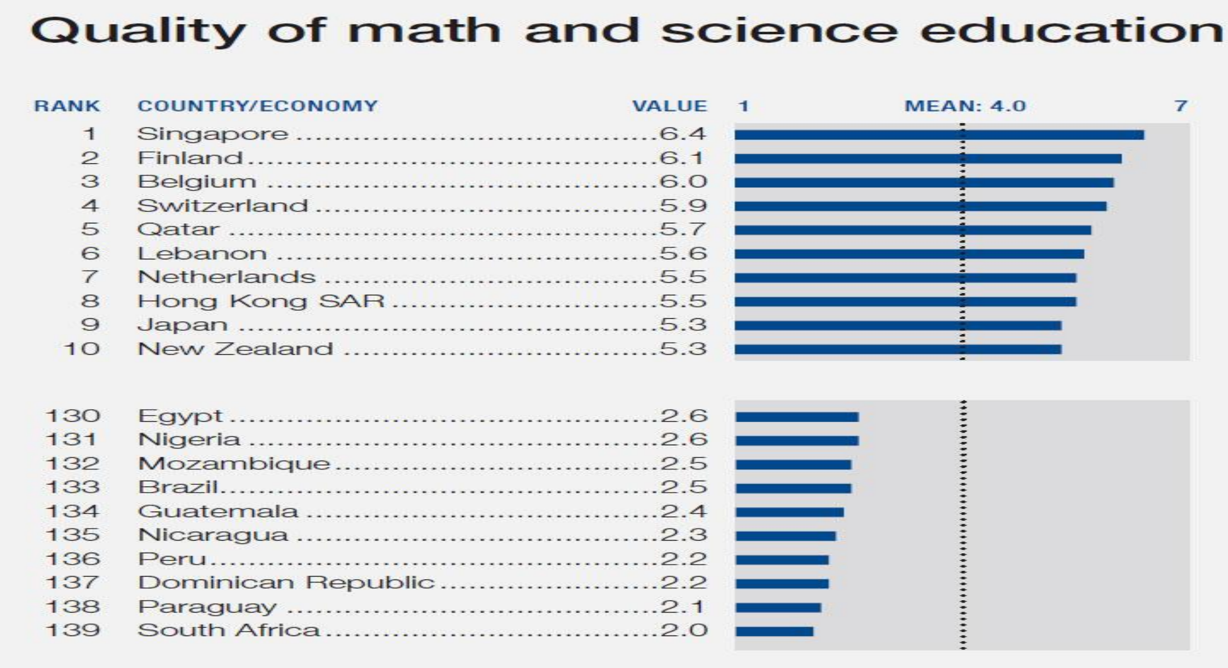


**Figure 1. 5 : Global quality of Mathematics (Adapted from Spaull, 2013)**

A large number of local and international evaluations of mathematical performance, some going back as far as 1995, support this idea, which is widely held by academic researchers and members of civil society alike (Howie and Hughes, 1998; Reddy et al., 2012; Fleisch, 2008; Spaull, 2013a; Taylor et al., 2013). Studies, particularly those concentrating on mathematics, have shown that children accumulate learning deficits early in their school careers and that these backlogs are the major source of underperformance in the later years of the schooling process. They argue that in order for initiatives to increase kids' mathematical skills to be successful, they must first address the deficiencies identified by the researchers (Taylor et al., 2003). A contribution to this body of work is made by the current study, which uses nationally representative data to determine the true amount and depth of these learning impairments.

Several studies, like those by Pritchett and Beatty (2012) and Banerjee and Duflo (2011), have shown major learning impairments among students in disadvantaged countries. They reveal that even children who attain very high levels of scholastic accomplishment frequently have extremely limited cognitive capacities as a consequence of the years of instruction they have received in school. Their hypothesis is that this happens as a result of poorer students falling progressively and further behind the curriculum until they eventually fall so far behind that no learning takes place. Using data from the Andhra Pradesh Randomized Evaluation Studies in India, Muralidharan and Zieleniak (2013) discovered support for this theory in a similar study by following the learning of a group of students over a five-year period. After five years of formal full-time schooling, only 60% of students reach Grade 1 competency, and the learning trajectories of the lowest performers completely flatten out in the later Grades, according to the researchers' results. This confirms the empirical validity of Lewin's (2007:10) idea of "silent exclusion," which describes a situation in which children are enrolled and attending school but are absorbing only rudimentary information.

Rather than large-scale international study, South African mathematics research has mostly focused on in-depth localised studies of student workbooks and classroom observation rather than on large-scale international research (Ensor et al., 2009). Carnoy et al. (2012) studied mathematics learning in Grade 6 classes from 60 schools in one South African area (the Northwest) and compared the findings to those from 60 schools in nearby Botswana, to name a few examples. Venkat and Naidoo (2012) conduct a smaller-scale investigation on coherence for conceptual learning in a Grade 2 numeracy class, focusing on 10 primary schools in Gauteng, South Africa. His research, like the work of Schollar (2008), included interviews with students and classroom observations, as well as an examination of a large sample of learner scripts, in order to determine the development (or lack thereof) of mathematical concepts during the duration of the learning phase. Figure 1.7 illustrates one facet of our current situation in 2011. Students from all around the globe take part in the Trends in International Mathematics and Science Study (TIMSS), which is an international standardised test for mathematics and science that is offered once a year to students from all over the world.

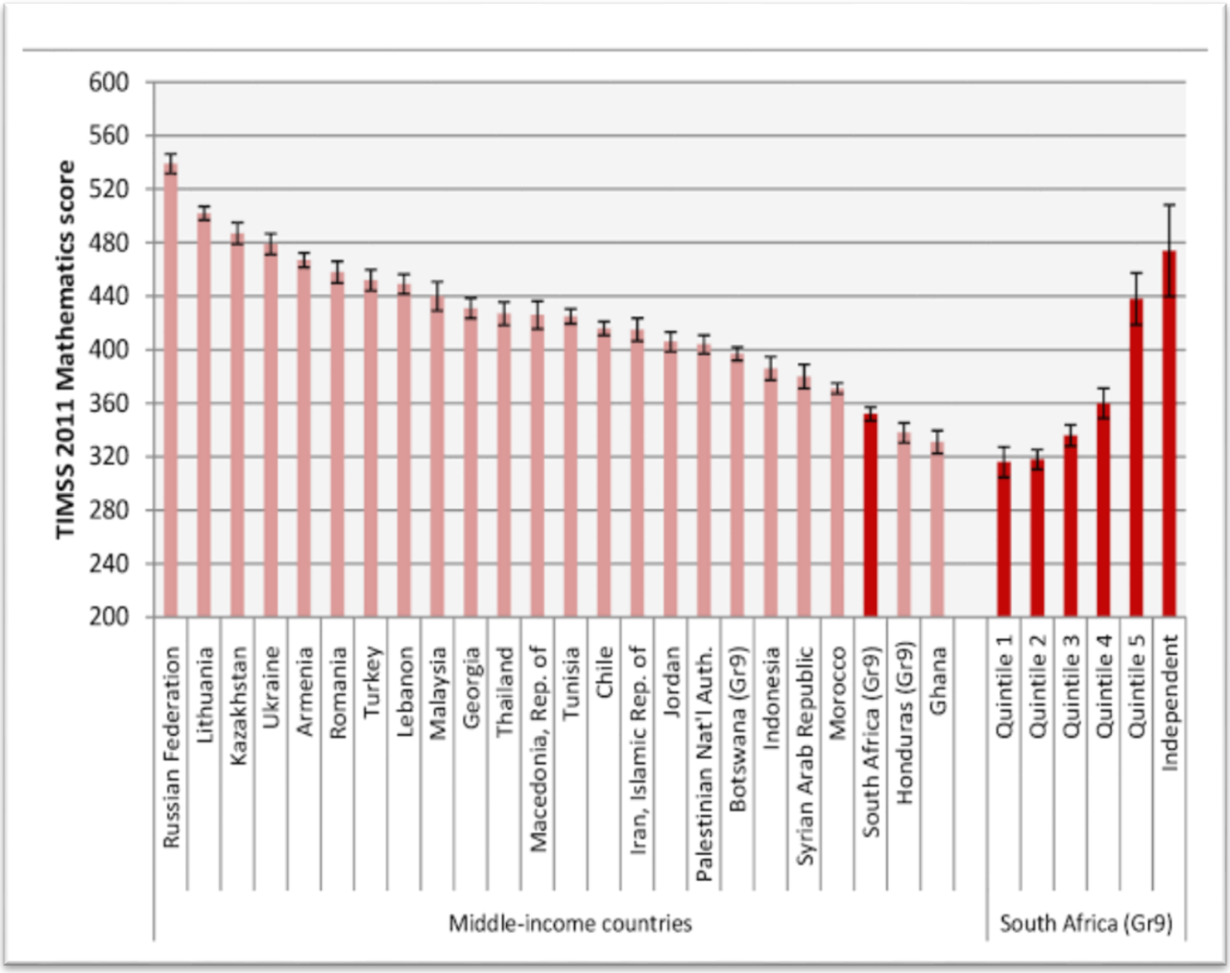


**Figure 1.6 : Global quality of Mathematics (Adapted from Spaull, 2013)**

Though intended for pupils in Grade 8, the tests were deemed too difficult for Grade 8 students in South Africa, and as a consequence, only Grade 9 students were required to take the examinations in 2011. There were 42 countries that offered assessments to Grade 9 pupils rather than Grade 8 children, with Botswana and Honduras being the only two exceptions. According to the results of the standardised exam, average mathematical skills in Grade 9 in South Africa were closest to those of Honduras and Morocco, but only marginally better than those of Russia (in terms of absolute scores), according to the test. Independent schools' Grade 9 learners outperformed the national average when South African schools were divided into many sectors, while they were only slightly behind the national average in Russian Grade 8 mathematical achievement when South African schools were divided into multiple sectors (although there are issues about the sample used for South African independent or private schools, which likely hide the good performances of the better of them).

Regarding South Africa's performance, there is a significant disparity. The bottom three quintiles (nearly two-thirds of the population – which is probably representative of the average rural area and small town, as well as most townships) perform marginally worse than their counterparts in Lesotho and Zambia, despite the fact that South African mathematics teachers in quintile five (the richest areas) schools can compete with the average Kenyan mathematics teacher on a level playing field. As an alternative to high-income countries such as South Africa, lower-income nations such as Lesotho and Zambia are lagging far behind South Africa in terms of economic development. Education expenditure per capita is significantly lower in the vast majority of countries that achieve comparable outcomes to South Africa. Tanzania, Uganda, and Zimbabwe, among other countries with significantly higher test scores than South Africa's, have per capita GDPs that are less than a quarter of South Africa's. Curiously, a large proportion of their learners attend low-fee private schools, according to Reddy et al (2016).

In a study on accountability, Spaull (2015) observed in research on responsibility and capacity in education that there were no or minor gains in learners' performance on the benchmark examinations in the Trends in Mathematics and Science Studies (TIMSS) worldwide assessments from 1995, 1999, 2002, and 2011. Based on Reddy et al. (2012), in 2011, 32% of South African Grade 9 students performed worse than guessing on multiple choice examinations, and 76% lacked essential understanding of whole numbers, decimals, operations, and graphs, among other things. Another study done in the Northwest by Carnoy et al (2011) found that Grade 6 Mathematics educators obtained an average score of 40% on a test consisting of Grade 6 subject components. Hungi et al. (2011) performed a TIMSS data comparison and revealed that just 32% of South African Grade 6 teachers had adequate levels of Mathematics content compared to their counterparts in Kenya (90%), Zimbabwe (76%), and Swaziland (55 percent). The skills described above show that there are gaps in mathematics education's teaching and learning, teacher quality, and curriculum implementation support systems.

### 1.3.2 FACTORS AFFECTING MATHEMATICS PERFORMANCE IN SOUTH AFRICA

Figure 1.8 depicts the performance of eleven subjects written at the matriculation level in South Africa's public schools from 2016 to 2020 during a five-year period.

Table 5.3.2: Candidates Performance in Selected Subjects from 2016 to 2020

| Subjects | 2016 | | | 2017 | | | 2018 | | | 2019 | | | 2020 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Wrote | Achieved 30% & Above | % Achieved | Wrote | Achieved 30% & Above | % Achieved | Wrote | Achieved 30% & Above | % Achieved | Wrote | Achieved 30% & Above | % Achieved | Wrote | Achieved 30% & Above | % Achieved |
| Accounting | 128 853 | 89 507 | 69.5 | 103 427 | 68 318 | **66.1** | 90 278 | 65 481 | 72.5 | 80 110 | 62 796 | **78.4** | 92 767 | 70 014 | **75.5** |
| Agricultural Science | 106 386 | 80 184 | 75.4 | 98 522 | 69 360 | **70.4** | 95 291 | 66 608 | 69.9 | 92 680 | 69 132 | **74.6** | 96 155 | 69 916 | **72.7** |
| Business Studies | 234 894 | 173 195 | 73.7 | 204 849 | 139 386 | **68.0** | 192 139 | 124 618 | 64.9 | 186 840 | 132 571 | **71.0** | 207 045 | 161 224 | **77.9** |
| Economics | 155 908 | 101 787 | 65.3 | 128 796 | 91 488 | **71.0** | 115 169 | 84 395 | 73.3 | 107 940 | 74 796 | **69.3** | 118 484 | 81 536 | **68.8** |
| Geography | 302 600 | 231 588 | 76.5 | 276 771 | 212 954 | **76.9** | 269 621 | 200 116 | 74.2 | 271 807 | 218 821 | **80.5** | 287 629 | 216 467 | **75.3** |
| History | 157 594 | 132 457 | 84.0 | 147 668 | 127 031 | **86.0** | 154 536 | 138 570 | 89.7 | 164 729 | 148 271 | **90.0** | 173 498 | 159 737 | **92.1** |
| Life Orientation | 663 975 | 661 903 | 99.7 | 620 626 | 619 336 | **99.8** | 618 726 | 617 041 | 99.7 | 610 234 | 609 101 | **99.8** | 589 870 | 586 360 | **99.4** |
| Life Sciences | 347 662 | 245 070 | 70.5 | 318 474 | 236 809 | **74.4** | 310 041 | 236 584 | 76.3 | 301 037 | 217 729 | **72.3** | 319 228 | 226 700 | **71.0** |
| Mathematical Literacy | 361 865 | 257 881 | 71.3 | 313 030 | 231 230 | **73.9** | 294 204 | 213 225 | 72.5 | 298 607 | 240 816 | **80.6** | 341 363 | 275 684 | **80.8** |
| Mathematics | 265 810 | 135 958 | 51.1 | 245 103 | 127 197 | **51.9** | 233 858 | 135 638 | 58.0 | 222 034 | 121 179 | **54.6** | 233 315 | 125 526 | **53.8** |
| Physical Science | 192 618 | 119 427 | 62.0 | 179 561 | 116 862 | **65.1** | 172 319 | 127 919 | 74.2 | 164 478 | 124 237 | **75.5** | 174 310 | 114 758 | **65.8** |

**Figure 1.7 Mathematics Grade 12 Performance (2016-2020) (Department of Education)**

With a cumulative average of 53.92 percent over the previous five years, mathematics has been rated second from the bottom in terms of national performance in the United States. The proportion resulted in 46.08 percent of learners, or 297445 students, attempting the mathematics assessments but failing, placing them at danger of quitting their dream occupations in mathematics and science. Therefore, a range of factors, including the quality of teachers, the educational system, and didactic features, have an impact on student progress in mathematics. These variables will be examined in further depth in the following section:

#### 1.3.2.1 QUALITY OF MATHEMATICS TEACHERS

Owing to the findings of a recent research, mathematics teaching and learning in South African schools is among the poorest in the civilized world. When it comes to mathematics and science, South African learners had the lowest score among learners from the 21 middle-income nations that participated in the Trends in International Mathematics and Science Study (TIMSS), which was performed in 2011, Reddy etal (2016). Education, especially mathematics instruction and learning, is a major area in which South Africa falls well short of the worldwide average. For example, low quality mathematics education is a typical occurrence, with instructors often failing to answer problems from the curriculum they are teaching. In many cases, national testing is deceiving because it fails to highlight the huge performance gap that occurs between students in lower grade levels. According to the National Centre for Education Statistics, pursuant to Bernstein (2013), just half of all pupils who begin school will complete Grade 12, and only a quarter will be eligible for university entrance. As per Spaull (2013), a high majority of South African teachers still possess only rudimentary topic understanding in the disciplines that they teach, in part because of the ineffectiveness of pre-service teacher education efforts. It is imperative that a method be developed for identifying which teachers need certain kind of help. Initially and most importantly, the DBE should work to guarantee that every teacher in the system knows the essential topic knowledge required to cover the curriculum for which they are presently accountable. Following that, the Department of Education should establish a nationwide system of diagnostic teacher evaluation and capacity development for mathematics teachers across the country. Teachers should be reassured that the purpose of these assessments is largely to diagnose rather than penalize pupils' performance on standardized tests. Their purpose should be developmental in character to avoid vilifying and humiliating teachers and the teaching profession, but rather to raise the capability and dignity of teachers and the teaching profession.

Low mathematics instruction, as per research, is one of the most significant factors contributing to poor academic achievement in mathematics. Stuart (2000) agrees with the assumption and asserts that low academic achievement in Mathematics may be traced back to weak or insufficient instruction. Studies conducted in the United States revealed similar findings when they discovered that low mathematics success might be attributable to elements in the classroom such as ineffective teaching techniques (Elliot et al 2013). According to research, the most often utilized teaching techniques are question and answer sessions, expositions, guided exploration sessions, and group work. An investigation carried out by Dhliwayo and Wade Sango (2012) in Zimbabwe indicated that the lecture technique is sometimes employed, but that hand on activities like as simulations and field excursions are not widely used. Moreover, this supports the findings of Jaji (1991), who said that the most widely employed techniques are question and answer, work from the textbook, and instructor demonstration. Shumba (1988) had made similar discoveries when he said that there is a strong positive association between the tactics utilized and the performance of the students in the classroom.

The behaviours, expectations, and beliefs of teachers in the classroom, whether deliberate or inadvertent (Gregory & Huang, 2013), have an influence on students' achievement. When instructors believe that there are significant barriers to student learning, Dell'Angelo (2010) finds that students' accomplishment levels are lower. If, on the other hand, instructors see fewer hurdles to student learning, then kids attain better levels of accomplishment even when poverty levels are high, according to research. As a result, teachers' knowledge of students' views, positive connections, and improved classroom dynamics help lower-income students achieve higher levels of achievement (Archambault, Janosz, & Chouinard, 2012; Whitehead, 2007). Schools that devote more instructional time to reading and mathematics have seen an improvement in the test results of pupils from low-income families. Teacher quality in high poverty school settings continues to be a significant policy focus for reform and development efforts (Hogrebe & Tate, 2010). Student accomplishment is favourably correlated with classroom management and student behaviour that is directed by the teacher.

There is some evidence in the literature that teacher impacts are more prominent in high minority schools when it comes to math achievement (Konstantopoulos & Chung, 2011). Teacher support functions as a moderator for students from lower socioeconomic backgrounds, and it may even be able to alter the unfavourable relationship established between poverty and academic success (Casper, 2013; Little-Harrison, 2012; Liu & Wang, 2008). Making the learning environment pleasant requires a devoted teaching cadre with a high degree of self-efficacy and cultural competence, as well as those who can empathize with the pupils either because of same ethnicity, language, upbringing or socioeconomic status, poverty, or challenges (Freitas, 2013). Banerjee (2016) believes that high poverty schools with such teachers are high-achieving schools.

Teachers in South Africa are not only lacking in subject expertise, but they are also lacking in responsibility and motivation. Teachers' motivation is examined in studies such as De Ree et al. (2015), which examine the effects of raising teacher compensation. A randomized phase-in methodology was employed to analyse the impact of doubling teacher compensation in Indonesia, and the authors found no indication of negative effects on teacher effort two and three years after the wage reform was implemented. Although South African teachers are generally well compensated, this result is consistent with the reality that they have low levels of motivation despite their high salaries (van der Berg et al., 2011).

South African teachers are absent from the classroom for an average of 11 percent of the time they are meant to be present in the classroom (Reddy et al., 2010). Researchers Reddy and colleagues found that 60 percent of learners reported being in schools where there was a worry about teacher absenteeism. The findings will be published in a forthcoming journal. As reported by Irving (2012), 20 percent of teachers are absent on Mondays and Fridays, while 33 percent are absent towards the end of the month (Monday through Friday). Teachers at mainly black schools spend an average of 3.5 hours each day in the classroom, as per the National Education Association. However, when compared to the average of around 6.5 hours per day spent teaching in previous white institutions, this is cause for concern. Thus, according Gustafsson and Patel (2008), this is equal to the number of hours spent teaching in other TIMSS countries; yet this is still a cause for worry (Irving, 2012). With the use of a conditional joint regression correlational model, Isdale et al. (2017) show that higher performance scores are negatively related to higher rates of teacher absenteeism and poor school discipline.

Teachers in South Africa are held accountable for the academic accomplishment of their pupils via a variety of measures that are restricted in scope. Low levels of accountability and teacher effort are often mentioned as the most important educational concerns facing South Africa (van der Berg et al., 2011). Related research by (Mbiti (2016) have shown that low teacher responsibility is a common occurrence in developing countries, especially in rural regions. Despite the fact that education expenditure and access in developing countries have expanded significantly over the previous two decades, accountability remains a significant impediment to increasing the quality of education, particularly in rural areas, as highlighted by Mbiti (2016). As is customary in developing countries, the great majority of

South African teachers are public sector workers who are represented by a union and get government remuneration for their services.

Parents and school administrators, according to Mbiti (2016), find it difficult to keep teachers responsible because of the centralized system's emphasis on political economics and accountability. This may be accomplished in the long term and indirectly by voting out politicians, but there is often an imbalance in the degree of knowledge between teachers and the general public, particularly in rural communities. Wößmann (2016) discovers evidence that school autonomy has favourable consequences in rich nations, but detrimental effects in underdeveloped countries, according to his research. As a result, he contends that institutional characteristics of educational systems account for a significant portion of the differences in student accomplishment between countries.

#### 1.3.2.2 DIDACTIC FACTORS

Didactic factors refer to any variables that occur inside a school's framework, including those that develop because of inefficient teaching and learning approaches or processes. As shown in a 2005 review by the Organization for Economic Cooperation and Development, "factors related with educators and teaching are the most important influences on child learning" (OECD). When Barber and Mourshed (2007:2) say that "the quality of the teachers is the most significant driver of variation in child learning at school," they're referring to this. It was pointed out to them that the schedule didn't allow for adequate breaks. As per Taylor (2007), there is strong evidence that following basic educational concepts and practices may improve the quality of teaching and learning in schools. To add to this, Taylor (2007) claims that factors such as optimizing student interaction time in class, as well as the presence of both students and instructors at school and in class, have an impact on educational results. When the timetables of the four schools are compared, it becomes clear that the contact time for teaching and learning is kept to a bare minimum, as per policy. These schools use a 35-minute period schedule, with one double period per week, resulting in 210 minutes of mathematics instruction each week. The teaching time for mathematics in the Senior Phase, according to DBE (2011b:8), is 4, 5 hours, or 270 minutes in total. In terms of mathematical education, this equates to a weekly loss of around one hour. This condition wastes a large amount of time each term and year. As a result of this circumstance, there is a chronic and systematic decrease in the quality of teaching and learning. Students have complained about how rapidly teachers go through the sessions. According to interviews, teachers' anxiety about keeping up with the work schedule and completing the curriculum contributed to the high pace. For learners, learning mathematics at such a rapid pace is tough. Consequently, students get apprehensive and develop a negative attitude toward mathematics.

Khan and Mahmood (2010) suggest that negative attitudes toward mathematics may have their origins in the teaching profession and teachers themselves, with maths nervous instructors in turn producing maths anxious learners at times. Over-reliance on conventional instructional activities such as exercises and memorization, textbook style teaching, one proper technique of addressing a problem, and a focus on fundamental skills rather than ideas are characteristics of this kind of teaching (Khatoon & Mahmood, 2010). Teachers expressed dissatisfaction with the lack of resources. Because the students did not have access to calculators, it was difficult for them to execute and answer various arithmetic tasks.

Taylor and Reddy (2013) indicate that a scarcity of resources such as models and photographs, as well as drawings, visual organizers, calculators, and charts, contributes to students' unfavourable views about mathematics. Mathematical sense of touch and feel should be present in all courses. Mathematics should be visible to students all around them. The classroom is also a location where students' attitudes about mathematics, whether good or negative, may grow and thrive. Performance suffered because of ineffective leadership. The chairs of mathematics departments never call meetings with instructors, and the department does not oversee or control students' work. Meetings aid in the improvement of communication and the flow of important information. Teachers feel that meeting on a regular basis will assist them in addressing curricular concerns, particular queries regarding topic matter, and improving their teaching style, among other things. The department's HODs seem to lack the technical skills required to administer the department. Teachers acknowledged a broad need for effective support, coaching, and mentorship in all parts of teaching, but particularly in lesson preparation and evaluation. This was supposed to be provided by their department heads, who are allegedly failing to do so. When examining the documents, it was discovered that the workbooks that were provided had not been used. This was a contentious issue. Teachers were only utilizing activities that were already included in the textbooks. In addition, the sample question papers that were provided were not used. This appeared to be a problem because the exemplars and workbooks contained questions pertaining to the four cognitive levels. Teachers were unable to utilise these tools, which resulted in their assigning learners only easier classwork exercises, but in the tests, students were presented with more difficult problems.

The lack of curriculum coverage is a significant effect on students' mathematics performance on standardized tests. According to the findings of a 2009 research conducted in 58 schools in the Northwest, "teachers did not teach 60 percent of the lessons they were planned to teach" throughout the school year (Carnoy, Chisholm & Chilisa 2012: xvi). Similarly, the National School Effectiveness Study (NSES) conducted in 2008 and 2009 found that just 24 percent of Grade 4 and 5 subjects were addressed in Grade 4 and 5 classes in South Africa, based on a nationally3 representative sample (Taylor & Reddy 2013). The causes for this are many, and include teacher absenteeism, poor time management, and a lack of a culture of teaching and learning.

The term "time on task" refers to the duration of time during which a student is actively engaged in an educational activity. It is significantly impacted by the way a teacher manages his or her classroom (Muijs & Reynolds, 2000). Classrooms organized and managed by effective educators’ function as learning environments in which academic activities operate efficiently, transmissions are short, and students spend minimal time putting themselves together. In a meta-analysis study, it was found that well-controlled studies resulted in higher learner achievement than poorly controlled studies. This was confirmed by the findings of the study, which found that learners learn more effectively when they are supervised by their teachers rather than when they learn on their own. "Teachers should be at school, in class, on time, teaching, with no neglect of duty and no abuse of kids," said the then President of South Africa, in reference to the significance of time spent on task for teaching and learning in the school setting. The students should be in class, on time, and engaged in studying; they should also be courteous of their professors and one another; and they should do their assignments" (Zuma, 2009). As a result, time on task is an academic engagement that allows students to be actively involved, committed, and attentive to the activities taking place in the classroom. Students' ability to complete homework, arrive prepared for class, maintain regular attendance, and avoid missing classes reflects their level of engagement and motivation.

Most effective classrooms are those that have well-established mechanisms for monitoring learners' progress in their subjects, for evaluating the class, and for putting in place continuous improvement programs for both learners and teachers (DEST 2004; State of Victoria 2005; Department of Education, Science, and Training (DEST) 2004). Overuse of assessment methods in schools and classrooms may lead to a shift in the attention away from the teaching and learning processes. Effective schools and classrooms take steps to avoid this. Testing does not constitute instruction in and of itself. It is important for instructors in successful schools to offer clear and useful feedback to students to maximize the learning impact of assessment (DEST, 2004; State of Victoria, 2005). In addition, educators abstain from publicly criticizing pupils whose performance on an evaluation falls short of expectations in front of the class. Teachers, according to the research, do not get appropriate pre-service training in the administration of formal and informal assessments throughout their tenure. This has resulted in many teachers being aware that their monitoring skills are insufficient and desiring training to improve their abilities; others being unaware of the importance of close monitoring of learner progress and of their own need for skill development in this variable; and still others being unaware of the importance of close monitoring of learner progress and of their own need for skill development in this variable, Kunene (2011).

#### 1.3.2.3 MATHEMATICS SYSTEMATIC FACTORS

This includes all policy-related aspects. Mathematics has its own policy relating to examinations, number of sessions taught, and other pertinent issues. The NDP research identifies institutional and structural barriers to growth in South Africa's education system, including education management, school principals' and department heads' competency and capability, teacher performance and accountability (NPC, 2012:38). Teachers believed the system placed too much pressure on them in terms of teaching and tasking. They remark that the weekly duties are too numerous given the need for corrections and instruction. Teachers must assign four assignments every week. This is difficult since they simultaneously teach other topics with packed classrooms and duties to handle. Teachers gripe about a constantly changing curriculum. They gripe about teaching new material they do not understand. Taylor and Taylor (2013) argue that students will not succeed in mathematics if their professors do not know the topic themselves. Teachers reported issues with transformations, measuring, and shape and space. Workshops are occasionally held, but not enough time is given to the material. Workshops are generally held after school for 2 hours or more since instructors say they are weary after the day's work. Some sessions are held over holidays, with many participants returning home from neighbouring provinces like Limpopo. As mentioned in earlier research, instructors may not appropriately communicate mathematical challenges with students due to inadequate training. According to the instructors questioned, the guideline stating that a kid may only be held back once each school phase contributes to low performance.

The South African Admission Policy for Ordinary Public Schools (1998) restricts grade repetition to one year each school phase (DBE, 2008). This compels schools to promote students to the next grade before they have acquired the required mathematical knowledge and skills. This strategy forces teachers to encourage mediocrity. Even if the number of school repetitions is limited, the policy warns that this should not be interpreted as advocating automatic promotion. The issue is also the lack of Math Curriculum Implementers visiting schools. The educators said CIs do not however visit their schools for help. Investigations revealed that just four CIs serve the whole area, with an average of 87 schools per CI. This does not allow for effective monitoring. Thus, good curriculum implementation and monitoring may enhance math results.

#### 1.3.2.4 MATHEMATICS TEACHING PEDAGOGIES

Teaching and learning environments, teacher quality and competence, time spent on task, disruptions in class, teacher confidence and attitude toward mathematics are all factors that have an impact on student math performance at the classroom level. Other factors include the number of pupils and teachers in a classroom, how much time is allotted for each student to complete their work, and how much time is allotted for each teacher (Bos & Kuiper, 1999; Howie, 2001; 2003; 2005; Lokan & Greenwood, 2000; Mac Iver, 1987; Muijs & Reynolds, 2000). In terms of achieving successful results, mathematics educational techniques come out on top. Fig 1.9 presented various teaching and learning methods that are used in mathematics and most of them are underpinned by use of socially interactive activities that encourage pupils to view mathematics positively.

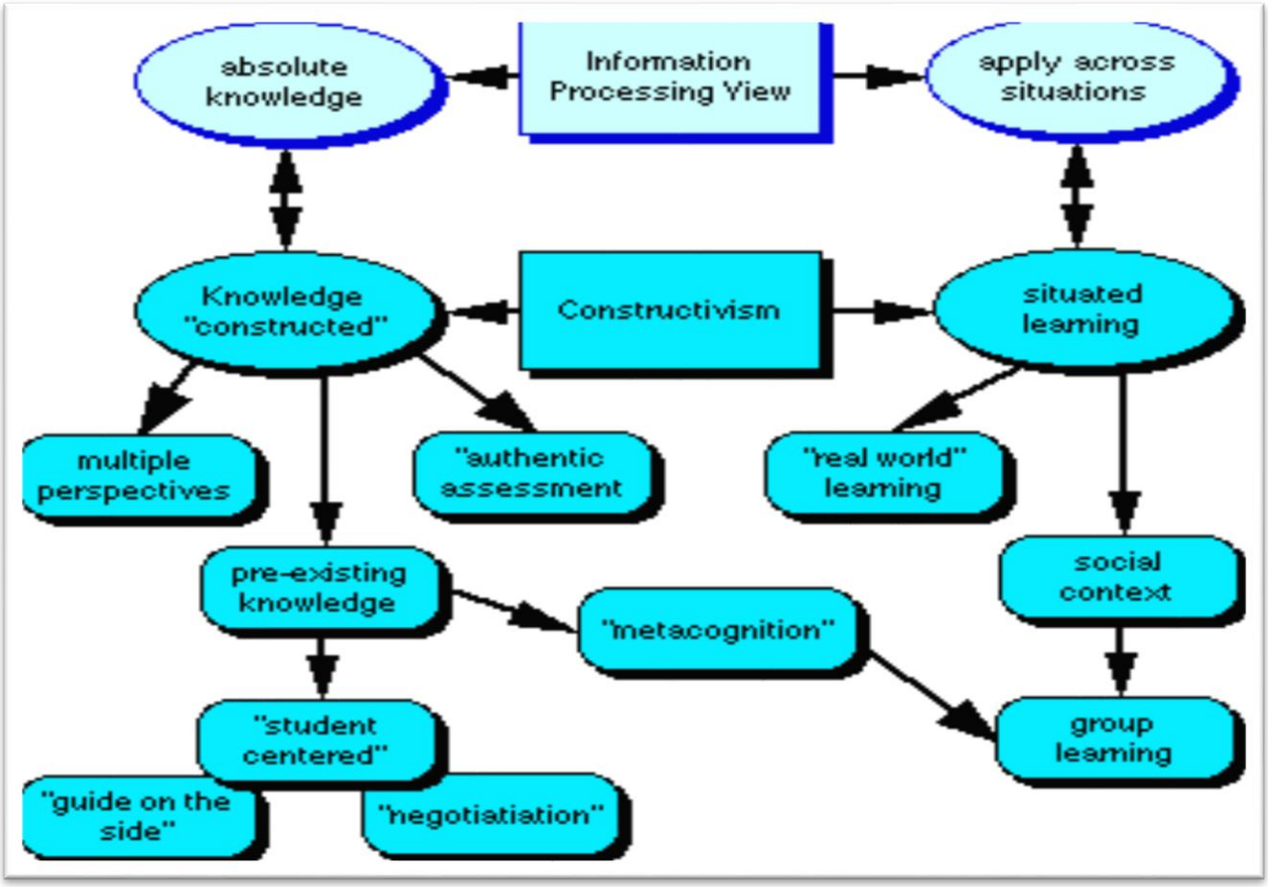


**Figure 1:8 Pedagogical approaches used in Mathematics (Adapted from www.researchgate.com)**

As a result, more people are motivated to find out more about it (Obodo, 2012). The methods used by the teacher should be enough to keep the subject interesting and exciting. In the teaching of mathematics, there are a wide range of options. To solve the problem of low academic performance in mathematics, students must be involved. Effort and time must be invested in the learning of mathematics for students to remain interested in the subject. Instead of treating them as passengers, they should be treated as active participants. Teacher competence is also important, according to Ajogbeje and Alonge (2012) a teacher's pedagogic content knowledge should be demonstrated in all the concepts they teach in the classroom. The goal of remediation is to bring students up to the same academic level as the rest of the class. In classrooms where teachers use interactive methods, students are more likely to participate actively. Group and project work have proven to be effective methods for teaching and learning mathematics, Makondo and Makondo, (2020) in the classroom.

Teachers' employment of a range of instructional methodologies for teaching mathematics reflects their differing didactic attitudes about the subject's teaching and learning, as seen by the following chart. It should come as no surprise that various tactics have diverse outcomes for students (Antonijevic, 2007). To be effective, educators must prioritize academic education as their primary classroom aim and provide academic guidance, while also establishing an atmosphere that is both business-like and task driven. These students spend their classroom time on a variety of academic tasks, demonstrating that good teaching is not just active, but also participatory (Muijs & Reynolds, 2000).

Thus, owing to cognitive-developmental psychologists working in the tradition of Piaget, learner-to-learner contact fosters growth by presenting cognitive difficulties to the participants. According to Piagetian theory, learner-to-learner contact serves as a stimulus for change but does not offer the content of the change (Copeland, 1984; Damon, 1984). The cognitive processes formed by learner-to-learner conversation, on the other hand, are highly valued by psychologists in the tradition of Vygotsky, with Vygotsky placing particular emphasis on "speaking as a vehicle for transferring information and possibly modifying understanding" (Mecer, 1994: 95). Many studies have concluded that learners' learning is enhanced by their active participation in class. According to Webb (1989), the provision of detailed explanations by students was shown to be associated with higher levels of individual success. Receiving detailed explanations, on the other hand, showed just a few statistically significant favourable associations with success. Students' understanding of their work improved when Russell and Kelly (1991) required them to explain certain aspects of their work to them.

Makondo and Makondo (2020) further suggest that instructional methods and approaches, when utilized in conjunction, are the most likely to result in increased learner success. Some of these instructional tactics include allocating appropriate time to academic tasks, maintaining an effective classroom management system, and measuring learner progress in a direct and regular manner. While moving from desk to desk, teachers actively monitor their students' understanding during class work. This allows them to guide those who are having difficulty and select appropriate learner work for whole-class review and discussion (Kaur, 2009). A detailed review of learner work completed in class or as homework is conducted by teachers during such lessons to ensure that their students understand the knowledge that was expounded during the whole-class demonstration. Orchestrating classroom activities and striking a balance between classroom management requirements and academic objectives involves juggling a tangled web of variables. It is more likely that poor learners will fail because they will not have enough opportunities to participate in meaningful and challenging learning experiences, positive feedback, review, and discussion, rather than because they will not have the necessary abilities or potential (State of Victoria, 2005).

The perceptions of the subject held by both students and teachers present an equal challenge to mathematics teachers. Both teachers and students agree that teaching mathematics is difficult (Chacko, 1989), and students agree that learning mathematics is difficult,(Gallop Youth Survey) (2004). Saad (2004) states that mathematics at the secondary level is poorly taught because some mathematics teachers lack pedagogic content knowledge and materials. Teachers are also confronted with the issue of the perception that mathematics is not for everyone. Mathematics is a specialized field reserved for a select few. It has been observed by mathematics teachers that students typically view mathematics to be a difficult subject to learn and master. Several studies have shown that achieving academic achievement is the most effective therapy for mathematics anxiety, and that this treatment should begin with the instructor. When it comes to pupils, the attitude of their lecturers is incredibly significant since it aids them in overcoming the challenges they are having with the topic. Every effort, no matter how little, should be acknowledged and praised by the mathematics instructor to enhance the overall level of accomplishment of his or her pupils in mathematics and other subjects. It has been found that pupils who have a history of frequent failure in mathematics develop an expectation that they will fail every time they attempt the subject. They are obliged to depend on the support of others to achieve things because they lack self-confidence.

Based on the literature, mathophobia has caused most students to assume that mathematics is a difficult subject (Sparks & Sarah, 2011). Most teachers stated that students who are slow in their learning face a great deal of difficulty when it comes to learning mathematics. In addition, they do not actively make connections between what they have learned and what is currently being taught. Whenever these students are presented with a problem-solving situation, they are incapable of using strategies or prior knowledge to solve the problem. Most mathematical topics are hierarchical, and as a consequence, students must build on their prior knowledge in order to progress. Several teachers in the mathematics department have claimed that certain students are experiencing memory difficulties, and they would like to ascribe this to a bad attitude on their side as well as that of the students. Some youngsters have trouble with the basic operations of addition, multiplication, and division. Others struggle with the concept of division. An example of this would be a student being asked to do a multi-step computation in which he or she may display ignorance, demonstrating that the student has memory challenges. The reason for this is once again since they have problems with their information storage, since the information they have gathered will never be saved in the computer system's Long-Term Memory. As a result, the calibre of leaners is also a source of concern (Sparks & Sarah, 2011). Several the difficulties that teachers encounter include a lack of mastery of the mathematical skills required to find solutions to problems. For most students, it takes a long time to master their skills. Another difficulty is related to the method of instruction used. Students' attention must be drawn to mathematics by teaching it in a manner that is clear, informative, and interesting to them (Sparks & Sarah, 2011).

According to the findings of a South African research conducted by Makhubele and Luneta (2015), learners should always be on time and attend all the times. They should never skip a period unless there is a serious problem with the sentence. Missing even a single period can spell doom for your academic career. They should put more effort into improving their conceptual understanding. The importance of conceptual knowledge for learners should be stressed, as it will go a long way toward making it easier for them to grasp mathematical issues rather than memorizing them, which will ultimately result in meaningful mathematics comprehension and retention. Learners should try to improve daily. All the problems in their workbooks and textbooks should be completed by the students themselves. Educators should emphasize to students that there is no substitute for dedication and effort on their part. They must resist the temptation to copy answers from their classmates if they are to achieve academic success. Make them aware that the greater number of problems they can solve on their own, the more confident they will be in class and during examinations. It is important for learners not to become discouraged if they do not always receive the correct answers right away. It is important for learners to make every effort to seek assistance when they require it. If a learner encounters a problem, he or she should seek help from his or her peers or from the mathematics teacher as soon as is reasonably practicable. Dissatisfaction with the task will result from an inability to complete it, and this dissatisfaction will manifest itself as a negative desire and attitude toward mathematics. Their parents and teachers should emphasize to them the importance of perseverance when it comes to mathematics.

Students' mathematical proficiency will almost certainly improve if the DBE, educators, and learners adhere to all the recommendations made, which are numerous.

## 1.4 CHAPTER SUMMARY

Within the discipline of mathematics education, this chapter explored the larger contextual backdrop to the issue of low performance among students in mathematics education. There was a detailed discussion of the global and South African contexts of both general education and mathematics education. In the next chapter, the research problem, research questions, goals, and objectives, as well as the reason for the study was discussed in detail.

## CHAPTER TWO: THE PROBLEM AND ITS SETTING

### 2.0 Introduction

Science, technology, engineering, and mathematics (STEM) are usually viewed as subjects that are essential to the nation's economic well-being and prosperity. It is vital for governments (particularly the South African government), business leaders, academics, and educators to expand and strengthen the STEM workforce, according to Letsoalo, Masha and Maoto, (2019). President Thabo Mbeki (2001), who perceives mathematics as a discipline that facilitates brain development, thus its centrality as a component of our human development strategy in the SADC Industrialization Strategy and African Union Agenda 2063; and Minister Pandor (2006a:2), who perceives mathematics as a discipline that facilitates brain development, thus its centrality as a component of our human development strategy in the SADC Industrialization Strategy and African Union Agenda 2063 (SADC: 2017). Apart from that, Azikiwe (mathematician and academic) observed that "Mathematics is the foundation of all sciences, and science is the prerequisite for technical and economic progress",(Betiku, 1999:49). The preamble chapter gave an in-depth context of the study through graphically presenting the global and South African context of education and Mathematics education. The current chapter presents the introduction of the study through an outline of the background of the study with particular focus on Centocow cluster of Sisonke district of KwaZulu- natal Province, the problem statement, research questions, objectives, questions, rationale, significance and limitations and delimitations of the study as well as the organization of the study.

### 2.1 Background to the study

In today's globalized world, scientific innovation is essential for Africa's and South Africa's economic competitiveness, quality of life, and national security, to name a few goals. A significant amount of future job growth will be accounted for by fields such as science, technology, engineering, and mathematics (STEM). There has been an alarming decline in advanced scientific and mathematical participation in many countries over the years, and there is a lack of qualified persons entering STEM fields in many countries (Watt, Shapka, Morris, Durik, Keating, & Eccles, 2012). Despite the importance of mathematics, the pass rate in mathematics in South Africa has remained poor, despite all the government's efforts to improve teacher training and learning environments in the country. The discipline is a vital steppingstone in the advancement of human development across the world. Owing to the African Union's Agenda 2063, Africa's most crucial task is to invest in capacity development via increased education in science, technology, engineering, and mathematics, among other areas of study. Kumar, and Ahmad (2014). This suggests that steps to promote a shift in people's mindsets, as well as actions to increase the capability of Africa's human resource via education, research, and knowledge acquisition, are required. Mathematics is currently considered to be a universal language of human existence, and it has a fundamental role to play in all practical and technological fields of study (Edger & Rao, 2000). Owing to Anthony and Leonard (2005), mathematics is a good predictor of autonomous, clear thinking and the capacity to solve issues in the workplace and in society.

South Africa was 144th out of 144 countries in Mathematics and Science education, falling below economically impoverished African nations such as Swaziland, Zambia, Zimbabwe, and Malawi (World Education Forum Report, 2011). It is disturbing that the Trends in Worldwide Mathematics and Science Study (TIMMS) revealed that the average student performance of South African Grade 9 students is much lower than the international benchmark of 500 points (Visser, Juan, & Feza, 2015). South Africa was rated sixth worst in mathematics achievement out of 63 countries that took part. This demonstrates a deficit in instructor topic expertise, which should encourage students to continue with mathematics until grade 12.

As a Mathematics educator in KwaZulu Natal Province since 2008 to date, I have observed that students lose interest in mathematics between grades 10 and 12 as evidenced by large numbers of learners leaving the pure Mathematics stream to study less difficult Mathematical Literacy offered in Grade 10- 12. Loss of interest in Mathematics may be ascribed to persistent underperformance in Mathematics on informal and formal assessments, as well as the use of routine and monotonous pedagogies in secondary school mathematics teaching and learning. As a result of South Africa's continued underperformance in mathematics education, as revealed by international benchmarking tests such as the Trends in International Mathematics and Science Studies (TIMSS) and the Programme for International Student Assessment (PISA), mathematics teaching and learning require improvement, as well as paradigm shifts away from traditional teaching methods and toward new, contextually adaptable pedagogies, Reddy et al, (2016).

South Africa, along with Botswana and Honduras, remained among the world's three lowest-performing nations in the 2011 TIMSS exams administered to Grade 9 students. Reddy (2012), on the other hand, highlights an intriguing contrast: despite their dismal performance, some of South Africa's top learners performed on a par with those in the best-performing nations such as Singapore, China, Taiwan, and Japan. South Africa was one of the five lowest-performing nations in TIMSS 2015 for both mathematics and physical sciences, with a mean score of 372 for mathematics8 and 358 for science, according to Mullis, Martin, Foy, and Hooper (2016). This implies that, despite South Africa's low overall achievement in Mathematics, there are some, albeit few, learners who can perform at the level of their global counterparts; thus, underperformance by the majority of learners may be attributed to socioeconomic factors, teacher quality, and an ever-changing school curriculum, among other factors. These may be manifestations of post-conflict and apartheid state difficulties.

Statistically, Western Cape, Gauteng, and Northern Cape were the top three performing provinces, while KwaZulu-Natal, Limpopo, and Eastern Cape were the worst three. As a resident of one of the lowest performing provinces, KwaZulu-Natal, the researcher took an interest in the low performance, which resulted in the recommendation of a collaborative model of teaching and learning mathematics which capacitates teachers as instruments of improving mathematics performance. It makes little difference whether the evaluation of learner performance is formative or summative, as long as it is an accurate representation of the product of the teaching and learning processes undertaken in schools. South African learners were compared to their worldwide counterparts regarding performance in Mathematics and Science in order to enhance the quality of educational delivery and provide possible interventions, Reddy etal (2016). The table 2.1 summarised national data on learners' mathematics performance in Grade 12 examinations from 2016 to 2020.

| YEAR | NO WROTE | NO PASSED | PERCENTAGE |
|---|---|---|---|
| 2016 | 263903 | 129481 | **49.1** |
| 2017 | 265810 | 135958 | **51.1** |
| 2018 | 233858 | 135638 | **58.0** |
| 2019 | 222034 | 121179 | **54.6** |
| 2020 | 233315 | 125526 | **53.8** |

**Table 2.1: Mathematics National percentage pass rates (2016-2020) (Source: DBE (2020)**

South Africa's Mathematics performance from 2016-2020 is an average of 53, 32 % implying that 46, 58% of the total of learners who sat for Mathematics national examinations failed. The poor National pass rates in Mathematics cascade to provinces and districts throughout the country. The Sisonke district of KwaZulu Natal (the research district) has recorded an accumulatively low pass rate in the last five years since the introduction of the National Senior Certificate in 2008.

Fig.2.1 below shows pass rates for Mathematics at Sisonke District from 2008-2012.

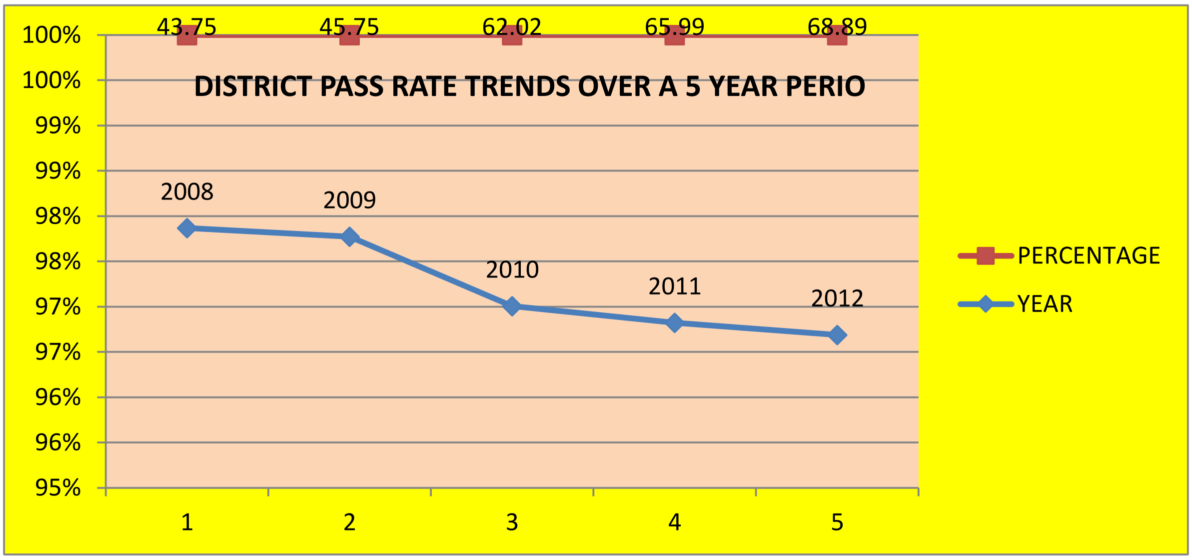


**Figure 2.1 Sisonke District Pass Rates in Mathematics per Circuit (2008-2012)**

Despite the cumulatively poor outcomes in the district mentioned above, the sciences, particularly mathematics, physical sciences, and life sciences, are consistently performing below the district's established objectives on a consistent basis. Based on Khathi (2013), the district attained a pass percentage of 35.81 percent in Mathematics in 2011, compared to the desired pass rate of 40 percent in 2011. For the 2012 school year, the district's intended pass rate was 43 percent; however, the district only obtained 35, 62 percent, a difference of 7,38 percent below the district objective. Detailed information about the pass rate for Mathematics in the district in 2012 is included in Figures 2.2 and 2.3 below:

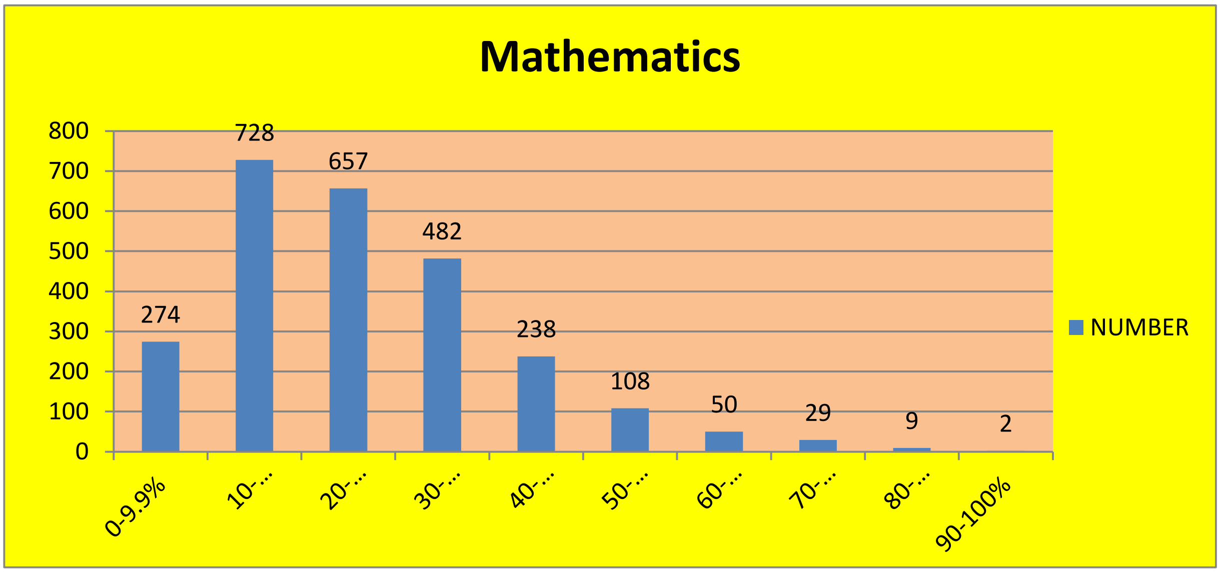


**Figure 2.2: Mathematics pass rates in all Sisonke circuits**

Fig 2.3 presented percentage pass rates of of Sisonke district now Harry Gwala and mirrors the broader Mathematics education context and performance of Centocow cluster the focus of the present study.

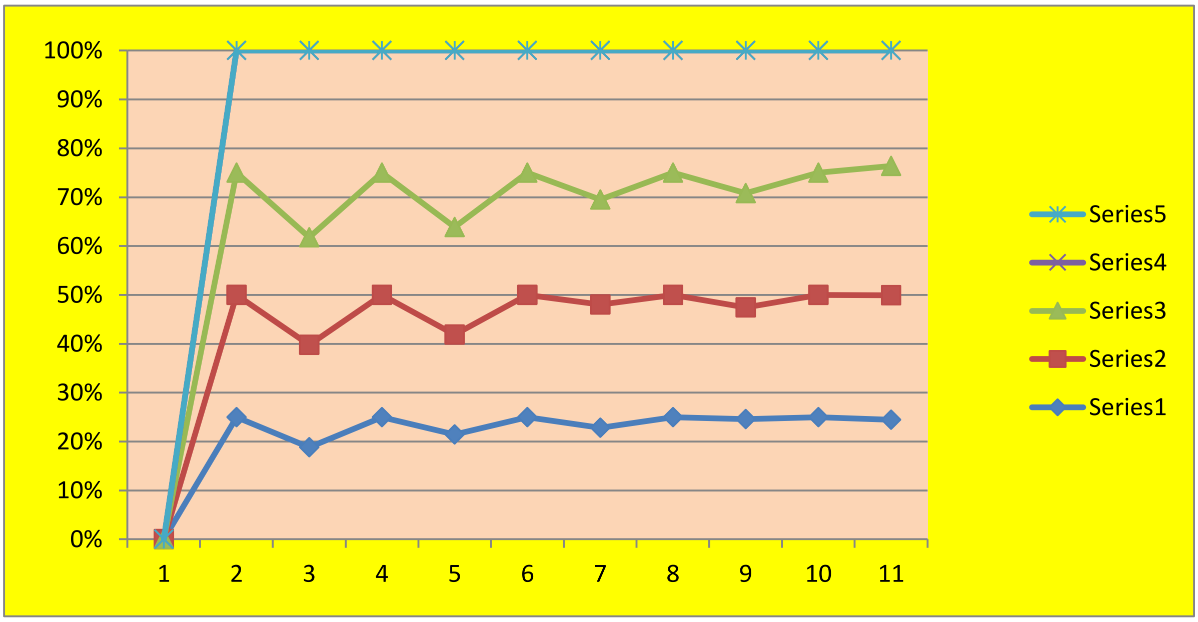

**Figure 2.3 Mathematics pass rates at Sisonke**

There was low pass rate of about 29% in the seventy-six public high schools offering Mathematics passing with a 50% pass mark (Khathi (2013). Among the lowest performers 3, 94% of the schools, got 0% pass rates in the subject. The above dismal failure in Mathematics in 2012 and the drop in the already low pass rate at Sisonke district testify the depth of the problems bedevilling Mathematics performance in public schools in the district. Khathi (2011- 2015) reveals the mathematics examinations pass rates for Sisonke district the last seven years are presented in Table 2.2 as follows:

**Table 2.2: Sisonke District passes rates in Mathematics (2009-2015)**

| SUBJECT | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| MATHEMATICS | 26,36% | 36,38% | 35,81% | 35,62% | 33,23% | 34,55% | 38% |

Concern has been raised about students' chronically low performance in Mathematics, which has continued despite a slew of interventions, including weekend refresher classes and seminars. As a consequence of the pupils' persistently low performance in mathematics courses at school, the researcher was motivated to develop a Collaborative model as an intervention to improve mathematics performance in the district. When curriculum developers and education reformers ask for activities that will result in school reforms and good mathematics teaching, this model will provide them with the information they need. Because of this, the researcher suggests an inclusive model of teaching Mathematics that involves learners, educators, and subject advisers in order to ensure effective content delivery, the use of a diversity of teaching pedagogies, enhanced networks, and high accomplishment in the subject matter. The increased level of mathematical performance, in turn, will add to the large quantity of public funds that are being pushed into educational possibilities.

The South African government has made significant investments in school infrastructure and policy provision to improve mathematics performance; yet, it does not seem to have recruited enough devoted mathematics educators to work on enhancing the quality of mathematics performance. Spaull (2013) asserts that the South African government has made remarkable strides in the provision of both access and funding for schooling since 1994, as evidenced by increased budgets for education, which, for example, totalled 227 billion in 2013/14 and represented 19.7 percent of total government expenditure, or 6.5 percent of the country's gross domestic product. The number of students enrolled in public schools has also increased, with 11 975 844 students enrolled in 24136 institutions.

Although the government has made the above-mentioned fiscal commitments, Spaull (2013) and Metcalfe (2008) agree that improvements in the quality of education still have a long way to go due to militating factors such as high learner drop-out rates (40 percent), loss of capacity in teacher supply, mismatch, and underutilisation of teachers in subjects in which they are not specialists, and under-resourcing, as well as curriculum changes that de-skill teachers.

South African academic Metcalfe (2008) asserts that the quality of an educational system can never be superior to the quality of its instructors. Fundamental in that it draws parallels between educational system input and output variables in that an education system that invests heavily in its teachers in terms of teacher standards and certification, training, deployment, salary, administrative support, and motivation of teachers is more likely to achieve good learner performance outcomes. Bernstein (2015) expresses concern that a qualified teacher is not always a competent teacher. Not all trained teachers are competent professionals capable of delivering high-quality instruction and learning experiences to their students. That which has been said so far demonstrates the need of continuing teacher development in providing chances for freshly trained and experienced educators to gain an understanding of and get acclimated to pedagogical subject knowledge of the phases they teach.

## 2.2 Statement of the Research Problem

There is low interest among the black communities to take mathematics at school and the facilities and environment was not generating interest enough within the black communities before 1994. Since 1994, various interventions and programmes have been initiated and implemented to reform and improve secondary school curricula in South Africa. Notable programmes were the Mpumalanga Secondary Science Initiative (2002), Learning for Sustainability Project (2000) and the National Strategy for Mathematics, Science and Technology Education (2001a). Despite the above initiatives and many more, the teaching and learning of Mathematics in contemporary South African classrooms remains traditional, teacher dominated, following predictable routine and boring processes. Educators in Mathematics classrooms still use the lecture method in teaching and continue to lose the interest of the learners they teach. Consequently, learners consistently exhibit low interest and only participate in lessons passively.

Consequently, Mathematics results are poor, embarrassing and are a cause for concern to curriculum planners, educators, and mathematics experts. Reddy (2011) revealed that South African Grade 9 learners came last at 48 out of 50 participating countries in Trends in International Mathematics and Science study conducted in 2011. National matriculation pass rates in Mathematics have consistently fluctuated in the last six years with 2010(46,0%), 2011(47,4%), 2012(54%), 2013(59;1%), 2014(53,5%) and 2015(49.1%) respectively. In another study by Carnoy *etal* (2011) in the Northwest it was found that Grade 6 Mathematics educators attained an average score of 40% in a test consisting of Grade 6 content items. In a comparative analysis of TIMSS results, Hungi *etal* (2011) found that 32% of South African Grade 6 teachers had desirable levels of Mathematics content compared to their counterparts in Kenya (90%), Zimbabwe (76%) and Swaziland (55%) respectively. The above learners and educators' competencies points to deficiencies in teaching and learning, quality of teachers and support systems for curriculum implementation in Mathematics education. Fig 2.4 showed South African educators' comparative performance in TIMSS benchmarks.

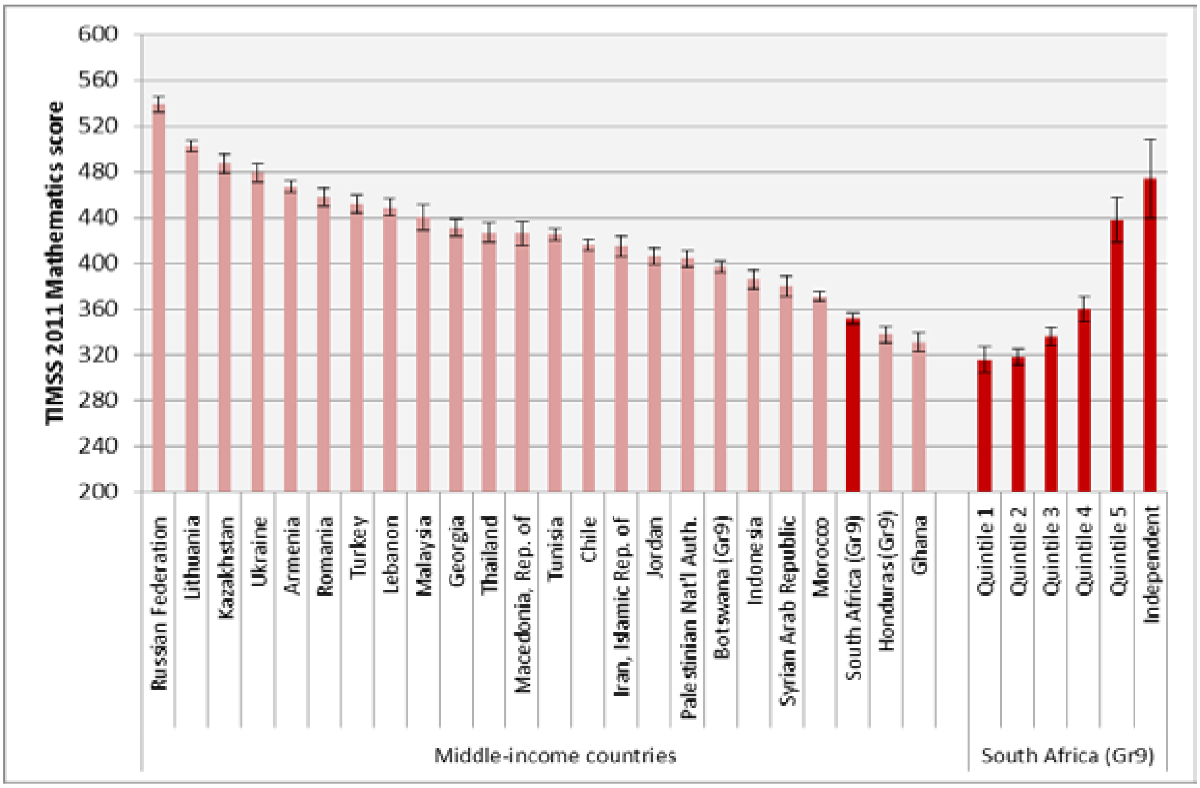


**Fig 2.4: Spaull (2013) South Africa Comparative Performance in TIMSS (2011)**

Another research was conducted to compare the performance and status of mathematics education in South Africa to those of other regional and internationally competitive nations in terms of educational attainment. The quality of mathematics educators in South Africa is so inadequate, according to Spaull (2013), that their proficiency levels in numeracy and mathematical content are low when compared to their counterparts in East and Southern Africa. The proficiency levels of Mathematics instructors in comparison to their regional equivalents are shown in Figure 2.5.

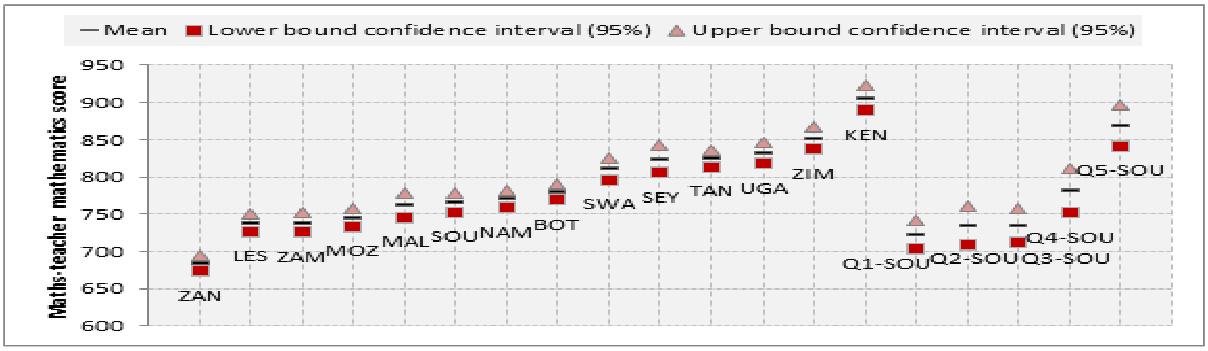


**Fig 2.5: Comparative competencies of South African Mathematics with their regional counterparts**

Consequently, the study's primary goal is the development of an interventionist, collaborative, and inclusive model that motivates learners and creates opportunities for their participation in Mathematics activities that interest them, resulting in the most effective learning of Mathematics concepts possible. Mathematics educators, who in most teaching and learning environments struggle to communicate ideas to learners owing to a lack of pedagogical topic understanding and a lack of professional support structures to assist them in improving practice in Mathematics, are also addressed by the approach.

The individual experiences of the researcher as a Mathematics educator for twenty years strengthen the justification for the study whose thrust is to demystify Mathematics and make it a social activity which both learners and teachers will enjoy and thus improve performance in secondary school education at the Centocow cluster of the KwaZulu-Natal Province of South Africa.

**2.3.1 Goals and Objectives of the study**

**2.3.1.1 Goals of the study**

The goals of the study were:

- To develop, design and construct a Collaborative Model/Strategy that will be used to improve Mathematics teaching, learning and performance in Secondary Schools in KwaZulu Natal Province of South Africa.
- Furthermore, the researcher aimed to build and develop future researchers' interest to evaluate the effects of the collaboration model of teaching and learning Mathematics. (Actual large-scale application of the Research Strategy is beyond the scope of this thesis due to time and financial constraints and the length of the thesis. It is suggested the further researchers apply the Research Strategy/ Model as given.

**2.3.1.2 Objectives of the study**

The following are the objectives of the research study:

a. To formulate intervention strategies to curb low performance in Mathematics in secondary schools.
b. To suggest the optimal conditions for implementing the developed model for curbing poor performance in Mathematics in secondary schools.

**2.3.2 Research Question**

The study was guided by the main research question which was:

What model can be used to enable stake holders (Educators, parents,learners, subject advisers,principals and Departmental Heads) to collaborate in improving student performance in secondary schools?

What processes and activities can be used to construct a collaborative model for teaching and learning Mathematics in secondary schools?

**2.3.2.1 Statement of the Research sub-questions**

The study answered the following research sub questions**:**

**a.** What are the possible factors that contribute to low performance in Mathematics education in secondary schools?

**b.** What intervention strategies and activities can education stakeholders (those involved in teaching and learning of Mathematics) who are educators, learners and subject advisors who collectively use a stakeholder's approach to curb poor performance in Mathematics?

**c.** How can the concept of collaboration be used in developing a model for teaching and learning Mathematics in secondary schools?

**d.** What conditions should be put in place to implement and measure the effectiveness of the intervention strategies of a collaborative model effectively?

**2.4 The Rationale of the study**

The study seeks to formulate, develop, as well as construct a Collaborative Professional Development intervention model of teaching and learning Mathematics for Sisonke District, Centocow Cluster of Quantile two schools in KwaZulu Natal Province of South Africa. This model must recognize the diverse contributions of skills, expertise, resources and commitment of stakeholders (participants in the study who are Grade 10, Mathematics educators, learners and subject advisors) in finding lasting solutions to recurring low performance in Mathematics in secondary schools at Sisonke district and KwaZulu-Natal Province in general. In the study, the researcher went beyond what other researchers have done that in identifying and discussing causes of Mathematics low achievement, to proposing and formulating a Collaborative model that principals, educators, parents, learners and subject advisors may use to address challenges of Mathematics failures amid resources and absence of qualified, experienced educators in the subject.

**2.4.1 Motivation for Research**

The reality of school reform in South Africa in the Mathematics discipline that will culminate in school improvement underpinned by collaboration of all stakeholders in education will undoubtedly result in the government getting high returns on investments in public education. The success of a Collaborative model of teaching and learning Mathematics will unlock huge potential in Mathematics communities and translate into high achievement which will in turn result in more graduates undertaking studies in science-related university studies. Fullan (1993:14) reiterates that," the ability to collaborate on both small and large scale is becoming one of the core requisites of postmodern society". This implies that the delivery of educational outcomes can no longer be left to individual teachers in schools or principals who must struggle in isolation, but it is now a communal, stakeholders' duty to share skills, expertise, resources and solutions to emerging educational challenges.

At Sisonke district, persistent and consistently low achievement in mathematics is the primary reason that the researcher was compelled to go beyond the usual approach of simply stating the obvious factors that lead to failure in schools and instead to suggest a model that is inclusive and accommodating of stakeholders' experiences and expertise in addressing the recurring challenges of low achievement in mathematics. A primary focus of the study process will be the comparison of first-hand crafts and computer-generated models, as well as the evaluation of the model and formulation of proposals and recommendations for expanded deployment in other areas and the province of KwaZulu-Natal in general.

### 2.4.2 Theoretical Frameworks of the Study

For this study, the researcher had to develop some theoretical or hypothesis on the improvement of learner and educator interest in mathematics. This facilitated him in coming up with research questions and guide his study.

Research studies are informed by theoretical lens or constructs of knowledge that help the researcher to develop the research problem, questions, literature review, research design, methodology as well as findings and conclusions. A theoretical framework is an 'explanation of a certain set of observed phenomena in terms of a system of constructs and laws that relate these constructs to each other,' (*Gall et al, 1996: 8*).

Theoretical frameworks form a basic component of research as they enable the researcher to construct theoretical underpinnings which result in the formulation of the initial research problem, ask appropriate research questions, select an appropriate population of study, guide their choice of research design, and assist in the interpretation of the data and conclusion reached (LeCompte & Pressle, 1953). The study focused on developing a collaborative model for teaching and learning Mathematics in secondary schools.

As such the social constructivist paradigm was used to inform the conceptualization of the model, components and conditions for implementation thereof. Fullan (2001) however, warns that curriculum initiatives are seldom completely successful. This implies that in crafting the model, the researcher was aware of the challenges of designing a model, materials needed and conditions for implementation of the innovation, especially in improving teaching and learning of Mathematics in secondary schools.Much details about social constructivism and network theories the twin underpinning theories of this current study are however given indepth analysis in chapter 4 (4.2.3) as this section merely outlines the highlights of the theories and their relevance to the study on developing a collaborative model of teaching and learning mathematics.

**2.5 Understanding of Social Constructivism as a Theoretical Framework**

Social Constructivism is a sociological theory of knowledge that was proposed and developed by theoretician Levy Vygotsky. It has some similarities to Jean Piaget's Theory of Cognitivism, which is also a sociological theory of knowledge. According to the idea, successful learning takes place in a familiar social setting in which learners are engaged in a social activity characterized by interactions and the development of greater awareness of the social context in which they find themselves. Kuklu (2000) argues that social constructivism is an extension of general philosophical constructivism to social contexts, and that people construct knowledge through interacting with one another and collaboratively creating small cultures based on shared artifacts with shared meanings, as opposed to individuals constructing knowledge independently. Based on the above argument by Kuklu, the research believes that by developing a Collaborative model for teaching and learning mathematics, educators, learners, and subject advisors will interact, discuss, create meanings, and form recurring behaviors in teaching and learning contexts that will result in activities and processes that will make teaching and learning mathematics enjoyable and better understood by learners.

If educators, learners, and advisors have created a social culture by networking, it enables them to understand the world as others understood it by employing the lens of Social Constructivism. This approach for collaborative model is interpretive in approach where Mathematics educators and their learners in classrooms create meanings as they attempt to solve mathematical concepts in real classroom contexts. Through data collection using triangulated instruments the researcher entered the real-life world of participants and gained insight into their experiences and ideas and how they intend on coming out with solutions to Mathematics challenges in their classrooms. Participants' views, experiences and subjective interpretations constituted a major social network which became the core of developing the theoretical model for teaching and learning Mathematics in secondary schools.

### 2.5.1 Curriculum Theory Innovation and Change

It is also important to understand curriculum theory, innovations, and change since these are the key outputs that the researcher, as a curriculum expert, is seeking to achieve. This is closely related to the fundamental theoretical paradigm of the study. Secondary schools are a kind of educational institution. In the same way that other disciplines of learning evolve, mathematics teaching and learning should be responsive to the always changing classroom environment. Since its inception in the 1960s, curriculum theory, change, and innovation have gained popularity. The unanticipated launch of the Russian satellite Sputnik in 1957 prompted deliberate reforms in the United States to align and revolutionize the Science and Mathematics curricula in order to produce more scientists who could compete with their international peers (Trowbridge and Bybee, 1990). As a consequence of the fight for technical supremacy, a proliferation of academic scholars was created, which led in the creation of new science and mathematics curricula. Curriculum theories are the result of research, and from the results, educational transformation models are generated, many of which are radical and non-sensitive to the environment in which they are implemented or tested. As per Hawes (1979), curriculum revisions and implementation should address the following issues:

- To what extent are the real planning implications of curriculum development realized?
- If they are realized with their true implications in terms of money, manpower, materials, and time, can realities be faced?

The above citation implies that the researcher must take into consideration the contextual differences of the schools sampled for the study, the nature of educators' qualifications and experiences in implementing curriculum changes and innovations in Mathematics. Successful reform, therefore, hinges on designing innovations that are teacher driven rather than imposed from the top by bureaucrats and armchair theorists.

Curriculum change is a general word that has been described by a number of different academics and researchers. Change, according to Hall and Hord (2006), is defined as a process through which individuals and organizations move as they progressively learn to comprehend and become experienced and competent in the usage of new ways of doing things. Educative change, according to Carson (1971), entails changes in practices that improve instructional programs in order to offer better education for students. In other words, curriculum change is a deliberate, non-linear process that focuses on the use of new or revised materials, the use of new pedagogical approaches, and the modification of beliefs and practices about curriculum and learning practices. New or revised materials, new pedagogical approaches, and modifications of beliefs and practices about curriculum and learning practices are all targets of curriculum change (Fullan, 2001). The Collaborative model, as a curriculum reform, necessitated that educators alter their responsibilities and classroom practices, as well as their beliefs and attitudes. As a result, training and support were necessary to help educators face the new difficulties posed by the model as it developed.

Three distinct strategies are often employed to distribute curriculum changes and improvements. Chin and Benne (1969) define passive dissemination as a centrally planned innovation judged required by the receivers. Agents of curricular change present a rational–empirical model based on the premise that rational educators would accept the suggested innovation (Nickolas & Forbes, 2001). Pursuant to Havelock (1971), the rational empirical model entails the formulation of an invention by an originator who recognizes the issue, conducts research to discover answers, creates the solution, and disseminates it to the receivers.

The process of change follows a cyclical pattern that includes design, assessment, feedback, and redesign (Havelock, 1971). On the other hand, a normative re-educative technique thinks that individuals can be re-educated to adopt new behaviors. This concept postulates that people's behaviors are objects of sociocultural norms, and that society may alter their attitudes, values, and abilities via direct contacts and interventions by change agents. The researcher used a rational–empirical approach to the reform and innovation of curricula. He recognized the issue based on contextual considerations and conducted research with practical educators who are his friends and coworkers. Through cluster workshops, educators at the Centocow cluster agreed that interventions for mathematics underperformance were necessary and volunteered to contribute to the model's collaborative creation. According to Pinto et al. (2005), innovations are more effective when instructors have a feeling of ownership over the invention.

### 2.5.2 Significance of the Study

The study shall be of academic and professional value to several stakeholders as shown below:

- ***Curriculum Planners and Analysts-*** Findings of the research will be used as the foundation for Mathematics curriculum planning and analysis to intervene in solving decline in Mathematics performance in secondary schools in the district and province respectively.
- ***Mathematics Educators-*** The study shall equip Mathematics educators with skills in teaching Mathematics in different classrooms. Educators will also benefit from networking, team teaching and collaboration strategies to improve teaching and learning of Mathematics in secondary schools.
- ***Policy makers-*** Findings on possible solutions to Mathematics low achievement will be of value to policy makers in that they will use them to resource schools materially through deploying suitably qualified Mathematics educators.
- ***Subject advisory in Mathematics-*** The research findings will empower subject advisors in Mathematics on the best practices in networking and creating platforms for staff development and capacitating educators through sharing resources, skills, and expertise in teaching and learning of Mathematics.
- ***Researchers-*** The researchers will further interrogate and perfect the Model as to give direction on how the strategy can improve the mathematics performance in schools.

## 2.6 The Delimitation of the study

The study focused on the following physical, social, and mental boundaries due to financial, time and capacity constraints.Fig 2.6 is a map of KwaZulu Natal Provincial district and indicated Harry Gwala district the host of Centocow Cluster the research site of the study.


**Fig 2.6 Map of Harry Gwala District (Formally Sisonke) Source: goooglemaps.com**

- It was conducted mostly in the rural Centocow ward where the five schools were sampled as research sites.
- The participants were Mathematics learners, educators, and subject advisors.

The study confined itself with investigating factors and interventions in improving Mathematics performance in secondary schools leading to crafting and developing a Collaborative intervention model.Critical to the choice of place of research was that the designed model is contextually suitable for rural and Quantile 2 schools which are underresourced and have poor Mathematics outcomes proberbly due to teacher incompetence and learners' inabilities to comprehend Mathematics concepts.Hence a collective and collaborative approach to solving a common educational challenge made corporation and eargerness to participate in the research for its utility was very high among teachers and principals alike in sampled schools.

### 2.8. Definitions of Terms

The study aimed at developing a Collaborative model where the thrust is to revolutionize teaching and learning of Mathematics to make it a social, interaction process. Definition of terms premises the discussion:

- ***Collaboration-*** The researcher discovered numerous critical components that explain the nature of cooperation throughout the different definitions of collaboration. The term collaborative learning is used to describe a wide range of instructional approaches that encourage interaction between students and/or between students and teachers. In order to create something, find meaning, answers, or understandings, or get to know one another, students often form groups of two or more. Collaboration in the classroom may take various shapes, but it always requires some kind of student research or practical application of concepts beyond what the teacher can provide alone. Cooperative learning is a deviation from the traditional model of higher education, which emphasizes the role of the teacher, lecturer or professor, MacGregor (1990).

The following components are described in detail: Cook and Friend (1991) recognized similar objectives, collaborative effort, or interdependence; Little (1990) and Gray (1989) emphasized parity or equality; Hargreaves (1994) and Cook and Friend (1991) included voluntary involvement. The following sections discuss each of the aforementioned critical factors and the role they play in collaboration:

- ***Common goals, joint work, and interdependence-*** Participants in collaborative relationships believe and hold common or mutual goals that are meant to benefit the group, the community or themselves (West, 1990). By implication, common goals are negotiated and not imposed by external authorities, and they are accepted by all the participants who commit themselves to their accomplishment. Little (1990) points out that there is shared responsibility to achieve goals of teaching in joint work since participants inter-depend on each other to attain the common goals. In the process of pursuing goals individuals develop a bond with each other which in turn results in a mutual commitment to each other and the achievement of set goals.

- ***Equality/Parity-*** Equality is also a critical component of a collaborative relationship; Cook and Friend (1991) and Steward (1986) agree that collaboration brings together people with unequal status in education, such as principals, teachers, parents, and learners, who should believe they have a significant meaningful contribution to make to the collaborative relationship and that their perspectives are significant and valued by others. Thus, according to Lieberman and Grolnick (1997:207), "learning to cooperate" entails "...sharing power, expertise, and influence." As a result, when stakeholders cooperate, they share power and equality, making it simpler to experiment with new ideas without fear of rejection or failure.

- ***Collaboration is voluntary-*** In a collaborative relationship, individuals freely and voluntarily participate without administrative compulsion but from common understanding and pursuit of a group goal with the premise that working together is beneficial and productive. Hargreaves (1994) coined the term contrived collegiality to explain conditions resulting from collaboration mandated by senior authorities. The kind of collaboration lacks the aspect of equality, thereby recreating a traditional top-down bureaucratic organisation. The study shall view collaboration as a stakeholder's approach towards problem solving premised on mutually agreed common goals, interdependence, and equality of status and voluntary participation of individuals.

- ***Collaborative learning-*** Collaborative learning is a catch-all word for a range of educational techniques that include students' collaborative intellectual effort or the collaboration of teachers and students. Typically, students work in pairs or trios, collaboratively seeking insights, answers, or meanings or producing a product (Smith & MacGregor, 1992). Thus, in a collaborative classroom, learning constitutes a paradigm shift away from conventional teacher-centered or lecture-centered educational techniques and toward learner-centered, student-centered debates and active participation in problem solving. In a collaborative classroom, the teacher takes on the roles of collaborator, scaffolder of learning, guide, adviser, and learning companion, as well as an experienced designer of intellectual learning experiences associated with emergent learning processes.
- ***School Improvement-*** Hopkins, Amiscow and West (1994:3) define school improvement as, 'general efforts to make schools better places, and ...a distinct approach to educational change that enhances student outcomes as well as strengthening the school's capacity for managing change." This implies that school improvement is a deliberate process of innovating programmes, activities, methods, and resources in schools with the aim of positioning schools as centres for change as well as positively contributing to improved learner outcomes and results in academic and sporting curricula offered in schools. Stoll and Fink (1996:43) posit that, "School improvement's ultimate aim ...is to enhance pupil progress, achievement and development." School improvement could be externally or internally initiated at provincial or district and at school levels respectively. Reynolds (1998) explains that there are the classical external Research and Development as well as the School Based Faculty Centered approaches to school improvement. The later approach is of interest to the researcher since the collaborative model that he seeks to design demands that grassroots initiatives respond to the contextual and cultural variables of schools implementing innovations.
- ***Model-*** For this study, the term model implies a broad teaching approach or strategy with complimentary processes that could be used to teach and learn mathematics in secondary schools. The term also meant a "staff development model" and the following definition is used in accordance with Joyce and Weil's (1972): a staff development model is a pattern or

plan that can be used to guide the design of a staff development programme (cited in Sparks & Loucks-Horsely, 1990:235)

**2.8.4. Organisation of the study**

The thesis is divided into seven chapters, each concluding with a summary of the findings and recommendations. The first chapter provided context for education in South Africa, specifically for Mathematics Education, which was the subject of the study. Chapter 2 discussed the research subject, research questions, aims and objectives, and significance of the study. Chapter 3 included a review of the literature, while Chapter 4 built on the review, focusing largely on the design framework used to construct the Collaborative model.

The fifth chapter defined the Research Design and Methodology Chapter and offered a baseline study of the research project, where the justification for a baseline study was emphasized and justified, followed by an in-depth data collecting from the research locations employing instrument triangulation. The data collected and generated using a mixed methods design was subjected to thematic analysis supported by descriptive statistics and quantitative analysis in Chapter 6, and Chapter 7 of the study highlighted the study's conclusions, recommendations for future studies, limitations, and gaps.

**2.9 Chapter Summary**

This chapter gave an overview of the background of the study and outlined its rationale and benefits to stakeholders, the possible constraints, mental and geographical boundaries of the research problem. The next chapter thematically expounded and evaluated relevant literature on the development of a collaborative model which attempts to improve the teaching and learning of Mathematics in secondary schools.

# CHAPTER THREE: REVIEW OF RELATED LITERATURE

## 3.1. Introduction

The purpose of this chapter was to define and assess the theoretical views on the constructing collaborative models for teaching and learning Mathematics in secondary schools, as well as to outline the knowledge, sample, and methodological gaps on a global, regional, and local context. In keeping with this goal, it first examined the challenges of teaching and learning Mathematics on a global and South African curricular framework and then gives an overview of the many pedagogical approaches used when instructing students in the subject. The need of interventions in the delivery of the mathematics curriculum is also examined, along with its rationale. The research also made a difference between professional development initiatives, programs, and models.

Limitations of preceding professional development approaches and recommendations on new projects were also being done. The chapter concluded by summarizing the recommended features of professional development programmes which include content, learning, coherence, types of activities and participative processes by educators. Conceptual frameworks of a Collaborative model, components of the model and conditions of implementing it and dynamics thereof are also elaborated on. Theoretical frameworks of the study are elaborated on interactively and provide the lens through which the study will be conducted.

To better understand perception across the educational sector, there has been a great deal of research work done. However, for this research, my review was limited to literature on behaviour theories, peer pressure theories, societal cultures and beliefs theories, and findings from other researchers on mathematics. According to Creswell and Creswell (2017), Hart (2018), Imel (2011), Babbie (2015), Marshall and Rossman (2014), a literature review enables a researcher to discuss the research issues and position that the study must develop within the context of collaborative Mathematics education. A literature review can also be used to identify gaps in the research. Reading and evaluating relevant material did not revolve on arguing for or against a particular point of view, but rather on presenting the facts as they were and reflecting on my observations and discoveries. In certain instances, the results of my study confirm the conclusions of earlier studies. In the study literature review was used to outline previous scholarly studies in mathematics education and the existing gaps were identified and how the current study sought to close them.

Mathematicians in South Africa have found that a lack of proficiency in the subject leads to a dearth of scientists and engineers in the nation, so it's clear that doing poorly in mathematics is a certain method to guarantee a dismal future for the continent. Researchers from both developing and developed nations have looked into the topic of mathematics education and accomplishment in schools and universities across the world, including in South Africa (Reddy et al. (2016), Jojo (2019).

Owing to Eacott and Holmes (2010), the future of mathematics education is in jeopardy both nationally and internationally, since the number of students studying advanced mathematics in upper secondary schools and universities continues to decline. Researchers speculate about the possible causes of this phenomenon in a series of studies (Chinnappan et al., 2007; Chinnappan et al., 2003; Hollingsworth et al., 2003; McPhan et al. 2008; Rubenstein, 2006), citing a variety of variables such as the irrelevance of contemporary mathematics curriculum content and the intransigence of traditional mathematics pedagogy. Although the origins of this decline are debated, all studies agree that the consequences might be severe, particularly given the growing shortage of competent people for occupations requiring a strong mathematical background. The expanding issues in mathematics education in general reflect the need for a professional revolution that will bring in motivated, appropriately prepared, and experienced educators who will take on the challenges straight on in order to achieve better Mathematical results. Thus, the quality of South African education depends on constant, continuing professional growth based on good philosophical and pedagogical foundations.

## 3.2 State of teaching and learning Mathematics in secondary schools: A global perspective

The ability to think mathematically is vital for any society's economic growth, as it is for any individual (Lipnevich, MacCann, Krumm, Burrus, & Roberts, 2011). International collaboration contributes to the advancement of scientific and technological knowledge in all countries (Enu, Agyman, & Nkum, 2015). This is due to the fact that mathematical talents are necessary in order to appreciate other subjects such as engineering, physics, social sciences, and even the fine arts and crafts (Patena & Dinglasan, 2013; Phonapichat, Wongwanich, & Sujiva, 2014). Mathematics serves a variety of functions in science and technology, as shown by Abe and Gbenro (2014), whose work points out that its use spans all sectors of research, technology, and commercial organizations. Mathematical relevance has propelled mathematics to the top of educational priority lists as a result of the subject's significance. Thus, according Ngussa and Mbuti (2017), the mathematics curriculum is specifically developed to provide pupils with knowledge and skills that are necessary in today's quickly changing technological world.

In comparable research that was carried out in India by Jayanthi (2019), it was shown that Mathematics plays an essential and one-of-a-kind role in the progression of human societies, and that it is a significant factor in the expansion of the human race as a whole. There is a possibility that mathematics is involved in each and every one of the aspects of our existence. This is evident in a variety of situations, such as waking up to the sound of an alarm, checking the time on a watch or calendar, picking up the phone, cooking in the kitchen, waiting for the countdown of the cooker, managing money, traveling to a destination, exchanging currency at a ticket outlet while taking public transportation, or checking in on a loved one after a long absence. These are all examples of situations in which time management is evident.

Unfortunately, a vast body of research indicates that mathematics education in Sub-Saharan Africa is in peril due to a lack of adequate resources. The learning gap between nations in the area and worldwide standards is so vast that, without broad and ongoing initiatives throughout all stages of education, it is unlikely that the gap will ever be decreased, much less closed (Beatty and Pritchett, 2012). Increasing in-service training opportunities for teachers, as well as ensuring that they have access to high-quality Teaching Learning Materials and educational technology will all have positive consequences. Longer-term reform of beginning teacher training programs for teachers who will teach mathematics at the elementary or secondary levels must be implemented. In the absence of significant change, insufficient beginning teacher preparation will continue to be a contributing factor to the issue, and poorly prepared educators will continue to be a stumbling block to progress toward improved results in mathematics, Bethell (2016).

In nations such as India, Britain, and China where the ratio of mathematics textbooks to students is much poorer than 1:2, there is likely to be an advantage to be obtained through increasing the availability of mathematics textbooks for students (Fehrler, Michaelowa and Wechtler, 2007). As per Fredriksen and Brar (2015), effective techniques for addressing the demand for textbooks in nations with significant budgetary restrictions are proposed in this paper. However, research has shown that just increasing the number of textbooks available will not result in large increases in mathematics proficiency – the textbooks must be the appropriate ones, and instructors must be taught on how to use them successfully.

To determine if a textbook is likely to be successful in the teaching of mathematics, it is necessary to conduct a thorough assessment prior to publication. At the moment, pre-publication assessment of textbooks is primarily concerned with alignment with curricular content, learner appeal, physical quality, and cost of production, among other factors. While new textbooks in South Africa are carefully assessed for their efficacy as learning aids and that they are closely linked with instructional goals, there is no indication that this is the case in other parts of the world, Bethell (2016).

In 2014 research on the worldwide condition of mathematics, the United Nations Educational, Scientific, and Cultural Organization (UNESCO (2014) discovered that various misconceptions impact people's perceptions of mathematical activity, due to their perceived image of mathematicians. Despite advances in technology, mathematics is still often seen as a lonely discipline, isolated from the concerns of the real world and unaffected by technological advances. It is also still often seen as a completely deductive activity in which absolutely rigorous formal arguments are used to create theorem after theorem. Finally, it is often believed that mathematics is a subject that is not suitable for all students, and that females are more prone than boys to have problems while studying mathematics in school. These many misconceptions have an impact on teaching and create obstacles to high-quality mathematics instruction for all students, UNESCO (2014).

The declining interest in mathematics study at universities in South Africa makes the problem more acute, generating a vicious circle (Holton, 2009). However, the main issues arise, concomitantly in developing countries in the form of an unattractive profession, a shortage of secondary-school pupils likely to study mathematics at university and a shortage of trainers to ensure that they are trained. In many of these countries, pupils or trained teachers leave in droves for countries where professional prospects are better. This is particularly the case in several African countries, as shown by the study on the state of teacher education in twelve countries, conducted at the behest of the Africa Mathematics Education conference (Adler et al, 2007). The quantitative teacher recruitment and retention problem is thus a major issue and, if it is to be solved, the problems of mathematics education after basic education must be examined. As highlighted in Mathematics in Africa: Challenges and Opportunities, a report produced recently by the Developing Countries Strategic Group of the International Mathematical Union for the John Templeton Foundation (DCSG, 2009), to concentrate on primary education alone will be futile if there are no qualified teachers; there can be no qualified teachers without skilled mentors to teach them. This implies that there will be sufficient mathematics learners enrolling into senior secondary education and into higher education. To overcoming this challenge, the real importance of the profession must be recognized socially and teachers' working conditions must be improved. Furthermore, systematic efforts must be made to give all teachers access to networks, resources, in-service training, exchanges, and collaboration with others.

Another issue is the quality of mathematics teacher education in many countries; in many cases, the quality of teacher education is far from sufficient even when there is no quantitative issue (UNESCO, 2014). As previously stated, there has been a significant increase in the demands placed on basic education. Mathematical, didactic, and pedagogical training are essential for instructors in order to fulfill the expanding needs of students. In numerous nations, the majority of basic education teachers, not just in the beginning classes but also in other levels, have had problems in their own mathematical education and have a bad picture of mathematics as a field. They are often general-purpose educators, and the credit hours they have earned in scientific education and, above all, mathematics education account for just a percentage of their total training time and education. Owing to this, their initial and in-service training are more difficult to complete. In light of these fundamental qualities of education, considerable consideration must be given to the information that must be learned in order to practice this profession, as well as the methods and means by which it may be developed. There is no doubt that the practice of one's job requires a thorough understanding of the mathematics that is the focus of educational efforts. The first and most significant aspect to note is that, as previously said, mathematics taught throughout compulsory education is no longer limited to the mathematics taught at that level just a few decades ago. All too frequently, prospective mathematics teachers are not taught to take into account these advancements while they are being educated, and as a result, they are not taught to present mathematics as a living science that interacts with many other educational subjects, UNESCO (2014).

Another challenge is that of lack of better collaboration among the various communities tasked with educational issues, in particular mathematicians, teachers and educationists. From this point of view, in the last few decades, the development and institutionalization of didactics as an academic research field, fueled by the disillusionment generated by the period of modern mathematics, have modified the traditional balance. In the last decade, in several countries, dissatisfaction with mathematics education has resulted in mistrust and even rejection of research ideas which, if not actually implemented in practice, were researched in several curriculum documents. This is particularly true in countries where mathematicians and mathematics education researchers work in separate institutions and hardly work together on teacher training, among other topics. This situation seems to be highly detrimental to mathematics education. It is not, however, inevitable and it is therefore important to raise awareness of successes in that area and to hold them up as a source of inspiration. The challenge of quality mathematics education for all will not be met unless collaboration is strengthened. Collaboration has traditionally been viewed in terms of North-South cooperation. Such collaboration is indeed essential, and projects on mathematics and mathematics education already abound. However, the importance of regional collaboration on mathematics education merits recognition on a wider scale. As already emphasized, mathematics education is rooted in contexts and cultures that must necessarily be considered to secure educational improvements, UNESCO (2015).

It was discovered by Panthi and Belbase (2017) that classrooms in Nepal are multicultural and multilingual in general because kids come to the school from a variety of cultural and linguistic backgrounds, according to similar research conducted in Nepal. Against this backdrop, Gates (2006:391) stated that "in many parts of the world, mathematics teachers are faced with the challenges of teaching in multi-ethnic and multi-lingual classrooms containing - immigrant children as well as native-born, migrant, refugee children, and if research is to be useful, it must address and help us understand such challenges." Mathematical classrooms in multi-lingual settings may provide linguistic and pedagogical issues that need the use of pedagogical skill and intervention on behalf of the instructor. These concerns present difficulties for us in the context of mathematics education and learning. However, language is more than a method of communication; it is also a vehicle for comprehension. Students make sense or generate meaning in their words by using figurative language. The most effective method of conveying meaning or developing a mathematical notion is to do it in one's native language. A growing number of people are becoming aware of the importance of language on mathematics learning (Orton 1996). The linguistic forms and tactics we use in mathematics instruction benefit certain social groups more than others, and this is reflected in the data (UNESCO 2015).

Based on related studies, it has been shown that students' mathematical performance varies greatly depending on their geographic region, ethnic background, and gender (Ministry of Education in Nepal, 2015). The National Assessment of Student Success (NASS) performed a study recently that found that private schools had a higher average accomplishment score in mathematics than community (or public) schools, with the former scoring 57 percent higher than the latter scoring 26 percent higher. In any case, it is unclear whether the difference can be attributed to the effectiveness of instructional methods in institutional schools or is a reflection of the differential in socio-economic situation of children in these two unique school systems, according to the Ministry of Education (2015). The disparity in performance between private or institutional institutions and public schools has been identified as a contributing factor to socioeconomic inequality in mathematics education. In Nepal, there is a mismatch between the achievement of Dalit students and those from other groups, which contributes to a second gap in mathematics performance between students from other communities and those from Dalit communities (MOE 2015). Several studies, including a NASA study, have shown a considerable achievement gap between pupils in rural and urban schools in Nepal, with the gap reaching around 24 percent in the eighth grade (MOE 2015). It was discovered in the same research that many children (about 37 percent) did not get any homework from their mathematics teachers, and their performance was demonstrated to be poorer than that of other students who did receive homework from their instructors. In Nepal, it has been revealed that the general performance of students in mathematics is right skewed (right tailed), which means that many students had a mark that was lower than the median grade. In certain circumstances, it has also been shown that parental education has a positive influence on the performance or success of pupils (MOE 2015). Although the government and non-governmental organizations have made several efforts to close the achievement gap in all areas of education, notably mathematics instruction, it has continued to be a chronic issue in Nepalese education.

According to Aldon, Cusi, Schacht, and Swidan (2021), the current outbreak of the COVID-19 pandemic, which has resulted in the use of Emergency Remote Teaching pedagogies to teach mathematics at several institutions in several countries, including South Africa, has had a similar impact on the quality of teaching and learning mathematics. While the COVID19 lockdown was in effect, Aldon et al. (2021) explored how mathematics educators from France, Israel, Italy, and Germany managed the teaching and learning of mathematics during this time. They noticed that, as a result of the exceptional circumstances, teachers were obliged to alter their instruction and change their educational techniques. Drijvers (2020) conducted research on distance mathematics instruction in Belgium, Germany, and the Netherlands during the period while the COVID-19 shutdown was in force. According to the results, teachers' engagement in distance education may have caused them to lose sight of the mathematical tools and pedagogical strategies that are used in mathematics classrooms. Drijvers (2020) recommends that mathematics instructors employ rich, didactic, and engaging remote teaching approaches to better serve their students in order to improve the quality of their instruction. During the COVID-19 outbreak, Mailizar et al (2020) investigated the attitudes of Indonesian secondary mathematics teachers on the implementation of e-learning in their classrooms. During their investigation on the use of digital teaching during school closures, the researchers revealed that teachers had had challenges. The use of e-learning was fraught with obstacles, not the least of which was Indonesian learners' limited access to equipment and internet connections, as well as their lack of comprehension and ability to utilize it effectively. Immediately after the outbreak of the COVID-19 virus, Naidoo (2020) investigated the experiences of South African postgraduate mathematics education students who used digital platforms for learning during the pandemic. They noticed that digital platforms provide unfettered access to module material and resources, which they believe is a significant advantage. The students, on the other hand, expressed dissatisfaction with the expense of digital resources and the fact that they needed training in order to effectively use digital platforms.

Furthermore, pertaining to the findings of Chirinda et al. (2021) in a South African study, teachers admitted to taking advantage of online platforms to obtain new ideas and methods for delivering mathematical content during a pandemic that disrupted normal classroom instruction. As per teacher X, he was required to join a Facebook group from Israel that focused on how to implement technology in an online environment when teaching Euclidean geometry and Analytical geometry. Many teachers indicated that they participated in international mathematics discussion groups on social media (WhatsApp, Facebook, Twitter, and Instagram) that were focused on implementing digital platforms in the mathematics classroom. A lot of his ideas for different learning exercises on circle geometry and other subjects were inspired by the group, and he was able to execute them on the WhatsApp platform.

Students' learning of mathematics and performance in mathematics are affected by a variety of factors, as per to a Tanzanian study conducted by Mazana, Montero, and Casmir (2019). These factors include students' attitudes toward mathematics, teachers' instructional practices, and school environment. Students in Tanzania, like students in any other nation in Sub-Saharan Africa (SSA), routinely do badly in mathematics and science, causing the country to lose economic advantages over other countries in the region. Students' performance in nations within Sub-Saharan Africa (SSA) is rated much lower than the global average in international evaluations (Bethell, 2016; 38). Bethell goes on to say that for nations in Sub-Saharan Africa to gain from a competitive global economy powered by new technology, they must make considerable advances in STEM education over the long term. When Kupari and Nissinen (2013), Yang (2013), Tshabalala and Ncube (2016) demonstrate that low mathematics performance is a consequence of cross-variables connected to students, educators, and schools, they are demonstrating that factors that may impact mathematics performance.

The attitude of a student, according to several studies, is one of the most critical characteristics that determine whether or not a student will achieve higher or worse levels of success in mathematics (Mohamed & Waheed, 2011; Mata, Monteiro & Peixoto, 2012; Ngussa & Mbuti, 2017). When it comes to a certain thing, scenario, idea, or another human, attitude is defined as a person's learned proclivity to respond favorably or unfavorably to that item, scenario, idea, or other individual (Sarmah & Puri, 2014). The development of positive attitudes may take place over time (Syyeda, 2016), and once a positive attitude has been created, it has the ability to improve students' academic performance and success (Akinsola & Olowojaiye, 2008; Mutai, 2011). In contrast, a negative attitude is averse to effective learning and, as a consequence, has a negative influence on the learning outcome and, thus, on performance (Joseph, 2013). Regardless of the circumstances, attitude is a critical component that must not be disregarded. Depending on the student's attributes, the influence of attitude on mathematics success might be either positive or negative for the student in question.

### 3.3. Challenges in teaching and learning Mathematics in secondary schools: A South African context.

"*Mathematics teachers should strive to provide multiple and varied opportunities for learners to develop their mathematical reasoning skills – the capacity for logical thought, reflection, explanation, and justification" (Department of Basic Education, 2019: 8)*

Mathematics education is one of the national priorities in South Africa. This fact is highlighted in the executive summary of the National Development Plan (NDP) and indicates the demand for an increase in the number of students achieving above 50% in Literacy and Mathematics, respectively (National Planning Commission, Department of the Presidency, Republic of South Africa, 2012).

The legacy of inadequate mathematics instruction provided to the majority of learners during the years of apartheid is still pervasive in most public schools in South Africa, even after more than two decades under democratic rule. According to the recently announced findings of the Trends in International Mathematics and Science Study (TIMSS) 2011, South Africa was, as has been the case in previous such studies, classified among the nations with the lowest performance (Spaull, 2013). Teacher shortages in South Africa, as well as many other developing and rising economies, are exacerbated by a lack of mathematics subject knowledge and the ability to apply what they know in the classroom. This is one of the most pressing issues facing educators worldwide. It is commonly recognized, according to Rowland and Ruthven (2011) that the quality of teaching is dependent on the knowledge that the teacher brings to the classroom. Many South African Mathematics educators, according to a survey conducted by the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ III) in 2012, have an inadequate comprehension of the curricular subject they are responsible for teaching. As part of the discussion about possible solutions to the mathematics problem in South Africa, issues are often raised concerning the type and manner of extra assistance for teachers that may have a good influence on their professional growth.

It has become common knowledge that the majority of South African learners struggle in maths. However, even the most hopeful analysts agree that the school system has a long way to go before we can be certain that it is providing excellent education to all students (Reddy et al. 2015; Spaull 2019; Van der Berg & Gustafsson 2019). As a result, Van der

Berg, Gustafsson, and Malindi (2020) observe that the quality of South African education is at a level that is more commonly associated with a low-income nation than with a middle-income one, and that this is a cause for concern. Taylor and Robinson (2019) point out that, despite the fact that South Africa spends more than 30 times as much on each primary school child as Uganda, the countries' scores on the Southern and Eastern African Consortium for Monitoring Education Quality (SACMEQ) have tracked each other closely for nearly two decades.

Following on the findings of a similar research by Jojo (2019) on the condition of mathematics in South African schools, mathematics performance in South African schools is among the lowest in the world. Unacknowledged deficiencies in mathematics instruction in the majority of public schools deny many students the opportunity to pursue further education as well as current, knowledge-intensive job skills. Due to the fact that the mathematical subject to be taught is deliberately defined, timed, and sequenced using specified mathematics textbooks that reference specific instances, this is the case. Ramatlapana and Makonye (2015), on the other hand, contend that the aforementioned prescription hinders the professional autonomy of mathematics instructors. This curriculum is popular in the nation because it is beneficial in the teaching of low performing learners from disadvantaged socio-economic backgrounds via the use of a more organized teacher guided instruction, according to Feza (2014), who developed the curriculum. Through Mathematics Continuous Professional Development programs, systematic efforts to change the practice, attitudes, and beliefs of mathematics teachers in the classroom, in order to affect the learning outcomes of students and familiarize teachers with the implementation of the curriculum are also influenced. They were designed to address the quality of mathematics education, the enhancement of the quality of mathematics educators, numeracy and mathematical education in lower grade levels, among other things.

As an additional point of reference, Feza (2014) asserts that South Korea and Singapore, which are two of the top performing countries in TIMSS, underwent curriculum reforms that were driven by political pressures and were ultimately successful in establishing their students as the top performers in TIMSS. However, South Africa's recurrent placement at the bottom of the TIMMS rankings, as well as the similarly bad outcomes in the yearly high-stakes national grade 12 matric test results, have prompted unending conjecture regarding the reasons and causes of South Africa's poor mathematics performance. Feza (2014) goes on to claim that some of the variables contributing to low mathematics performance in South Africa includes those that are associated with curriculum implementation and teacher preparation. Despite the fact that the currently adopted curriculum specifies specific material that must be taught to learners at different levels, the classroom methods of mathematics instructors have remained largely constant. According to Motshekga (2013), the education minister, South Africa is substantially underperforming in education in general, and specifically mathematics instruction and learning. One evidence of the difficulty is that mathematics instruction is often of low quality, with educators often unable to answer problems from the curriculum they are teaching. National testing might be deceiving since it does not often reveal the significant achievement difference at lower grade levels. With a view to resolving this dilemma, the government decided to develop a set of values for the teaching and learning of mathematics in the framework of the South African educational system. It was also accepted that, in terms of education, the nation was performing well in terms of the fact that all learners had access to some mathematical studying, equality, and accessibility, but that quality remained a problem. It was mostly noticeable in public sector institutions, which account for around 80 percent of all educational opportunities in the nation.

Based on the Organization for Economic Cooperation and Development (2008), the exacerbation of an excess supply of unskilled workers and the worsening of wealth inequality in the nation have both had a negative influence on South Africa's mathematics educational achievements in recent years. This crisis has recently gotten worse as the Department of Education decided to progress learners who did not meet the minimum mathematics requirements for progression to the next grade in the senior phase, grades 7–9, even though they did not meet the minimum mathematics requirements for progression to the next grade. In this chapter, I claim that the advancement of learners who fail mathematics jeopardizes the future quality of human capital and economic prosperity of the nation. As a second suggestion, I believe that underqualified mathematics instructors, particularly those who have just completed standard grade mathematics, may be remedied by exposing them to an intensive mandatory in-service mathematics teacher training procedure. Teachers of mathematics would be prepared with both pedagogical understanding and mathematical material in order to effectively teach the subject, Jojo (2019).

In terms of global statistics, South Africa has a long history of low performance in both national and international exams, which is reflected in its poor performance in national testing. In the most recent Trends in Mathematics and Science Study (TIMMS), the nation was placed second to last out of a possible 100 countries (Reddy et al., 2016). While the results of the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) show that South African learners' performance in mathematics is improving (Department of Basic Education, 2017), the World Economic Forum (2015) ranks South Africa as the worst country in the world for higher education mathematics and science education. There have been numerous studies conducted in the region that have looked into factors that influence poor mathematics performance, ranging from language and learners' background information (Phakeng & Moschkovich, 2013) to home and school resources (Visser et al., 2015) to teacher classroom practice (Arends, Winnaar, & Mosimege, 2017) and other perspectives. Despite how beneficial they are, the recommendations from this research are restricted in terms of their applicability in the classroom.

There are several obstacles facing mathematics teaching and learning, which vary in type but have an impact on both developing and developed nations in different ways. Historically, colleges have served as user systems, with their main societal purpose being to follow national program policies, which are sometimes distributed by the central government. Their discourse variances have an influence on the quality of their academic delivery, just as they do in their home surroundings.

### 3.3.1. Infrastructure and Mathematics educational materials-challenge

The provision of material resources is critical for the achievement of successful learning outcomes. In 2001, a median score of just 8,7 was achieved on a list of twenty-two engaging resources for teaching that were made available in fourteen different geographic locations across Southern Africa. The quality of education in most nations was deplorable, and as many as 10% of students (45 percent in Zanzibar) were unable to find a seat in overcrowded schools. According to the United Nations Educational, Scientific, and Cultural Organization (UNESCO (2004), the higher rate implies that the absence of such basic resources as school rooms, desks, chairs; chalk and textbooks mean that different factors that square measure crucial for quality education (teacher, subject, knowledge) may not have a significant impact on rising learner performance. The purpose of the research is to determine whether or not a school's resource endowment has an impact on students' performance in the areas of arithmetic teaching and learning.

As a general rule, a lack of resources in underdeveloped nations will preclude the delivery of sound education; yet, in comparably affluent countries, schools have attracted skilled and accomplished academics to underprivileged universities (Jeanne Kriek, 2005). According to research conducted by UNESCO Education for All (2014), a shortage of academic resources in colleges makes learning very difficult, and the inability to achieve desired performance results, particularly in science and mathematics education, happens. In addition, World Bank (2010) research revealed that in some of the world's poorest nations, the optimal mix of resources had a positive impact on the performance of students. The provision of high-quality, clearly written, and easy-to-understand textbooks or a variety of high-quality room resources continues to have an impact on the quality of teaching and learning.

Therefore, if academics are not given with sensible textbooks, no matter how intelligent they are, they will be unable to raise the level of teaching and learning at higher education institutions. The distribution models used in school rooms and universities, for the most part, are also closely related with resources. It is explained by Borg (2008:9) that "part of the resource constraint in poor colleges may result from inequitable distribution of resources; typically resources square measure a lot of accessible to quality education in urban areas than in far geographical regions or in poor neighborhoods within cities." For this, it follows that unequal allocation of resources across institutions is a critical issue that must be handled with respect and equity, lest it result in poor performance, especially in critical courses such as mathematics. The research attempted to determine the resource matrix in Sisonke secondary schools, and as a result, the kind and quality of textbooks that are utilized, as well as whether or not they have an influence on learners' mathematical performance.

### 3.3.2. Human resource distribution-challenge

Human resource distribution, including administrators, educators, and support staff, is also a critical factor in determining the successful implementation of faculty program mathematics in particular. Employing inept, incompetent, or slothful instructors may have a detrimental effect on learning and teaching results in arithmetic education. Teachers are critical to the long-term growth of educational institutions. They are currently the primary impediment to universal access to high-quality mathematical education. The issues are many, quantitative and qualitative, according to UNESCO (2012). Numerous studies demonstrate that instructors' insufficient topic understanding accounts for a significant portion of the issue. Venkat and Spaull (2015), for example, conclude from a study of SACMEQ teacher test scores of South African Grade 6 mathematics instructors that 79 percent of teachers lack the topic understanding required by the Grade 6 school curriculum. In other words, they lack an understanding of the curriculum for which they are accountable. They are imprisoned from the very beginning of the intellectual trajectory defined by the school curriculum. For instance, a sample of 158 final-year students at a rural college earned an average of 26%, whereas the 46 students specializing in math earned an average of 37%. (Bowie 2015). These dismal outcomes are unsurprising: Bowie (2014; also see Taylor 2014a) shown that across these five institutions, which represent a range of institutional kinds, the curricula of student teachers who choose not to specialize in mathematics devote as low as 5% of the four-year curriculum to the subject. However, test results indicate that pupils who specialize in mathematics learn little more than their non-maths peers.

Bowie (2015) laments that these insufficiently educated but soon-to-be-qualified teachers are the agents who, unknowingly and through no fault of their own, perpetuate the country's abysmal educational performance year after year. It is not fully obvious why final year students have so little topic expertise. Is it just that inadequate time is allotted to mathematics in BEd curriculum; or are lecturers themselves using inefficient pedagogical strategies with their students? These are open-ended questions that need more investigation. However, it is quite evident that professors are issuing credentials to people who are unqualified to teach mathematics in South African elementary schools. Thus, under-resourced schools provide numerous factors that dissuade competent academics from enrolling, which can result in a situation where poor, incompetent academics are trapped in under-resourced colleges and perpetuate a cycle of poor performance, thereby amplifying the magnitude of poor performance, particularly in critical subjects like arithmetic. Teacher impressions of the difficulties they face while educating children from low-income families will be gathered, as will the strategies they use to equalize learning opportunities in their classrooms. The impact of the Department of Basic Education's attempts to recruit and retain competent academics via incentives will also be investigated and analyzed as part of the analysis study.

### 3.3.3. Impact of teacher challenges on teaching and learning Mathematics

Globally, research indicates a favorable association between students' mathematics performance and educators' professional backgrounds and instructional approaches.

Darling-Hammond (2000), Rice (2003), and Ingvarson et al. (2004) concur that teachers' backgrounds, which include education, subject specialization, and experience, as well as teachers' professional development and teaching practices, all play a significant role in determining students' achievement in mathematics education. This indicates that without effective instructors, schools would struggle to attain high levels of mathematics achievement regardless of their financial and infrastructural resources or the quality of their students. The purpose of this research is to establish a correlation between the credentials, experiences, and professional development of mathematics instructors at Sisonke and the learners' success in the learning area. Thus, according Kaino et al. (2015), present mathematics instructors in the field include a mix of teachers with varying levels of school subject knowledge and competing models of classroom practices, as well as proactive, reactive, and over-reactive teachers, Lindeque, Gawe, and Vandeye (2016). Additionally, the authors, Kaino et al. (2015), note that teachers who teach unrelated school subjects require ongoing professional development in order to address and adapt to the consequences of an environment marked by massive infrastructure backlogs, resource constraints, an insufficient supply of high-quality learning support materials, and the absence of common national standards for learning and assessment.

Fig 3.1 highlights an array of contextual and professional challenges confronting teachers in their conduct of teaching and learning of mathematics and how each of them impacts on students achievementgs and how the current intervention research handled them throughconstruction of a collaborative model for teaching and learaning mathematicsc in secondary schools.

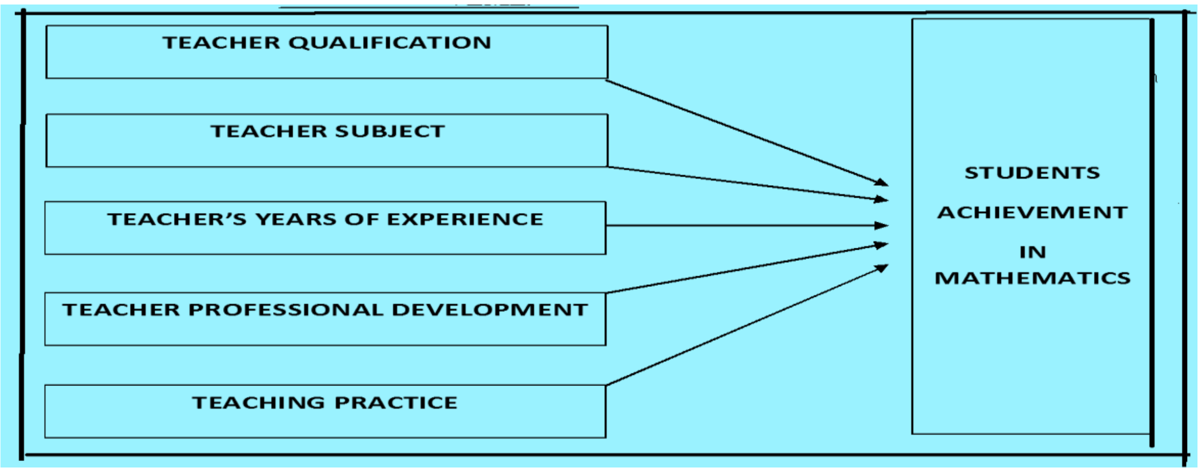


**Figure 3.1: Scheme of teacher challenges and how they affect students' achievements.**

### 3.3.3.1. Teachers' backgrounds.

In a study done Bretts, Zen, and Rice (2003) in the United Staes of America it was discovered that there is a favorable association between teacher credentials and students' mathematics performance. They discovered that instructors with advanced degrees in the field taught more confidently and had a better knowledge of the subject's substance than those with less advanced degrees. Goldhaber and Brewer (1996) discovered that teachers with advanced degrees in the subjects they teach produce greater student accomplishment than teachers with just a basic certification in the topic. This demonstrates that a teacher's mastery of subject knowledge is a predictor of students' success in the topic, since he teaches with clarity and comprehension of the material, ensuring that learners pass the subject.

This study conceptualized teacher's backgrounds as encompassing the teachers' qualifications (certificates, diplomas, degrees obtained by educators), their majors and teaching experience. On the contrary, findings by Wenglinsky (2000) and Greenberg *et al.* (2004) postulate that post graduate qualifications at master's or a higher grade were not significantly related to learner achievement. This study evaluated if teachers' qualifications have an impact on learner achievements in Mathematics education in secondary schools.

### 3.3.3.2 Effects of teacher experience on Mathematics teaching and Learning

Bernstein (2013) discovered that mathematics instruction in South African schools is among the poorest in the world. According to the 2011 Trends in International Mathematics and Science Study (TIMSS), South African learners perform the worst out of the 21 middle-income nations studied. A recent CDE study underscores the problem further by revealing fast growth in enrollment in private additional mathematics lessons, which was partially a result of inadequate instruction in public schools. According to 2007 statistics, the majority of Grade 6 instructors in South Africa are unable to answer a question that their students should be able to answer based on the Grade 6 curriculum. In one instance, 'just 23% of South African Grade 6 mathematics instructors were able to properly answer [such a Grade 6] question - with the percentage correctly responding varying from 13% for quintile one teachers to 46% for quintile five teachers, Spaull said (2013). Obviously, it is very hard to teach something one does not understand. After Grade 9, when South African schools have significant drop-out rates, the cumulative learning deficiencies seem to approach a tipping point. South Africa did lower than any other middle-income countries in the 2011 TIMSS. In mathematics, the average Grade 9 student in South Africa is two years behind the average Grade 8 learner in 21 other middle-income nations (and 2,8 years behind in science). Competence of teachers is a concern. Taylor (2011) contends in his most recent report as Head of the Department of Basic Education's National Education Evaluation and Development Unit (NEEDU) that low student achievement in the majority of schools is mostly the result of teachers' lack of subject understanding, particularly in mathematics. In his contribution paper for the National Development Plan, he again emphasized the need of patronage in teacher appointments.

Other studies by Wilson and Flodden (2003) in the United States of America found that students of Mathematics lecturers with mathematics as a major demonstrate a better level of educational action in arithmetic compared to their counterparts whose educators do not seem to be arithmetic majors. Goldhaber and Brewer (1996) and Darling-Hammond (2000) concur that specialization during a teaching subject capacitates the teacher to show competitively and is the most reliable predictor of learners' performance in arithmetic. This means that majoring in arithmetic by educators widens and will increase their content grasp within the subject and their education skills in content delivery to learners within the schoolroom that absolutely leads to sensible performances.

On the opposite hand, studies by Ingvarson *et al.* (2004) found that the correlation between teachers' majors and students' achievements in arithmetic were complicated and inconsistent. This could imply that alternative discourse factors within the user systems may well be accountable for the correlation between the two variables. Further studies by Martin *et al.* (2000) and Wenglinsky (2000) found that majoring in arithmetic was not associated with teacher effectiveness. Mathematics educators the globe over is specifiable by their subject major in arithmetic as proven by getting a 3 year or four-year faculty or university diploma or degree within the subject. This implies that lecturers of arithmetic ought to drill positive arithmetic practices absence of which can end in learners' poor action despite that they are educated by extremely qualified educators. The study can request to seek out if there's a correlation between teachers' majors in arithmetic and student achievement within the subject. Confirmation of the findings can guide the analysis method and account for contrary views on the link between the two variables.

Numerous worldwide studies in Britain, Norway and the United States of America have shown a direct correlation between educators' years of experience and pupils' accomplishment in arithmetic passes. Bretts, Zan, and Rice (2003) discovered that educators with extensive experience teaching arithmetic established rational connections between student performance and the topic. Additional research conducted in America by the Center for Public Education (2005) demonstrates a strong association between teacher skill and outstanding students' arithmetic proficiency. Lecturers with five years or more of teaching experience outperformed novice lecturers with fewer years of teaching experience. This means that teaching competence as a variable adds to lecturers' comprehension of curriculum requirements and mastery of appropriate, beneficial teaching methods; hence, the more years a teacher spends on the job, the more proficient the instructor gets at teaching the subject.

Similar studies by Rosenholtz (1996) in Darling-Hammond (2000) and Hawkins, Stancavage, and Dorsey (1998) in South Africa discovered that while teaching expertise correlates with learner achievement, the relationship is not linear; students educated by lecturers with fewer years of experience had lower levels of arithmetic action compared to those with five or more years of experience who had reasonable but non-progressive achievements. This is perhaps why such instructors have a tough time improving students' performance and reaching their full potential in teaching arithmetic. As per Darling-Hammond (2000), this is due to the breakdown syndrome and a lack of interest in everyday work duties.

Hanushek (1997), Martin et al. (2000), and Wenglnsky (2002) discovered that the number of years spent teaching does not correspond with student success. Extremely experienced lecturers made extremely unsafe decisions in certain instances, whilst other less experienced educators performed well. The severity of the problem may be linked to discourse characteristics or faculty differences that affect instructors' knowledge and comprehension of subject material. A further explanation might be that freshly trained instructors are more grounded in subject knowledge and so more adept at understanding topic than more experienced educators. The study's objective is to determine whether or not teaching skill has an effect on learner behavior in mathematics at Sisonke secondary schools. Additionally, the quality and amount of performance for each educator will be compared to establish if the distinction is due to expertise alone or to other discourse elements inside the user system.

### 3.3.3.3. Pedagogical challenges in teaching and learning Mathematics.

Fig 3.2 presented approaches that have been used in the teaching and learning mathematics and the study discusses them and their relevance in the design of the collaborative model for teaching and learning the subject in secondary schools.

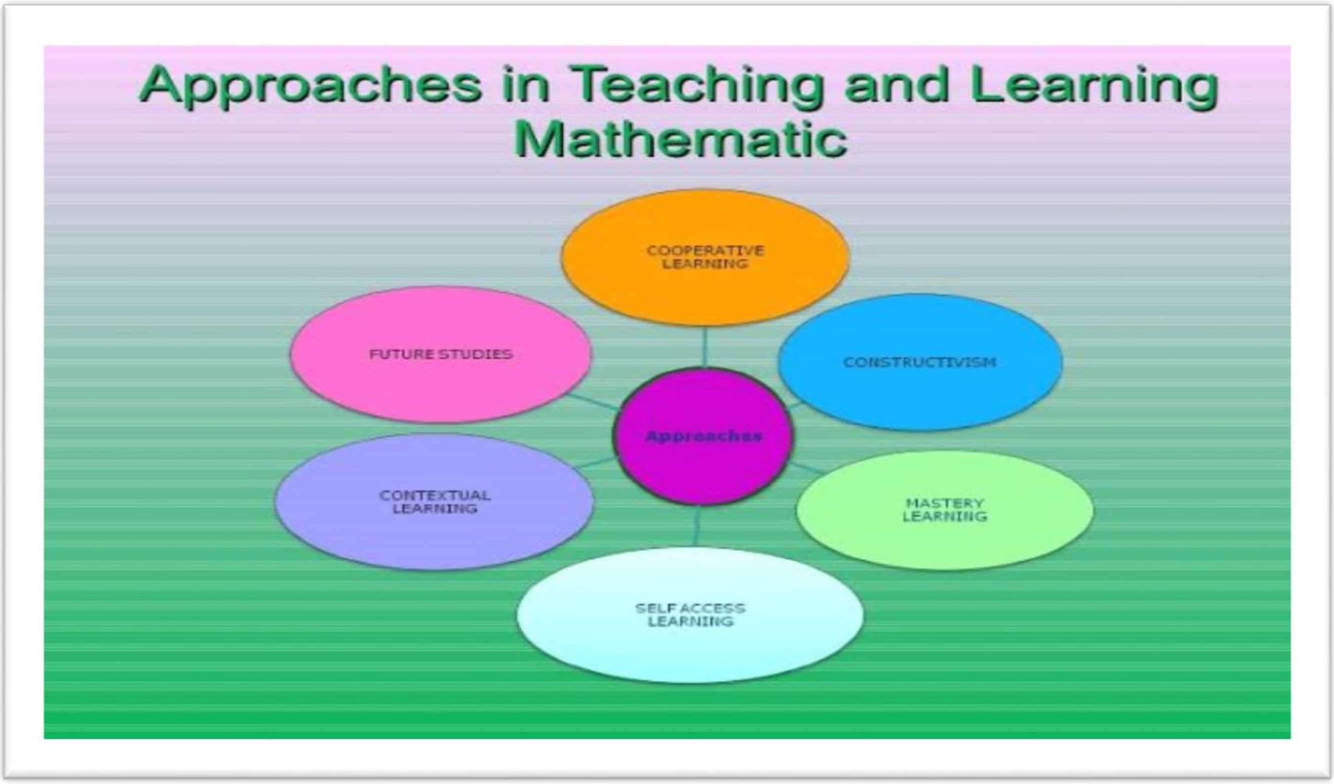


**Fig 3:2 Approaches to teaching and learning Mathematics (Source: Dickey (1997)**

Dickey (1997:1) postulates that, “Today’s Mathematics teachers are experiencing major changes not only in the mathematics content they teach but also in the way they teach”. This implies that the changing teaching and learning contexts in Mathematics classrooms in the nature of the mathematics taught is not only a collection of facts and skills to be memorized but a challenging academically structured content. Equally challenging is handling the changed Mathematics learners in contemporary classrooms who are diverse as opposed to previously homogeneous learners.

The shift in arithmetic pedagogy from inductive and deductive teacher-centered approaches to activity-based and learner-centered pedagogies has had a significant impact on the level of teaching and learning arithmetic, Fey (1997). The simple fact is that the majority of Mathematics Educators may have attended Gymnasium at a period when arithmetic was not as tough as it is now, and so their way of teaching arithmetic may be a result of their schooling. Fey (1997) determined arithmetic categories in a case study done in the United States of America and discovered that: In all arithmetic categories I visited, the sequence of activities was consistent. The educator or a student worked on the most difficult topics at the board. A brief justification, typically none in the least, of the new content was provided, and publications were scheduled for the next day. The most immediately evident flaw with mathematical categories was the sequence's repetition.

The overarching scenario and procedures shown in the case study are a reflection of the everyday issues academics encounter while teaching mathematics. Repeated and inescapable procedures are superficial and will not result in effective arithmetic instruction and learning. Thus, despite the fact that the content and type of learners in arithmetic classrooms are constantly evolving, teaching has remained antiquated and eventually requires fundamental restructuring to include cooperative, inclusive, and activity-based learning. The study's objective is to provide significant ongoing professional development opportunities for academics to assist them in establishing innovative teaching methods that are contextually relevant and successful for today's learners. Critically, the study's foundation is the recognition that optimal arithmetic instruction requires students to participate in classroom room activities such as constructing, chatting, comparing, and producing useful noise, as opposed to traditional mathematics instruction.

Mhlolo (2017) in a study in South Africa on capacity of learners to explore multiple solutions to mathematical problems found that they are less competent mostly because their teachers lack expertise in developing mathematical solutions and are unaware of the importance of MSTs in developing learners' mathematical thought in a related study on efforts to improve performance. Thus, many South African learners often fall short of their real mathematical potential as a result of their instructors' failure to provide appropriate assistance for students to explore numerous answers in their courses (Donohue & Borman, 2014; Hoth et al., 2017; Mhlolo, 2017; Oswald & de Villiers, 2013). After getting a solution to an issue, South African learners often abandon the answer without reflecting on it or seeking alternate options. If learners can be engrained in the habit of constantly thinking on and seeking alternate answers to mathematical problems, their ability to solve them will increase. This implies that as these learners mature, their drive to constantly think on mathematical answers increases, and they find themselves unintentionally searching for various solutions to mathematical problems in a self-directed manner.

Even though pupils are not always compelled to find multiple solutions to mathematical problems, it is their initiative to develop their mathematical problem-solving abilities as they diagnose their learning, reflect on the best approach, and attempt to employ multiple strategies to find the same answer, Leikin & Lev, 2013). South African learners must comprehend mathematical concepts and procedures for solving regular problems, as mathematical creativity must be shown (Leikin & Lev, 2013). Thus, South African educators must transform ritualistic discourse into exploratory ones that stimulate creativity via the use of MSTs. Although some argue for a distinction between gifted and regular classroom practices (Leikin, 2010) and that different students have unique educational needs (Levav-Waynberg & Leikin, 2012b), the teaching practices advocated for gifted learners are ideal for students deemed unqualified in the South African context (Mhlolo, 2017). Thus, the majority of South African schools focus on teaching learners who lack fundamental knowledge how to pass examinations and exams. Certain thinking processes pertaining to mathematics problem solving are often overlooked and not developed in the South African mathematical education curriculum. Mahlaba (2020) is one of these thinking movements whose objective is to uncover multiple answers to mathematical problems.

#### 3.3.3.4. Pedagogical approaches in secondary school Mathematics

Instructional techniques refer to the tactic used by a teacher to fulfill learning objectives. What you learn is contingent upon not just what you are taught, but also on the manner in which you are taught, your developmental stage, and your interests and experiences. These beliefs need a closer examination of the ways used to communicate information. Over the past decade, research has provided a new perspective on how learners might develop understanding. By monitoring student replies, teachers may assess the ability level of all students throughout the course. Bukhari, Khan, and Haider (2016).

All students should receive rigorous mathematics education that is founded on the utilization of evidence-based resources and fidelity to instructional methodologies. For example, in teaching concepts educators ought to concretise their classroom interactions and enable learners to apply what has been learnt in practical contexts. When a high-quality core curriculum and effective teaching are applied, the majority of pupils will succeed in learning, Paul (2019). Children should be informed as little as possible and structural system to get the largest amount possible. Mathematics as a science has been taught for hundreds of years using a number of pedagogical techniques. There is no universally approved or optimal approach for teaching arithmetic that is acceptable across all Mathematics disciplines, and no separate method that is applicable to all given scenarios (Herrera, Kanold, Koss & Ryan, 2007).

In recent years, South Africa's dismal mathematics achievements have garnered much attention. For example, in 2015, the proportion of learners who got 50% or more on the Grade 12 Mathematics test was just 20% (Department of Basic Education (DBE), Republic of South Africa, 2016). This suggests that 80% of learners who wrote had a grade below 50%. Complaints about low mathematics performance naturally raise concerns about whether mathematics instruction is as successful as it might be. When considering how mathematics education might be made more successful, a critical topic is the teaching techniques used by educators to promote mathematics. To ensure that their students obtain a solid knowledge of mathematics and statistics, educators must constantly update their present teaching techniques and evaluations. Innovative instructional strategies may help students connect mathematics and statistics to real-world situations and prepare them to be investigators and problem solvers. Learners are required to use their knowledge in order to build new perspectives and abilities and to solve issues using mathematical reasoning in order to be competitive in today's and tomorrow's economies (Kilpatrick, Swafford & Findell, 2014).

Teaching strategies underpin all learning in the classroom. They influence what is taught and how students and educators engage. As the European Commission has highlighted recent research (Eurydice 2011), a common approach followed by many nations is to offer pupils a more active role in the production of information to acquire mathematical competence. "Activated learning methods enable students to take part in their own learning via conversations, project activities, exercises and other means of helping them reflect and explain their maths" (Eurydice, 2011: 56). Herbert Spencer in Sharan and Manju (2006) postulates that each methodology is sensitive, that there is no reasonable methodology. As an assistant in learning, the teacher thus has the advantage of deciding and adapting teaching methods according to the topic and thoughts and nature of the learners. Below are some of the key strategies of teaching mathematics:

- ***Inductive method of teaching Mathematics-*** The inductive technique is the ancient and central technique of teaching arithmetic, it returns from concrete to abstract, specific to general and from examples to formulae. Sidhu (2000) explains that induction could be a means of proving a universal truth by showing that if it is true for a specific case, it is true for fairly masses of variety of cases. Inductive technique follows four general steps of presentation of example, observation, generalization, testing and verification. Within the four steps each the teacher and the learners actively participate within the lesson processes.
- ***Deductive method of teaching Mathematics-*** Deductive method is the opposite of inductive as it proceeds from general to specific or from abstract to concrete. A pre-construed formula is given to students, and they are requested to find a solution with the help of the formula. Sidhu (2000) further asserts that the formula is acknowledged by the learner as a pre-established and well-established universal truth. In this approach the formula supplied is used to find a solution to problems. Deductive method is mostly used in teaching topics such as algebra, geometry and trigonometry.
- ***Heuristic method of teaching Mathematics-*** Heuristic method derives from the assumption by philosopher Herbert Spencer who holds that little should be told to learners while providing more opportunities and encouraging them to discover and learn by themselves. This method aims at development in learners' problem-solving skills, imaginative and logical thinking and scientific attitude towards problems (Narayana, Krishma & Rao, 2004). This method emphasises experimentation and discovery of solutions by learners. In the Heuristic method students are given opportunities to be actively involved in their knowledge construction hence they become self-reliant and independent of the teacher.
- ***Laboratory method of teaching Mathematics-***The laboratory method like the name infers derives from the laboratory processes of engaging learners in activities that help them to discover mathematical facts. It is a learner centered approach based on the principle of

learning by doing, learning by observation, and proceeding from concrete to abstract. Sarit and Sarivasta (2005) expound that in laboratory method activities, students are stimulated and encouraged to make discoveries on their own. The success of the method, however, is subject to conditions of a well-equipped Mathematics laboratory. This implies that use of this method requires a laboratory and skills to manage learners. Most Mathematics educators may not be familiar with the above method as few schools have laboratories.

- ***Project method of teaching Mathematics-*** In the project technique students do mathematical tasks in both an open finished approach and victimization downside determination approaches. They style and place into observe their own plans for managing the analysis queries and take possession of the trials and results. Students get to rummage around for their materials and should acquire improvisation skills within the method (Nayak & Rao, 2002). The philosophical proponents of project primarily based learning argue that it will increase the retention level of scholars, promotes students' interest and motivation, the chance of establishing a network with the outside world the college is provided through project technique. This approach is fruitful in developing collaboration, creativity, downside determination, communication, and significant thinking skills in students (Nastu, 2009). Types of activities are concerned in the project technique. It is supported by the subsequent principles, learning by doing, learning by living and children learn more through association, co-operation, and activity.
- ***Synthetic method of teaching Mathematics-*** This method is holistic in approach, in which several facts are combined, to perform certain mathematical operations and arrive at a solution. Start is taken from the known data and connects it with the unknown part (Jeanne Kirk, 2005). This method saves time and labour but encourages cramming as students are passive recipients of mathematical facts. In this method, there is no room for discovery and students often lack confidence.
- ***Thematic method of teaching Mathematics-*** In an exceedingly thematic technique, teaching of arithmetic within the college and conjointly arithmetic use and its application outside the college (Handal & Bobis, 2004) has proved productive to increasing student knowledge retention. The Thematic teaching approach focuses on teaching of arithmetic with application to world situation.

De Villiers and Heideman (2014) build on Lockhart's (2009) observation that classroom mathematics is often disconnected from mathematicians' work. While their final comments regarding Albert Einstein's words are amusing, they do represent mathematicians' activity, namely the activity of exploring numerous answers to mathematical problems. De Villiers and Heideman emphasize the importance of exploration in mathematical activity (De Villiers & Heideman, 2014), which is often used to discover different solutions to mathematical issues (Santos-Trigo & Reyes-Rodriguez, 2016). They emphasize the importance of investigations in the development of mathematical reasoning during problem-solving (Samson, 2015, 2017; Samson & Kroon, 2019). Additionally, problem-solving is critical for developing not just creative thinking in mathematics, but also mathematical thinking as a domain-specific style of thinking (Schoenfeld, 1985, 1992). The development of mathematical thinking in schools is encouraged by the curriculum, but largely by educators in their various classes in diverse ways. One strategy is to include MSTs into mathematics training.

De Villiers (2016, 2017) claims that the reflective processes involved in issue solving might help improve one's mathematical reasoning and problem-solving abilities. Prior knowledge of issue solvers is advantageous since the generation of many solutions in mathematics needs some degree of mathematical knowledge acquisition (Schindler et al., 2018; Schoenfeld, 1985). MSTs allow learners to use a variety of tactics while solving mathematical problems and have been shown to increase their success rate in future mathematical problem-solving situations (Erbas & Okur, 2012). Encourage learners to pursue multiple solutions to mathematical problems can increase their effectiveness and flexibility in solving such problems (Daher, Tabaja-Kidan, & Gierdien, 2017; Levav-Waynberg & Leikin, 2012a, 2012b; Stanislaw & Krug, 2014), even if it does not always improve their mathematics performance (Schindler et al., 2018; Schukajlow, Krug, & Rakoczy, 2015).

Additionally, using MSTs enables a greater number of potentially creative students to submit their innovative solutions to challenges (Levav Waynberg & Leikin, 2012a; Sriraman & Dickman, 2017). Deductive reasoning and critical thinking abilities are vital in solving geometry problems and in the twenty-first century, and the usage of MSTs may help students develop these abilities (Segal, Stupel, & Flores, 2017; Sriraman & Dickman, 2017). MSTs may also be utilized to train young mathematicians capable of thriving in the fourth industrial revolution (4IR), based on their capacity to solve issues using a variety of diverse solution methodologies. This is a fruitful technique for teaching mathematics that emphasizes mathematical contexts; it requires the application of arithmetic data; for example, the application of mathematical content such as percentages, measure, statistics, or pure mathematics is frequently emphasized, while presenting a central theme of sports or shopping for and mercantilism situation.

## 3.4. Professional development initiatives

### 3.4.1. The Rationale for professional development of Mathematics educators

Loucks-Horsley et al. (1998) explain that professional development for teachers is a continuous process that occurs both within and outside the classroom, where instructors may be educated by other teachers, for example, at professional organizations and teacher union meetings. Additionally, it may be accomplished via a variety of seminars and lectures in which instructors exchange their expertise with one another, or by receiving formal education from subject-matter specialists. A study of variables influencing teacher educators, trainee teachers, and newly certified teachers in six countries (Ghana, Kenya, Mali, Senegal, Tanzania, and Uganda) discovered that an emphasis on how mathematics is taught, rather than on teachers' expertise, is necessary (Pryor et al., 2012). Primary mathematics teachers often felt unprepared to teach mathematics and depended on information gained from colleagues' tutors and out-of-date textbooks. There was little classroom interaction observed in teacher training sessions. Discussion amongst trainees as to how to apply understanding and methods to effectively promote meaningful learning is needed, Bethall (2016).

Although mathematics may not alter formulae and ideas, it is still necessary to raise and improve the mathematics performance of learners. This may be accomplished by providing opportunities for practicing educators to further strengthen their teaching abilities. The possibilities provided to a practicing teacher for the development and deepening of new information, skills, teaching styles, and dispositions in order to increase their performance in the classroom are referred to as teacher professional development initiatives (Loucks-Horsley et al., 1998) Teacher understanding of students, subject content, teaching practice, and education-related laws, per the Professional Affairs Department (1999), is enhanced via the development of teacher knowledge. In other words, professional development includes both formal and informal methods of increasing educators' knowledge and skills in pedagogical and content skills, with the goal of enhancing strategies that explore new and advanced understandings of subject matter and the use of resources in the classroom, among other things. Workshops, weekend staff development courses, and school-based in-service courses are some of the ways in which Heads of Department and subject specialists may help.

The study measured and analyzed teachers' participation in professional development through nine indicators listed below. The indicators are the amount of time spent on professional development in the last three years:

- Taking a short formal college or university course in teaching Mathematics.
- Taking a formal college or university Mathematics course.
- Observing other teachers teaching Mathematics.
- Meeting within a cluster to study or discuss Mathematics teaching and learning issues on a regular basis.
- Collaborating on Mathematics teaching and learning issues with a group of teachers at a distance using communication.
- Serving as a mentor or facilitator/peer coach in Mathematics teaching.
- Attending workshops or seminars on Mathematics teaching.
- Attending a Mathematics Association meeting.

The study sought to find out if professional development for Mathematics teachers at the Centocow cluster is being done and how it affects learner performance.

### 3.4.2. Global and local interventions in improving Mathematics and science teaching and learning in secondary schools.

#### 3.4.2.1. Overview and analysis of selected professional development approaches

To creating a solid foundation for this study, the researcher looked at professional development programs that have been tested and implemented in numerous nations and have been shown to be long-lasting. Following that, several distinct professional development programs and models are examined, which serve to demonstrate a range of approaches to professional development. The sequence in which these techniques are given, on the other hand, is completely irrelevant.

#### 3.4.2.2. Professional development projects

- ***Project for Enhancing Effective Learning (PEEL)***

As part to the Collaborative Model all these teacher development initiatives create a bond between the educator and the learner. The reason for launching the project was that academics and teachers shared concerns about the prevalence of passive, dependent, unreflective learning in their classrooms. PEEL focuses on how students are learning.

A working-class high school in Melbourne, Australia, was the site of the first implementation of the program in 1985. (Northfield, Gunstone and Ericson, 1996). The effectiveness of new teaching techniques was assessed in terms of their ability to activate cognitive behaviour in pupils (Mitchell 2000).

In addition, PEEL is an example of a teacher education strategy that is founded on research from a constructivist viewpoint, and it creates circumstances for teachers to do action research in their classrooms as part of their professional development (Northfield et al. 1996:206). Because the project has continued to operate 20 years after its inception, it may be sustainable. Because instructors took the initiative, it is possible that the project was dependent on practitioners' ability to be reflective rather than the other way around. They were able to keep the project going without the assistance of an outside agency. A web portal (PEEL, 2004) and a periodical named PEEL SEEDS were created by PEEL to promote the organization. Every two years, they conducted two-day in-service activities for professional development coordinators and consultants, as well as two-day in-service courses for all other employees. The National Education Association (NEA) hosted an annual conference for teachers, teacher educators, and other officials. Participants from all around the globe have been invited to present at the conference.

- ***Science Teacher Education Project (STEP)***
  It was the formation of a "community of tutors" who were all interested in improving their teaching skills that was the project's defining characteristic (Yager & Penick, 1990:667). STEP is an example of model teacher education methods in the worldwide arena, which was developed in the United Kingdom and implemented there. A study conducted by Yager and Penick (1990:667) looked at basic advances in Science Teacher Education outside of the United States. It was viewed as having the potential to be the most successful technique available for improving science teacher education at the time of publication. More than 200 instructors from throughout the United Kingdom took part in STEP. The activities that made up the program had the following characteristics.
- Integration of content of science and pedagogy.
- Small group discussion and team planning.
- Short activities, not more than 1 – 1.5 hours.
- Enhancement of qualities and skills of teachers.

- Usage of resource materials such as films, videos, audiotapes, and slides.

  A conscious effort was made in STEP activities to show how theoretical matters bear on actual classroom practice and how Science subjects can be taught sustainably and result in improvement of learner performance.

  ***Discovery***

  This is a USA based initiative which could be adopted in many countries and improved. A project entitled Discovery was launched in January 1995 with the support of schools and communities in Ohio, USA. With the goal of improving learning for all students, Discovery strived to meet three objectives:

  Initiate validated professional development models designed to build a critical mass of teachers who are knowledgeable in content and skilled in equitable and exemplary instructional practices:

- Develop an infrastructure to support those models and teachers; and
- Act as a catalyst for lasting systemic reform of the teaching and learning of Science and Mathematics.

  Discovery's mission was to enhance the teaching and learning of Science and Mathematics through sustained professional development of teachers “within the overall context of systemic change” (Discovery 1996).

  The following lessons have been learnt from this project (Discovery, 1996):

- Increased use of problem solving, and inquiry approaches enhance student achievement.
- Regional infrastructures are needed to support teachers and schools undergoing reform.
- Systemic reform is dependent upon constant attention to equity issues, particularly opportunity to learn issues.
- Teachers readily access and exchange information and ideas through electronic media and evaluation of reform needs to be coordinated centrally, using specialised personnel and external consultants. Responses to these lessons have been made (Discovery, 1996) in the USA context which indicates its sustainability.
- ***Mpumalanga Secondary Science Initiative (MSSI)***

  In response to Science, Technology, Engineering and Mathematics challenges in South Africa, South Africa, and partners-initiated Mpumalanga Secondary Science Initiative (MSSI). MSSI is an intervention created through a partnership between the Mpumalanga Department of Education (MDE), the Japanese International Cooperation Agency (JICA) and the University of Pretoria (UP).

In general, it aimed to strengthen the teaching of mathematics and science at the junior secondary level in the province of Mpumalanga, with a particular emphasis on mathematics (Rogan et al, 2002). To carry out its professional development activities, the MSSI intervention made use of the notion of teacher clustering (or networks). Cluster leaders are brought together on a regular basis for professional development events to exchange ideas. During their school days, they are supposed to share their observations with the other members of their cluster (Jita and Ndlalane, 2005). Nevertheless, since it was unable to accomplish its intended purpose, the teachers who served as cluster leaders demonstrated "misconceptions" in their topic understanding (Jita and Ndlalane, 2005:300). Conclusion These are some of the difficulties that models face if they are not properly regulated. The Collaborative Model made use of the lessons learned from such oversights to enhance its performance.

- ***The Learning for Sustainability Project***

  The Learning for Sustainability Project supported syllabus development and piloted a model for in-service teacher capability building inside the sphere of environmental learning. An element of the work entailed developing and testing a model for skilled development that's congruent with the Outcomes-Based Education syllabus framework (Du Toit and Sguazzin 2000:7). Ten key options of the spiral model for skilled development that were employed in the project are:
- Contextualisation: Social, academic, and environmental contexts within which skilled development occur should be taken into consideration. Academics use and see things that return directly from their own socio-political, biophysical, and academic contexts.
- *Participation:* depends on active participation by academics in cluster and individual activities. Examples embody discussion of and experience with current policy, discussing and negotiating aspects of skilled development, practicing skills, polishing off skilled development tasks, and contributory opinions, data, suggestions, and criticisms.
- *Dialogue:* Constant dialogue among education practitioners on relevant problems permits the sharing and growth of progressively refined understanding of ideas. It additionally provides the chance to debate new information, skilled problems and room observe.
- *Reflexivity:* By reflecting critically on previous actions, academics learn to “do” higher, put concepts into observe so selecting whether their implementation is beneficial or not, are

often a crucial tool for skilled development, and ensure a variety of inbuilt self-evaluation and analysis of policy.

- *Integration of theory and practice* permits for the building and purification of competencies within the context within which they are going to be used. It provides the chance to debate theoretical problems, strive their sensible implementation in colleges and replicates on this implementation and the way it is often improved. The combination of theory and practice helps to make an ever-increasing feedback cycle that helps to confirm the appropriateness of sensible implementation of policy.
- *Flexibility*: A model that responds to desires as they arise and permits for current modification and adjustment of skilled development processes encourages continuous change of skills and competences and long learning. Totally different contexts resulted in several desires, and problems could have totally different relevancies in several contexts. Additionally, there was high diversity inside the South African education system, and not all academics had identical skilled development desires. This model took this into consideration, in contrast to the "one size fits all" approach of many of the previous models.
- *Democracy:* Academics take responsibility for his or her own learning processes – they negotiate aspects of the skilled development programme and supply arrangements, attend cluster conferences, and complete their negotiated tasks. This model encourages a high level of negotiated self-determination and transparency.
- *An artist approach*: If learning is the creation of knowledge within a creative, artistic social context, that means information is socially negotiated, it is necessary to recognize that there's not one single right approach which will be adopted uncritically. The socially artist orientation of this model acknowledged the importance of the development of the foremost acceptable information and a crucial orientation to learning processes during an explicit context.
- *Development of sophistication of meaning*: The extended timeframe and frequent dialogue that fashioned a part of the spiral orientation to skilled development inspired the event of progressively complicated understandings of academic and, within the case of the educational for property project, environmental themes. The educational processes that fashioned a part of this model expedited the event of that means that was acceptable, relevant, and contextually located.
- *Continuous learning*: Beyond tertiary learning could be a construct embraced by the new education and coaching policy framework. The future nature of the spiral model for skilled

development allowed for the mediation of continuous learning, instead of providing isolated workshops of inputs to skilled development (Du Toit & Sguazzin, 2000:16). Lastly Du Toit and Sguazzin (2000) prompt that the cluster approach to skilled development is often wiped out a mass of the way. However, they used clusters in line with the spiral model with the on top of mentioned options. The highest drawback experienced within the project was to search out competent and intended facilitators.

## 3.5 Professional Development Programmes

### 3.5. 1 Collaboration, Enactment, Extended and Reflection (CEER)

- ***Collaboration with others*: -** Teachers and university researchers worked together to inform, criticise, and support each other. Collaboration provides opportunities for sharing and criticising ideas, plans and classroom practices.
- ***Enactment of new practices in classrooms:* -** Enactment emphasised that the process of planning for innovating and conducting new practices in the classroom is generative and constructive. Teachers determine what is feasible in their situation and modify their ideas accordingly.
- ***Extended effort to initiate change:* -** Change requires more than helping teachers to learn new approaches to their craft. For example, if there is a change of curriculum, it influences local, district and national policies and implies changes in the broader social setting in which schools are embedded.
- ***Reflection on practice:* -** There is a general agreement amongst authors that experience education via reflection. Hence, teachers must reflect on teaching to extract the knowledge that leads to improved student learning (Marx *et al.* (1998:674). CEER has been tested and further shaped by designing and conducting a range of interpersonal interventions (e.g. two seven-day workshops, monthly face-to face meetings and on-site consultations) and designed and deployed a suite of computational and communication tools that complement the interpersonal intervention and provide unique supportive functionality (Marx *et al.*, 1998:675).

CEER as described by Marx, Freeman, Krajcik and Blumenfeld (1998:678) was an attempt to use the research literature to produce a coherent and sophisticated conception of professional development. A range of interpersonal and technological tools was used to help teachers to change their instructional practices.

CEER is not aimed at the acquisition of a set of prescribed behaviours, but rather the development of theoretically congruent practices (Marx *et al.*, 1998:672). In a professional development programme involving 100 Science teachers in Michigan, USA, the elements required for successful staff development were identified as the interplay between the following four elements (Marx *et al.*, (1998:672).

### 3.5.2 The Japanese approach to professional development

The central Education Ministry of Japan designed a model plan and determined guidelines for professional development of teachers. This programme consisted of the following elements (Collison and Ono 2001:228 -239):

• *In-school initial training,* comprising at least 60 days a year (two days a week) which allowed for the observation of new teachers by mentors and *vice versa*, for exchange of ideas, for writing of reflection notes and for receiving of individual coaching after observation (p. 228).

• *Out-of-school initial training* which involved 30 days per year (one day per week) that takes place at a prefectural Education Centre and covers the common basics, such as "basic knowledge of the educational service, personnel duties and ethics". This is done in addition to the 60 days in school training for beginner teachers.

• *Ongoing, school-based training* which was conducted in all schools. Teachers had to decide on a theme related to a subject area. They stuck to the theme for a period of three years, publishing research reports at the end of each school year. A Research and Training committee was responsible for school-based training and coordinates in Japan have been considered since this country came out as one of the top five countries in the TIMSS evaluation. South Africa also has links with Japan in science teacher development activities. The core of the training is collaborative research on the teaching and learning processes.

• *Professional development programmes at a Centre* which comprised five days of essential training for teachers in their 5th, 10th, and 20$^{th}$ years of teaching. This element was compulsory for all teachers.

• *Other professional development opportunities.* The government offered teachers the opportunity of becoming a teacher consultant and supports them financially for one year of training.

### 3.5.3 Professional development schools

Professional development faculties were created as a result of the Holmes cluster, a light-emitting diode developed by the Dean of the School of Education at the University of Wisconsin in the middle of the 1980s in the United States and are now recognized as a requirement for educators to attend skilled development faculties. A realization had been reached those many institutions' coaching programs for pre-service lecturers were concentrating on supplementary teaching theories rather than on equipping these lecturers with the key abilities and practical knowledge required for no-hit daily teaching in the classroom. As a result, a number of practicing lecturers were facing difficulties as a result of "misguided teacher coaching programs," as described above (Riel, Gossard and Bass, 2000). Following the operations of the Holmes Group, professional development institutes were established with the goal of preserving the effectiveness of lecturers who had been exposed to such inadequate training or incoherent professional development (Riel et al. 2000). Specialized Development Centers (SDCs) are intended to provide pregnant women with on-the-job training via the partnership of teaching staff and academic institutions (universities). Within the official administration of education, guidelines for information and instruction were developed to a greater or lesser extent by a single authority and then distributed to many institutions. Developing new structures and approaches for deepening and sharing information for teaching; developing shared norms for learner-centered practice; transforming lecturers to assume responsibility for professional commonplace setting; and inducting new entrants into the profession were all sought after by the government (Riel et al., 2000).

The strategy used by Professional Development Schools was like the technique taken by prefecture teacher centres in Japan, and it was successful. That it recognized and valued the teacher's experience and expertise, entrusted teachers with critical decisions, and helped create a climate where teachers could collaborate, take risks freely, and work responsibly toward common goals all contributed to the teacher's sense of self as an adult professional (Riel et al., 2000). In the United States, there are several Professional Development Schools that are being tested, and it is challenging to establish consistent results. However, it was discovered that instructors had a greater feeling of professionalism, responsibility, and teamwork, as well as an enhanced use of reflective practice, the use of research as a foundation for self-evaluation and practice, and more supporting connections with one another (Riel et al., 2000).

Furthermore, it was shown that lecturers used more inventive techniques to knowledge generation and training, as well as a greater feeling of effectiveness. Issues such as insufficient resources and a reluctance to change, on the other hand, were met at both of these institutions (Riel et al, 2000). Colleges of universities and colleges of skilled development form relationships between professors and colleges of skilled development. In the United States, there were ninety-one professional Development schools that were required to be reported in 2000. Through collaborative talks, university colleges share the findings of their research and the insights they have gained. Analysis, discussions, and the implementation of innovations were carried out by the lecturers in a sequential manner. It was via participation in the debates and experimentation that new instructors serving "internships" were introduced into the culture. As a result of introducing creative person teacher learning into classroom instruction, the likelihood of generating lecturers who can do the same with students grows as well, (Riel et al., 2000).

**3.6. Professional development models**

**3.6.1. Teacher development model of Bell and Gilbert**

This was a model that focused on science teachers, and which could be used in a Collaborative Model to improve the learning and teaching of Mathematics in South Africa. Further study on the model for collaborative learning and teaching will take lessons from Teacher Development Model of Bell and Gilbert.

Learning in Science Project (Teacher Development) was a three-year scientific research project carried out by the University of Waikato, which was supported by the New Zealand Ministry of Education. The project was targeted at the development of science lecturers in their nation. The researchers observed the "evolution of science lecturers as they learned new teaching activities that allowed them to take into account students' thinking," as described by the researchers,(Bell & Gilbert, 1996:10). The initiative included the participation of 48 educators who volunteered their time. In tandem over the course of three years, both the teacher development program and the evaluation of its effects were carried out. The study's findings were used to fine-tune the lecturers' own method of efficient science instruction and comprehension. Researchers found that as participants in the study interacted with one another and shared ideas and techniques for improving scientific education, there was an increase in social growth, a byproduct of the process of renegotiating and reconstructing what it means to be a teacher.There was also acknowledged personal development, which involved each individual teacher constructing, evaluating, and accepting or rejecting for herself/himself the new socially constructed knowledge about what it means to be a teacher of science, as well as managing the feelings associated with changing their activities and beliefs about science education, particularly when these went "against the grain" of socially constructed and accepted knowledge, as well as managing the feelings associated with changing their activities and beliefs about science education, particularly when these went against the grain of professional growth of the teacher was a result of the two factors of social and personal development, which included the employment of various educational activities, the development of beliefs and conceptions that underpinned the activities, and the development of subject matter knowledge and skills (Bell & Gilbert ,1996).The greatest challenge to their model is that it did not have a formula that may mechanically result in higher learning for lecturers (Bell and Gilbert, 1996).

### 3.6.2. Five Models of Staff Development

Education authorities in the United States of America considered staff development to be a critical component of their school reform initiatives in order to enhance educators' performance on tough topics such as science. In their 1990 paper, Sparks and Loucks-Horsley outlined five models of staff development. When it comes to professional development, my suggested Collaborative model would compress all five models into a single model with the sole purpose of satisfying the individual professional development needs of teachers, which will differ from one teacher to the next. The five-model method enabled educators to choose the learning models that they felt were most effective for their students. It is possible to modify these models in order to enhance the suggested Collaborative model in learning and teaching mathematics in a South African perspective, by including the five models of:

- *Training model:* - This type of model will be the creation of network of educators in Mathematics in cluster format. Teachers acquire knowledge or skills through appropriate individual or group instruction. The use of subject advisor and peer monitoring will form part of training model post qualification.
- *Individually guided staff development:* - It is a process through which teachers plan for and pursue activities they believe will promote their own learning in improving teaching.
- *Observation/assessment model*: Using this model to improve self-assessment, the Collaborative Model will seek to provide objective data and feedback regarding their classroom performance.
- *Inquiry model:* - Required teachers to identify an area of instructional interest, collect data, and make changes in their instruction based on an interpretation of those data.

- *Development/improvement process:* - As curricula developer, it was ideally for the improvement of this process model used in the USA. The development/improvement process engages teachers in developing curricula, designing programmes or school-improvement processes to solve general or specific problems.

### 3.6.3 REVIEW AND ANALYSIS OF PROFESSIONAL DEVELOPMENTS APPROACHES

The design and execution of important and successful skilled development efforts for math and science education did not include learners, resulting in increased pressure on the educator while the learner is treated as a passive consumer of knowledge and skills. The educator has the primary responsibility for students' learning and acquisition of new information. As a result, my proposal for a collaborative learning and teaching model is a strategy of shared accountability between teachers, students, and society as a whole.

Despite widespread agreement that the five models are great in terms of defining what constitutes successful skilled development, there is a blind hole in terms of the progressive learning of the student who is not held responsible in any way other than via their participation in class. If a student fails, the instructor is seen to have failed in his or her efforts to influence the learner's mindset. In response to these paradigm shifts in skilled development, a shift in stress was required: from transmission of data to experiential learning; from reliance on existing analysis findings to examining one's own teaching follow; from individual-focused to cooperative learning; and from replicating best practice to problem-focused learning (Loucks-Horsley, et al.1998).

As a final point, after evaluating and discussing several skilled development objectives and programs, as well as models, it is important to remember that they should not be employed in isolation from the teacher's surroundings, social and academic background. However, much will be learned from these skilled development ways and possibilities of those skills' development objectives, programs, and models will be taken into consideration once the collaborative model is established, as will be shown in the following sections.

## 3.7 LIMITATIONS OF PROFESSIONAL DEVELOPMENT APPROACHES

Most of the models are not intended to be used beyond the duration of the experiment (Collison and Ono, 2001). Although they were acknowledged, professional development has suffered from a bad reputation for decades and has yet to be supported by a coherent theoretical framework (Fullan, 1995a). In general, they are seen as fragmentary and random (Edelfelt and Lawrence, 1975; Lortie, 1975; Joyce et al., 1976; National Commission on Teaching and America's Future, 1996, :20; National Commission on Teaching and America's Future, 1996:20). "Nothing has promised so much and has been so painfully wasteful as the hundreds of workshops and conferences that have resulted in no major change in practice when the teachers return to their classrooms," Fullan (1991) wrote (cited in Collison and Ono, 2001:230). It has been highlighted that the Professional Development Model's deployment in the United States was short-lived and did not include any follow-up actions (Kahle (1999:1) as an in-service supporting program. They would perform better if they were implemented over a longer period and evaluated on an annual basis for their impact on school subject performance.

In addition to the shortcomings in the current development programmes, Bell, and Gilbert (1996:9) indicated that teachers had concerns of their own regarding their professional development. They often had to do it on their own initiative, in their own time and at their own expense.

On top of that, it was asserted that there was little information available on effective in-service teacher development interventions that were appropriate for use in developing country contexts because the literature on effective in-service training models has only gradually emerged internationally over the last decade and the information for developing countries is still quite scarce. Furthermore, poor nations are not exempt from this rule. As according De Feiter, Vonk, and Van Den Akker (1995), in a study conducted in the BoLeSwa-countries (Botswana, Lesotho, and Swaziland) in Southern Africa, a major problem regarding in-service teacher education projects experienced in the early 1990s was how to design interventions for optimal effect and how to determine the effectiveness of those interventions. South Africa is following the same trajectory as the rest of the world, both domestically and globally.

**3.8. Recommendations for Professional Development**

With the widespread recognition of the importance of professional development in education, it is expected that educationists on a broad scale will give serious consideration to the shortcomings that have been identified in current development activities, as well as suggestions for how to improve them. So many writers who are considered experts in their fields have replied in recent years with comments and proposals aimed at improving the overall quality of professional growth in their fields. Professional development, as per Glenn (2000), should ideally be a collaborative educational process focused on the continuing growth of educators. It is hoped that such a procedure will: improve their capacity to monitor students' work, allowing them to offer constructive comments to students and refocus their own teaching in the proper manner. The following is an example of the sort of professional growth that should be fostered and supported, Kahle (1999).

- Keep up with developments in their fields and in education in general.
- Be sustained, content-based and use new teaching methods.
- Provide incentives (graduate credit) and be tied to career goals, including differential staffing and teacher career ladders.
- Be accountable, including research to assess changes in teaching practices and in student learning.
- Generate and contribute new knowledge to the profession.
- Provide for follow up experiences so that teachers have opportunities to test, discuss and analyse new teaching strategies.
- Include leadership opportunities and model strategies that teachers will use with their students.
- Deepen their knowledge of the subject (content knowledge) they are teaching.
- Sharpen their teaching skills in the classroom.
- Provide time for teachers to reflect on and practice what has been learned.
- Include on-going assessments that provide information to revise and redesign the professional development experiences.

The National Institute for Science Education in the USA wrestled with the question of whether the Science and Mathematics community on the one hand, and the professional development communities on the other, shared a common understanding of what the nature of effective professional learning experiences was, and on how teacher development should be guided. After an extensive review of standards and related material, it was concluded that professional development experiences for science and mathematics educators can only be effective if based on the following seven principles: (Loucks-Horsley, Stiles, and Hewson ,1996).

- Effective classroom learning and teaching.

- Provision to teachers with opportunities to develop knowledge and skills to create better learning opportunities for students.
- Promotion of instructional methods that enhance learning for adults which mirror the methods to be used with students.
- Establish and strengthen community of learning of science and mathematics teachers.
- Exposure of educators in leadership position in the community as teachers master the skills of their profession, they need to be encouraged to step beyond their classrooms and play roles in the development of the whole school and beyond.
- Provision of links to other parts of the educational system.
- Change management and continuous assessment.

For the effectiveness of the professional development of teachers, there must be a continuous job-embedded, career-long process planned to specifically focus on improving teaching and learning (curriculum, instruction, and assessment), Collison and Ono (2001:13). In South Africa, according to Dunlap cited in Steyn (1999:211) for professional development to be effective, programmes must be based on the following principles:

- Educators are learners and they need the necessary opportunity to learn continually about their practice, their students, and their discipline.
- Collegiality and collaboration in a collegial context require the necessary support.
- Professional development is a long-term investment and commitment.
- The focus on professional development is educators` questions, needs and concerns.
- The organisation of professional development requires the necessary infrastructures as well as innovative approaches to it.
- Improved coordination is likely to increase professional development initiative through collaboration between the different directorates and other partners in the private sectors. There are too many uncoordinated activities running at the same time, sometimes duplicating each other. There is currently no support after training initiatives are completed. If learning cannot be implemented, then the learning outcome is useless.

### 3.8.1. Recommended features of Professional Development Programmes

In contrast there is little direct evidence on the extent to which these characteristics contribute to better teaching and improved student achievement (Hiebert 1999; Loucks-Horsley *et al.* 1998 as cited in Garet et al., 2001:917).In a three-year study undertaken jointly by researchers from the Vanderbilt University, the University of Wisconsin and the

American Institute of Research (Desimone, Porter, Garret, Yoon & Birman, 2002:81) three core features of professional development activities were significant positive effects on the teachers' knowledge and consequent changes in their classroom practice (Desimone *et al.*, 2002:83).

#### 3.8.1.1. Content

According to Garet, Porter, Desimone, Birman and Yoon (2001:923), research suggests that the content covered during professional development activities mainly varies. Science and Mathematics to Pedagogical content knowledge (PCK) (Shulman,1986), subject knowledge should go beyond knowledge for teaching but focuses on specific mathematics and science content and the ways students learn such subject matter (Cohen & Hill, 2002; Fennema *et al.*, 1996) cited in Garret *et al.,* (2001: 917 – 918).

#### 3.8.1.2. Active learning

In collaborative model, there will be a fusion of active learning according to Garret *et al.*, (2001:925–926) focusing on observing and being observed by peers. This monitoring is supportive and improves learning through peer learning and supportive exchange visits.

#### 3.8.1.3. Coherence

During my study, it was observed that professional development activities for teachers lacked coherence which is critical feature to staff development and interrelatedness between the various activities. In other words, individual activities did not necessarily form part of a coherent programme of teacher learning and development. This could be improved if it is going to be assessed (Garret *et al.*, 2001:927–928) the connectedness of goals and other activities. Each activity must build on preceding activities and must be followed by more advanced work.

The collaborative Model will be aligned with the national curriculum and assessment. All professional development activities if they are to be collaborative, need to talk to all efforts to reform their teaching in similar ways. If teachers start to communicate with colleagues regarding their successes in their classrooms, a professional community can be developed, and the programme designers can be assured of sustainability.

#### 3.8.1.4. Form/type of activity

All learning planned activities should generate interest in the reform types of professional development such as study groups or mentoring and coaching. These types of reform activities are easier to sustain over time (Garret *et al*., 2001:920–921).

#### 3.8.1.5. Participation

Participation of learners and other non-teaching staff in the staff development (Garret *et al.,* (2001:922) is an advantage if professional development programmes are designed for groups of teachers from the same school, department, or grade. Assessment of the staff development involving non-teaching staff will help not only teachers in Mathematics but other staff members to appreciate and offer support. Teachers who share the same learners can discuss their needs across classes and grade levels. Few research results are available on the effects of collective approaches to professional development. Garret *et al.* (2001:923) reported that collective participation "reinforces teachers' sense of commitment to their school's goals. Similarly, active assistance, support, and encouragement to teachers as they attempt to enact new practices in their classrooms could greatly enhance the process of professional development (Marx *et al.,* 1998:670).

#### 3.8.1.6. Duration of activity

Professional development must be sustained over time. In addition, activities that extended over time were also more likely to allow teachers to try new practices in the classroom and obtain feedback on their teaching (Garret *et al.,* 2001:921-922, Shields, Marsh, & Adelman, 1998; Weiss, Montgomery, Ridgway, and Bond 1998) as cited in Desimone *et al.,* (2002:82). The incorporation of these six recommended features in the construction of the Collaborative model is discussed in a later chapter.

### 3.9. Collaboration as an alternative framework in developing a teaching and learning model in Mathematics.

Fig 3.3 is a presentation of the components of collaborative learniung which emphasizes on teamwork and use of interactive and engagement skills and activities which were the pillars of designing the collaborative model the thrust of the research study.


**Fig 3.3: Components of Collaborative Learning (Researcher source)**

Spaull's (2013) study on teacher professional development indicates that teachers lack the desired knowledge and skills in mathematics. Spaul (2013) also argue that teachers lack pedagogical content knowledge (PCK) in mathematics and these findings resonate with the results obtained by the Trends in Mathematics and Science Study (TIMMS) tests (Howie, 2001; Reddy, 2006) that learners performed very poorly in mathematics in South African schools. This poor performance becomes evident when one scrutinises the Annual National Assessment results particularly in the senior phase (DoE, 2014). The continued underperformance in Mathematics can no longer be left to teachers and schools alone in isolation to find solutions. Doing so focuses on the symptoms of a problem and targets the failing learner using a single target-single delivery approach which has not yielded positive results.

The research developed a model for professional development to address the difficulties connected with teacher education. The iterative evolution of the model is a design study that develops a new knowledge of educational phenomena while creating practical educational solutions (Edelson, 2002). Edelson argues that design research aims at producing new information about theoretical ideas, effective design processes, and successful design solutions. In research, the study questions existing professional development paradigms of mathematics educators. The aim is to create a successful model while gaining a theoretical knowledge of how in-service teachers view their professional growth and how teachers interpret the model's evolution in the context of research-based integrated mathematics. Design research was nonetheless critiqued for lack of scientific rigour and defined criteria (Dede, 2004; Kelly, 2004), and for lacking credibility in its assertions of simultaneous design assessment and theory development (Phillips & Dolle, 2006). Sandoval (2014) offers speculation mapping to address these methodological issues as a methodological approach to study design. A hypothesis map helps explain how the theoretical assumptions of the planned model are implemented and how embodied behaviours lead to desired results via mediation. Sandoval (2014) recommends that research studies must first record and explain the mediating mechanisms that contribute to these outcomes to verify the results of the design such as the intended improvements in educational practice.

Increasing research on professional development models sees teacher collaboration as an effective forum for teachers to access professional development opportunities close to their places of work, Pirtle (2014) Avalos (2011). Collaboration is thus very important for professional development as it not only provides the necessary support for learning but also provides teachers with feedback and brings about new ideas and challenges, Zulu, and Bertram (2019). Several education researchers and practitioners, such as, Friend and Cook (2010); Dove and Honigsfeld (2010); Milteniene and Venclovaite, (2012); Taylor, Smiley, and Richards (2015); Richards, Frank, Sableski and Arnold (2016); Dettmer, Knackendoffel, and Thurston (2013); Hay and Raymond (2013b) and Engelbrecht and Hay (2018), defined collaboration as a voluntary social interaction process in which two or more professionals learn from each other by exchanging expertise, plan and identify aims together and distribute roles equally to generate creative solutions to problems, and in the process share responsibility for the outcomes of the collaborative process. In a school context, according to Taylor et al. (2015); Slater and Ravid (2010); Loreman, Deppeler, and Harvey

(2010) and Engelbrecht and Hay (2018), experts can be teachers, students, leaders, parents, other professionals, community members, business owners, policy makers and educational administrators who are willing to contribute their knowledge and skills to the issues being addressed.

According to Kwakman (2003) collaboration of teachers involves intensive interactions in which teachers together engage in activities that facilitate learning. However, understanding the nature of collaborative activities and what is learnt from collaborative activities is still limited in South Africa especially in a rural context. There is some literature (Jita and Mokhele 2014; Brodie and Borko 2016) on teacher collaboration which explores the formal collaboration required by the Department of Basic Education (DBE) on school-based collaborative structures.

It is evident from all the above that, to take up the challenge of quality mathematics education for all, synergy must be achieved among a variety of experts such as mathematicians, teachers, teacher trainers and educationists. Adopting a new approach which will be a multi-target multi-delivery approach encompassing all stakeholders in Mathematics education will most likely yield lasting results as it will not only improve the results but also develop a culture of working together consultatively in search of solutions to problems besetting educational discourse. The stakeholders in the mathematics curriculum enterprise comprise learners, educators, principals, examination bodies, teacher associations, parents, subject advisors as well as educational management officials from circuits and district offices.

### 3.9.1. Conceptual roots of collaboration

The term collaboration and its connected terms, principally has its abstract roots in a social artistic movement, a social science theory of information propounded by Levy Vygotsky supported by Jean Piaget's Cognitivism, who argues that effective learning takes place during a context that learners are conversant in and could be a group action. In this it is related to reference to different individuals, our academics, peers, and family.

The concept of collaboration is overused, and its real meaning remains unclear. Several authors such as Hargreaves (1994), Forte and Flores (2014), Robutti et al. (2016) have drawn attention to the ambiguity and complexity of the meaning of "collaboration" and misuse of it as a synonym of "cooperation". Robutti et al. (2016) point out, "collaborate means to work jointly with and cooperation indicates that individuals contribute to various aspects of a particular task". Robutti et al. (2016) further suggest that these terms are related regarding describing joint activities of individuals or institutions. Collaborative learning is an educational approach to teaching and learning that involves groups of learners working together to solve a problem, complete a task, or create a product, Laal, and Ghodsi (2012). CL dates to at least the 1970s and finds support in many theories of learning, including Sociocultural Theory (Vygotsky, 1978), Social Interdependence Theory (Johnson & Johnson, 2006), Humanist Psychology (Maslow, 1968), Social Constructivism (Palincsar, 1998) and Multiple Intelligences Theory (Gardner, 1993). Forte and Flores (2014), argue that "collaboration" involves developmental activities with consequences for several people going beyond the superficial exchange of help, support, or assistance. In line with the literature, collaboration in this study involves sharing and interaction "going a step beyond mere cooperation" (Forte and Flores 2014, 92). There is a growing belief that collaboration is essential for teachers because it enables them to share practices and perspectives with colleagues which can create new possibilities for learning (Dixon, Reed, and Reid 2013). The 12 principles of collaboration are presented in Fig 3.4 and constitute the key elements of the collaborative model.

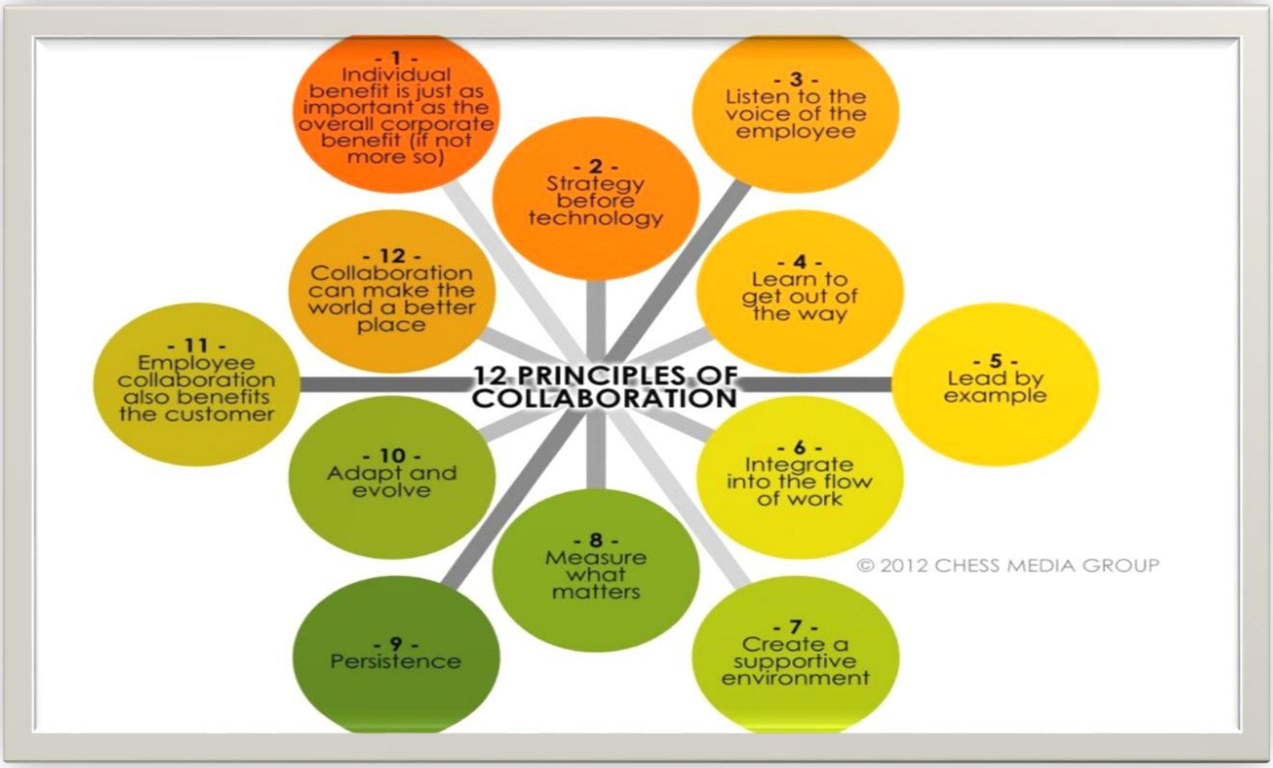

**Fig 3.4: Principles of Collaboration (Source:** (Dixon, Reed, and Reid 2013)**)**

The DBE (2015) supports the establishment of professional learning communities as a way of encouraging teacher collaboration and strengthening teacher professionalism. This is in line with findings in international literature on teacher "continuing professional development" (CPD) which describes various structures such as teachers' subject clusters, "communities of practice" (CoP) and "teachers learning communities" (TLCs) which are also sometimes called "professional learning communities" (PLCs). It is argued that these structures are used to support teachers' collaborative professional learning (Butler, Schenellert and MacNeil 2015; Mistry 2008; Jita and Mokhele 2014; Bantwini 2018). Pirtle (2014) has pointed out that the term PLCs has become overused, and the meaning is often lost. This study therefore uses the term "teacher learning community" to describe the group of mathematics teachers who met on a regular basis, as organised by the Department of Education. Teacher learning communities "embody the concept of teacher learning in a setting in which teachers come together over time for the purpose of reconsidering their existing beliefs and practice, gaining new professional knowledge and skills and reconstructing reform agendas that enhance student learning and professional practice" (Chow 2015, 288). The literature shows that teacher groups can only be regarded as PLCs when they adhere to a particular set of practices which includes collaborative learning, reflecting on their practice, meeting regularly, shared leadership, collective responsibilities and collective decision making (Pirtle 2014, 1).

Hargreaves (1994) identifies two cultures in which collaboration occurs in different structures: namely "collaborative cultures" and "a culture of contrived collegiality". He describes a collaborative culture "as typically involving working relationship between teachers and their colleagues which tend to be spontaneous, voluntary, development – oriented, pervasive across time and space and unpredictable" (Hargreaves 1994, 192). In contrast, the culture of contrived collegiality involves administrative regulation, compulsion, an implementation orientation, fixed location time and space, and predictability. Hargreaves (1994) is in favour of collegial interaction as the most important aspect of collaboration. While Hargreaves (1994) argues for a collaborative culture that is development-orientated, Day (1999) claims that these two cultures work together in that a culture of contrived collegiality may act as a prompt towards more collaborative cultures in providing added chances for development. In the South African context, this linking of contrived collegiality and collaborative culture relates to transforming a cluster from administratively regulated teacher collaboration to a teacher-driven collaborative learning space, which is the case for this group of mathematics teachers who were the subject of the research.

Existing South African literature on teacher collaboration such as Brodie and Borko (2016) and Bantwini (2018) seem to focus on teacher collaboration through teachers learning in TLCs and professional learning communities (PLCs) that are operating within schools. The findings of one of these studies suggest that “success in establishing sustained teacher collaboration requires that the teachers have a broad range of support personnel, internally and externally, whom they can consult on various issues pertaining to their teaching practices”, (Bantwini 2018, 15). Furthermore, collaboration of teachers within schools is also promoted in South African education policy, namely the Integrated Strategic Planning Framework for Teacher Education and Development (DBE and Department of Higher Education (DHET) 2011). According to this policy, the DBE and DHET envisage that support and resources for teachers, and access to professional development opportunities, “will be enhanced at local level by the establishment of PLCs” (DBE and DHET 2011, 10). Studies done of cluster groups (teacher’s groups initiated by DBE for administrative purposes) and teacher learning communities (Graven 2002; Jita and Ndlalane 2009; Jita and Mokhele 2014; De Clercq and Phiri 2013) indicate on the benefits of teacher collaboration. For example, a study on teacher learning communities in a South African context have established that through collaborative learning teachers developed confidence that was essential to their professional development (Graven 2002).

In an international context, Schnellert, Butler and Higginson, (2008) studied six teachers in one Canadian school, where collaborative learning of six teachers was supported by university researchers. The findings of this study indicate that the collaboration of the six teachers enabled them to use learning tools designed to develop and measure the progress in literacy skills among students. According to Schnellert et al. (2008) the six teachers were able to meet part of the Canadian policy target called Learning through Reading. A group of researchers in Scotland, Priestley et al. (2011) and Butler, Schnellert and MacNeil (2015) in Canada have focused on TLCs that are outside of the school. These two international studies reports show that teachers engaged in TLC activities among other things as a way of sharing ideas and thinking about their own professional development in relation to the education policy. The findings of these two studies appear to suggest that teacher collaboration was characterised by "compulsion" (Hargreaves 1994, 195–196) to meet the policy target, a mandated agenda of the education system. Although the positive results of collaboration are reported in the above-mentioned studies, Chen, Elchert and Asikin-Garmager (2018:4) highlight that teacher do not always like the opportunity to work together to share teaching practices "particularly when collaboration practice is a result of a top-down mandate and tied to staff appraisal". Teacher knowledge and collaboration are related in that collaborative activities in which teachers engage in may result in learning that enables teachers to develop or enhance their professional knowledge. Professional knowledge is defined as "a body of knowledge and skills needed in order to function successfully in a particular profession" (Chauraya and Brodie 2018:223). In line with this study the knowledge needed is to teach mathematics is divided into five components namely, "common content knowledge, specialised content knowledge, knowledge of content and students, knowledge of content and teaching, knowledge of content and curriculum horizon" (Ball, Thames, and Phelps 2008:399). These scholars have aligned domains of teacher knowledge to mathematics by refining and expanding on Shulman's (1987) subject content knowledge and pedagogical content knowledge (PCK). Shulman (1987) describes PCK as a combination of subject matter knowledge and pedagogical knowledge. Elaborating from Shulman's (1987) notion of PCK, Ball et al. (2008) and Hurrel (2013) claim that PCK is the combination of content knowledge with one or more categories of Shulman's domains of teacher knowledge.

Common Content Knowledge (CCK): Ball et al. (2008) state that CCK is not specific to teaching but it is a subject-specific knowledge needed to solve mathematics problems. An example of CCK in arithmetic algebra is 10×10 = 100. These scholars maintain that this knowledge is critically important for teachers because it is difficult to teach without common sense or to teach what one does not know. Specialised Content Knowledge (SCK): According to Ball et al. (2008), SCK is defined as mathematical knowledge and skills unique to teaching. "Teachers need to have a specialized understanding of, for example, how $(xx+yy)2$ can be expanded" (Ball et al. 2008, 400). SCK enables the teachers to understand learners' strategies and sources of error better and it also includes knowledge of representing mathematical procedures and ideas using pictures and manipulatives. The understanding of learners' strategies and error is in line with Shulman's notion of PCK. Knowledge of content and students (KCS): According to Ball et al. (2008), KCS allows an interaction between specific mathematical understanding with students and their mathematical thinking (Ball et al. 2008, 400). For example, they say that in exponents, a teacher's KCS enables the teacher to expect students to incorrectly think that $(xx+yy)2 = xx2 + yy2$ and to anticipate misconceptions about the distributive property and exponents. Knowledge of content and teaching (KCT): In line with Shulman's (1987) description of PCK that it is the amalgamation of pedagogical and content knowledge, Ball et al. (2008) state that KCT integrates knowing about teaching and knowing about mathematics. However, Ball et al. (2008) clarify that in relation to mathematics, knowledge of content and teaching is a combination involving a specific mathematical idea or procedure in addition to familiarity with pedagogical principles for teaching that specific content. Knowledge of content and curriculum (KCS)/(Horizon): Knowledge about content and curriculum means "teachers' knowledge of the available materials that they can use to support students' learning" (Ball et al. 2008, 401). The mathematics teachers drew upon their knowledge to decide which textbooks are best for teaching geometry and algebra for a certain grade. Knowledge of the curriculum is part of the mathematics content knowledge domain, and it is an advanced background of the subject matter of mathematics (Krauss and Blum 2012).

Generally, a curriculum policy is essentially a course of study or plan of what must be taught and learnt. The Curriculum and Assessment Policy Statement (CAPS) is the curriculum that South African teachers currently need to follow and know. This study was undertaken when CAPS was introduced in 2012 in Grade 10. During the data collection stage in 2013, CAPS was introduced in Grade 11. Thus, the curriculum knowledge in this study is based on CAPS. South African studies on teachers' mathematical knowledge such as that of Pournara et al. (2015) have established that many teachers in South Africa lack subject content knowledge. The research literature and DBE and DHET suggest that collaboration of teachers is a solution to the problem of the shortage of professional development opportunities. This study therefore contributes to this on-going discussion about teacher collaboration by examining the nature of collaborative activities and the types of knowledge that is learnt in a TLC located in a rural part of South Africa.

Teacher professional learning and development frequently happens within the teacher's own school environment. Increasingly, school leaders are establishing systems that encourage teacher learning in collaborative groups and participation in professional communities of practice, to personalise learning and involve a wider range of stakeholders in school improvement, Crowley (2017). The term „teacher collaboration‟ has been widely used by scholars such as Datnow (2011), Little (2003) and Kelchtermans (2006). In defining teacher collaboration, Little (2003: 331) sees it as "a level of collegiality at which teachers in successful schools discuss, design, conduct, analyses, evaluate and experiment with their teaching". Likewise, Datnow (2011: 152) defines teacher collaboration as "sharing of expertise in delivering a lesson, solving a problem or working together on a project". From these definitions, one can conclude that teachers agree to work together, sharing their teaching advice while using their varied expertise.

However, different from other professions, teachers still prefer to work individually, which hinders their professional learning. Similarly, this view is shared by Maloney and Konza (2011) who argue that teachers work within the confines of their classrooms, with little time to engage in collegial conversations about their practices. From my own teaching experience, teachers seldom observe other teachers‟ teaching and the classroom seems to be their private domain. Psychologically, teachers prefer to work individually, avoiding evaluation and critique by their colleagues. Without the flow of ideas and sharing of professional skills, teachers remain uncertain about their performance. Rytivaara and Kershner (2012) and Austin (2001) agree that the role of teachers has changed from them being transmitters of knowledge, into facilitators of learning.

From this, one can conclude that teachers are now required to provide diversified learning experiences to learners. In her study, King (2012) asserts that teachers align collaborative teaching with the model of education involving what someone does to someone else, which involves teachers changing their practices to enhance learner achievement. This may be due to collaborative teaching being viewed as like other teacher learning activities where teachers are expected to adhere to their requirements. Austin (2001) suggests that this may result in teachers engaging with it in a compliant and non-critical manner, thus hindering teachers‟ professional learning. This view ignores teacher autonomy, which is a prerequisite for deep professional learning.

Collaborative teaching has been defined as "joint planning, peer observation, implementation, and post evaluation of lessons by teachers, to have well prepared lessons and thus, fostering the process of learning for both teachers and learners (Anderson & Landy, 2006: 2). The term collaborative describes a situation where leaners of the same academic performance can do similar activities and work towards a common goal, Muuro, Wagacga, Oboko, & Kihoro (2014). For this to take place, teachers need to work together, sharing their expertise and teaching strategies. Furthermore, sociocultural studies emphasise that knowledge is learned in groups. However, in defining collaborative teaching, teacher educators focus on the procedure of collaborative teaching which includes pre-lesson planning, peer observation and post-lesson reflection by teachers.

Therefore, the projected model could be a social artist model whose thrust is to mobilize educators, parents, learners, and subject advisors into a joint instructional enterprise of downside finding the answers to poor mathematical outcomes in public high schools of the Sisonke district. Mathematics teaching reform is thus underpinned by new thought systems that shift from centralized approaches to decentralized, cooperative approaches underpinned by principles like shared higher cognitive process, selection and democratic voice of learners, teacher management and programmes based on innovations and collaboration among others.

Restructuring faculty systems through developing new, decentralized, cooperative models is premised on the need that education of a learner could be a shared socio-instructional method that is not solely the educators' task, however a joint enterprise comprising parents, learners, politicians, teacher organisations, subject advisors and instructional managers, all targeted on achieving desired instructional outcomes. Current socio-instructional trends like decentralization, promotion of teacher expertness, developing community focused faculty cultures and faculty-community partnerships have wedged on trendy school operations. Murphy and Hallinger (1993) justify that these ever-changing associations and patterns of interactions among instructional stakeholders have created new contexts for programme implementation. Within the context of this study, efforts geared towards improving Mathematics performance in secondary schools at Sisonke demands the creation of the latest complicated networked contexts and mind sets wherever arithmetic education stakeholders have shared leadership, shared responsibilities, shared vision, clearly outlined roles and decentralized higher cognitive process among key variables of faculty improvement campaigns.

Collaboration and its tenets as a philosophy were expounded by Vygotsky (1933) in his Socio-cultural theory in that he argued that an inherent social nature of learning exists which is shown through his theory of Zone of Proximal Development. The idea assumes that people at intervals form joint social enterprises and construct data through active learning and making of meanings. So, a social construct is performed on the far side the Zone of Proximal Development incorporating teams of interacting people can perform even higher and refine their thinking on the far side of the present levels through social interaction. Vygotsky's cooperative learning principle emerges as a pillar in developing collaborative models that humanizes teaching and learning in classrooms.

In the study the collaborative model was conceived through the theoretical view of its role in contributing to School Effectiveness that results in School Improvement, of Mathematics in Sisonke district secondary schools. Creemer (2007) expands that Schools Effectiveness is strongly focusing on student outcomes and characteristics of schools and classrooms that are associated with these outcomes, while School Improvement is mainly concerned with changing the quality of teachers and schools. Thus, the former (School Effectiveness) attempts to find out what is to be changed in schools to make them more effective, while the later explains how schools can change to improve. In the study the two paradigms were guiding principles upon which the model was premised in that secondary schools, through use of the Collaborative model of tackling Mathematics under performance emerge changed, effectively and improved through a comprehensive framework that brings together all user systems' stakeholders to contribute to finding challenges that affect curriculum implementation.

Ultimately through implementing a collaborative model, schools are envisaged to enhance and be effective establishments that are proactive and innovative in handling challenges that beset their contexts. Creemer (2007) further asserts that faculties would like external pressure from the tutorial contexts to start out rising and a few pressures embody competition among faculties external analysis and responsibility, external agents, participation of society in instructional changes and materials and non-materials styles of support. The above implies that schools as social establishments ought to add harmony with different external stakeholders and contexts collaboratively to lead to improved outcomes in arithmetic in secondary schools.

### 3.9.2. Assumptions about Learning in a Collaborative Classroom

Collaborative learning, a component of Social Constructivism takes on a variety of forms and is practiced by educators of different disciplinary backgrounds and convictions. The discipline is informed by several important assumptions about learning and the learning processes. Smith & MacGregor (1992) define collaborative learning as an umbrella term for a variety of educational approaches involving joint intellectual effort by students, or students and teachers together. According to Laal and Laal (2012), learners form small groups to help each other to complete some tasks such as their assignments. Learners conduct the face-to-face meetings either before or after the sessions. In some cases, learners conduct the meetings during the sessions with the approval of their respective tutors. In collaborative learning, learners can acquire knowledge through discussions and exchange of opinions among themselves (Brindley, Walti, & Blaschke, 2009). Usually, students are working in groups of two or more, mutually searching for understanding, solutions, or meanings, or creating a product. There are numerous characteristics of collaborative teaching that have been identified.

Thibodeau (2008) claims that successful collaborative teaching activities should exhibit the following characteristics: (a) Parity in collaboration: Each teacher's contribution is equally valued, and each teacher has equal power in decision making. Collaboration requires parity among participants (Friend, Cook, Hurley-Chamberlain & Shamberger 2010), this simple means, according to Hay and Raymond (2013); Miltenienė and Venclovaitė (2012); Engelbrecht and Hay, (2018), that group members must agree to view all participants as equal with diverse and needed expertise. Hay and Raymond (2013), as well as Loreman, Deppeler, and Harvey (2010), made a point of saying that this supports the freedom of all members to offer processes and assess ideas and information, as well as the freedom of all members to supply processes and evaluate ideas and information. According to Taylor et al. (2015) as well as Slater and Ravid (2010), equity is shown in inclusive schools when parents of students with disabilities are included in decision-making regarding where and how their children are taught. Pursuant to Hay and Raymond (2013), another example comes when general education educators, special education teachers, and associated service providers collaborate on curriculum creation with the understanding that their combined knowledge helps all students. (b) Voluntary: Teacher collaborative relationships are most successful when they are entered into freely and exist by choice. (c) Mutual goals: There is a need that is jointly shared by teachers. (d) Shared responsibility: Teachers should share responsibilities and, in the decision, making it entails. (e) Shared accountability: Teachers have equal accountability for the outcome of their endeavour. (f) Shared resources: Teachers should share material and human resources.

Stanley (2011) notes the following characteristics of collaborative teaching: (a) Shared values and vision. Collaborative teaching emphasises shared goals aimed at improving teachers‟ performance in the classroom and learner performance. Collaboration should be based on mutually agreed-on goals (Friend et al., 2010) and this means that participants must work towards a clearly articulated common goal or goals and this will help escape confusion and give participants a focus (Slater & Ravid, 2010; Loreman, Deppeler & Harvey, 2010; Engelbrecht & Hay, 2018). Miltenienė and Venclovaitė (2012); and Engelbrecht and Hay (2018) suggested that participants must firstly identify the aims and jointly plan activities to solve problems, and then distribute the roles equally. This value, according to Turk (2012), is displayed when a student's educational team develops an Individualized Education Program with one set of goals and objectives to which they are all committed, rather than each professional pursuing separate out-comes. According to Taylor et al., (2015), the process of identifying and achieving common goal can be a challenge for general education teachers and special education teachers as they might have different agendas. For common goals to be achieved, Taylor et al., (2015); and Turk (2012) suggest that these teachers can begin with common agreed-upon goals of successful progress for all learners and then they can proceed to negotiate more specific goals for a collaborative effort.

(b) **Collective responsibility.**

This is demonstrated when teachers share teaching responsibilities which eases isolation. Collaboration depends on shared responsibility, resources and accountability for participation and decision making (Friend et al., 2010 and Engelbrecht & Hay, 2018). This means that all participants must be part of decision making so that the decision will have the full support of every participant (Slater & Ravid, 2010; Loreman et al., 2010). In decision making, it is very important, according to Taylor et al. (2015) that each participant be willing to compromise as needed, accept any group decision, and abide by decisions arrived at through a fair and collaborative effort. Miltenienė and Venclovaitė (2012) made an example of how responsibility can be shared. They stated that team members add agenda items for team meetings that they would like to discuss, they rotate responsibility for chairing meetings, and handling minutes, they come to meetings prepared so that they can contribute information, ideas, and opinions, and take responsibility for decisions.

(c) **Reflective personal inquiry.**

Here teachers converse about serious content issues and share knowledge through joint planning.

(d**) Collaborative.**

This is demonstrated when teachers work together, exchanging ideas, jointly reviewing each other's work, and providing feedback.

(**e) Group learning.**

This emphasises collective knowledge creation, shared meanings, and a sense of belonging which leads to increased understanding and learning opportunities for teachers. Other characteristics of collaborative teaching are mutual trust, respect and support and openness. These are needed when teachers engage in regular discussions about their classroom practices as they receive supportive feedback. Smith and MacGregor (1992) outline the following:

- ***Learning is active, constructive; -*** To learn new information ideas or skills, learners must work actively among themselves in purposeful ways. They need to integrate new material with what they already know or use to re-organise what they thought they knew. In collaborative learning classrooms learners not only take in new information or ideas but they construct new information and ideas which measure their understanding of phenomena.
- ***Learning depends on rich contexts: -*** Brown *et al.,* (1989) in their research found that learning is influenced by the context and activity in which it is embedded. Thus, collaborative learning activities involve learners in challenging tasks or questions. Rather than commencing with facts and ideas and moving to applications, collaborative learning activities begin with problems for which students must marshal pertinent facts and ideas. In a collaborative class, students do not become distant observers of questions and answers or problems and solutions but immediate practitioners. Rich learning contexts challenge students to practice and develop higher order reasoning and problem-solving skills.
- ***Learners are diverse: -*** Collaborative classrooms are composed of learners from multiple backgrounds, experiences, learning styles and aspirations. Thus, educators in a collaborative classroom cannot assume that a one size fit all pedagogical approach will suit learners. On the contrary learners work together on their learning tasks in class and fuse their experiences and backgrounds, and in the process diverse perspectives emerge into illuminating teaching learning experiences for both educators and learners.

- ***Learning is inherently social: -*** Golub (1988) explains that collaborative learning has as its main feature a structure that allows for students to interact among each other and it is in this talking that much learning occurs. A famous technique of collaborative learning is the use of group work to learn a task. Learning is more effective when peers come together to share ideas about a problem (Johnson & Johnson, 1989). Lin (2015) posits that group work is preconditions for effective CL. Learners develop effective cognitive learning strategies through group discussion and social interactions. Group discussion is one of the key activities of collaborative learning (Zhu, 2012). Garrison and Cleveland-Innes (2005) confirmed that the activity of group discussion is indeed effective in helping learners perform better. CL can thus help learners to gain more knowledge while working on their assignments if they work together rather than working alone. But group work has its own challenges. One group member may not master learning as quickly as the others and can be left behind and ultimately not be able to learn anything from the group work. Consequently, the whole group might end up falling apart. Svolik (2009) also drew attention to the balance of power as one of the biggest problems of a group situation, where dictatorship is recurrent. Moreover, conflicting personalities might interpose with each member's chance to fully participate in collaborative group learning. Therefore, collaborative learning produces intellectual synergy of many minds coming to bear and interrogate on a problem and the social stimulation of mutual engagement in a common task or endeavour. Apparently mutual exploration, meaning making and feedback leads to better and enduring understanding in students and creation of new understanding for both educator and learners in the learning contexts.

### 3.10. Collaborative Learning Approaches

Anderson-Butcher and Ashton (2004); Cha and Ham (2012); Diamond and Rush (2012); McLean (2012); LaRocque, Kleiman and Darling (2011); Green and Johnson (2015) and Mellin and Weist (2011) listed five models of collaboration that teachers may become involved in, namely, intra-organization collaboration, interagency collaboration, inter-professional collaboration, family-centered collaboration, and community collaboration. It is worth noting, according to Green and Johnson (2015), that schools must understand different types of collaboration but implement the type that best meets their needs and the needs of their learners. Fig 3.5 is a presentation of collaborative learning strategies (Adapted: Zuniga Vargas (2018) and made up the key components of the design framework and activities of the collaborative model constructed and tested in the study.

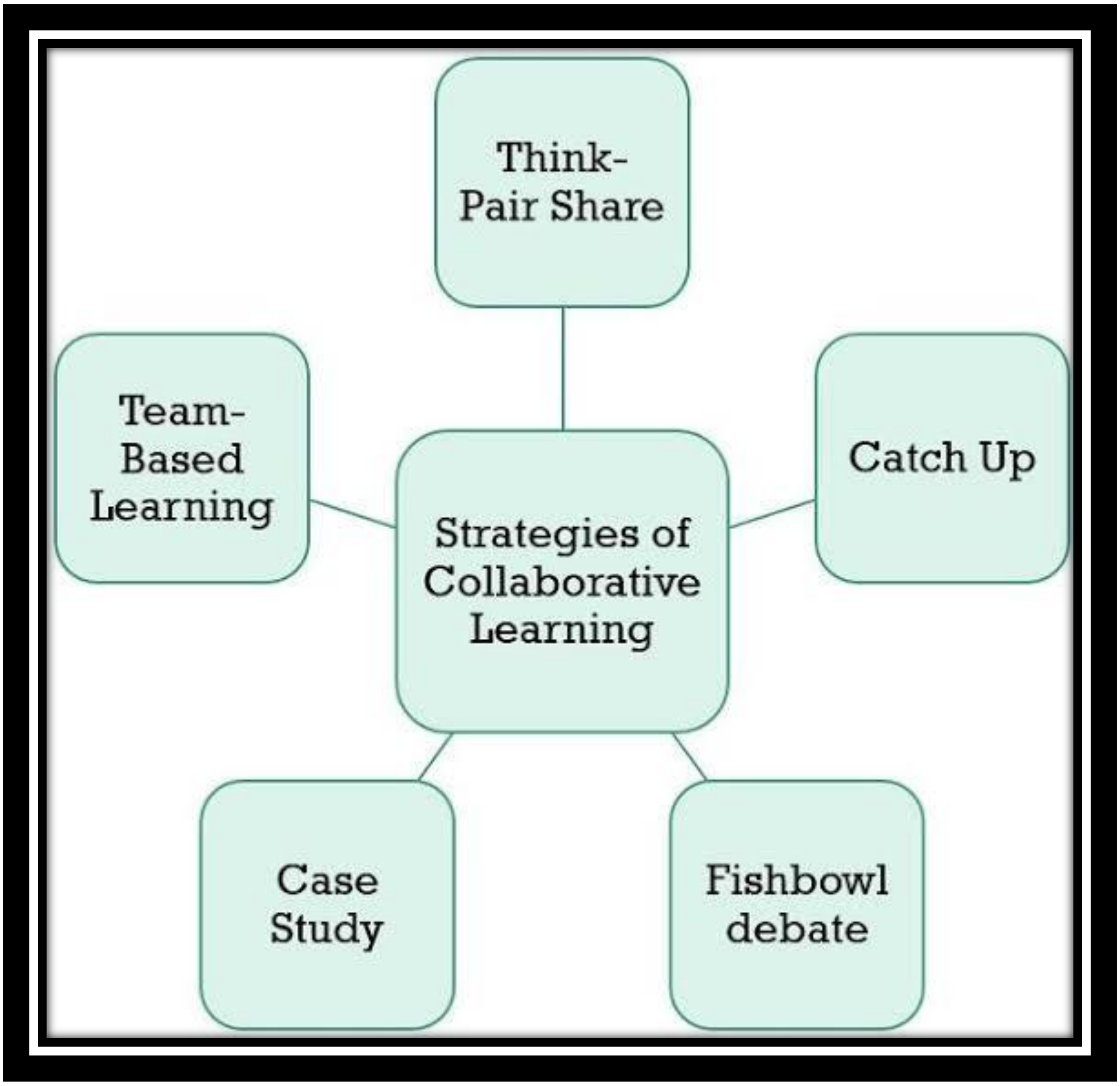


**Fig 3.5: Collaborative Learning Strategies (Adapted: Zuniga Vargas (2018)**)

Collaborative learning covers a broad discipline with a variety of pedagogical approaches whose centre is variability in the amount of in class or out of class time revolving around group work. The concept of Cooperative Learning (CL) essentially refers to the pedagogical use of group work activities to encourage students to work collectively to increase their own and one another's learning, Zuniga Vargas (2018). Collaborative activities vary from classroom discussions interspersed with short lectures, through entire class periods or study of research teams that can last the whole term or year. Goals and processes of collaborative activities also differ. Some are designed as small groups working around specific sequential steps or structured tasks. In other contexts, learners created clearly delineated products, in others the main goal is to participate in the process, an exercise of responding to each other's work or engaging in analysis and meaning making.

**(a) Intra-organizational collaboration**

The process of intra-organizational collaboration involves groups of people brainstorming ways to resolve learner problems before they become serious, as well as accommodating learners in the general classroom by providing them with the additional support and individualised instruction they require to succeed (Anderson-Butcher & Ashton, 2004; Diamond & Rush, 2012; Cha & Ham, 2012; Harris, 2010). Teachers, social workers, school psychologists, administrators, nurses, speech therapists, school counsellors, teacher support teams, and volunteers are all members of these teams (Anderson Butcher & Ashton, 2004; Diamond & Rush, 2012; Cha & Ham, 2012; Harris, 2010). This approach contributes to the institutionalisation of dependency connections among the various services and supports that are available in school systems, which is beneficial (Anderson-Butcher & Ashton, 2004; Diamond & Rush, 2012; Cha & Ham, 2012; Harris, 2010).

Teachers cooperate in teacher support teams, according to research by Markle, Splett, Maras, and Weston (2014), as well as Lingo, Barton-Arwood, and Jolivette (2011). Teacher aid teams are made up of teachers and other support workers who are either elected or volunteer, and whose responsibilities are to highlight issues, discuss them, and create solutions using their varied talents and expertise, which they bring to the table (Markle et al., 2014; Lingo et al., 2011). Thus, according Markle et al. (2014) and Lingo et al. (2011), the fact that these teams are working together indicates that positive interdependence exists among team members and that their interactions are cooperative rather than competitive. The effectiveness of teacher support teams is dependent on school administrators' ability to ensure that instructors are not overcommitted and are willing to serve as members of a group (Harris, 2010). Considering administration's support is critical, Harris (2010) suggested that administrators either engage as team members or pick a team member to represent the administration.

When team members work together in classrooms, they often choose from several approaches, such as pull-out services; pull-in services and collaborative teaching, depending on the needs of their students (Markle et al., 2014; Lingo et al., 2011). Teams may choose to use the pull-in approach, where they will schedule planned support and services to be provided in the classroom or during class activity (Markle et al., 2014; Lingo et al., 2011). For some students, teams may use a pull-out service with collaboration planning where students will be removed from the general education classroom for instruction only when teams agree on the purpose, the time frame, and the need (Markle et al., 2014; Lingo et al., 2011). This approach requires planning up front and on-going communication about student progress with team members who are not directly involved with the pull-out services (Markle et al., 2014; Lingo et al., 2011).

**3.10.1. Corporative Learning**

Fig 3.6 dipicted the collaborative learning components which are supportive elements of designing a collaborative model for teaching mathematics.

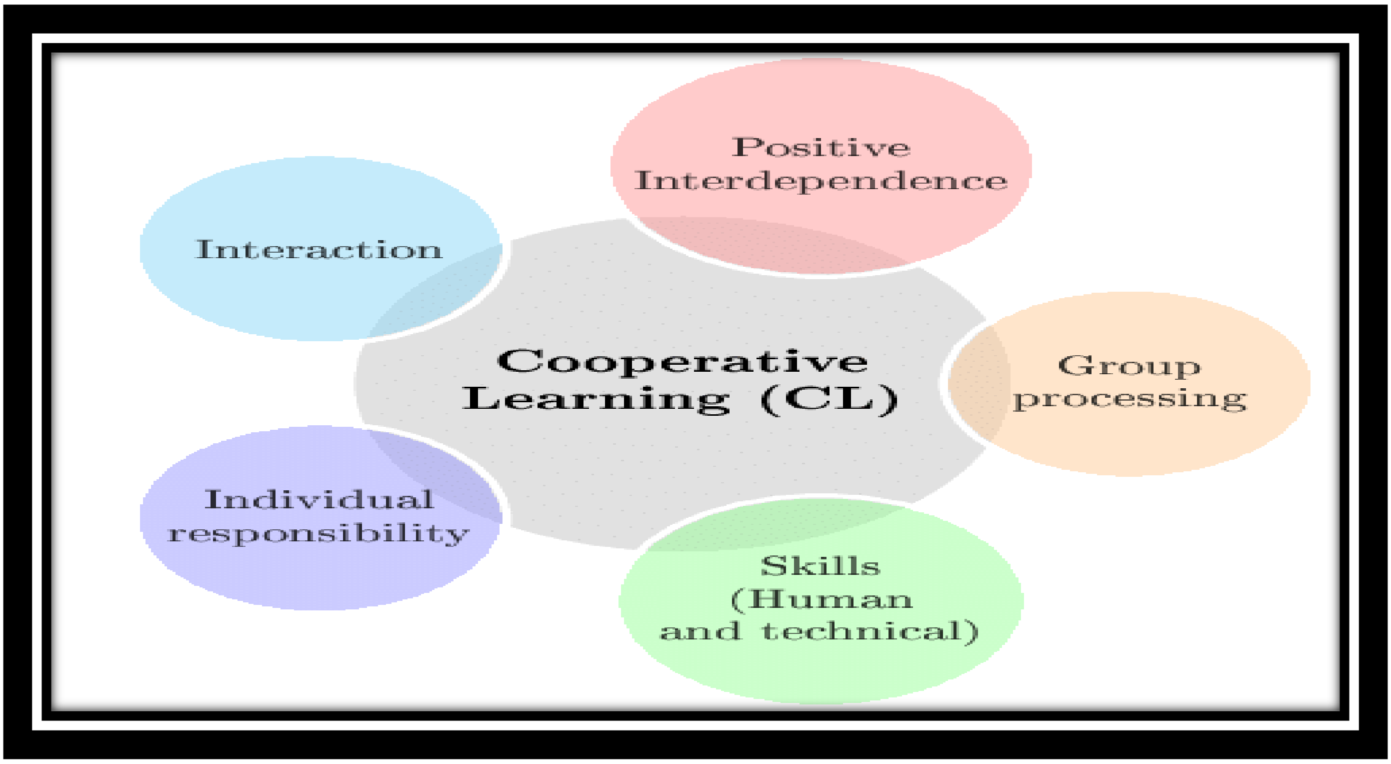


**Fig 3.6: Collaborative Learning components (Researcher Created)**

Corporative learning is the most structured end of collaborative learning continuum. Johnson *etal.*, (1990) define it as, the instructional use of small groups so that students work together to maximise their own and each other's learning. Cooperative learning was pioneered by David and Roger Johnson at the University of Minnesota, Robert Slavin at Johns Hopkins University and Elizabeth Cohen at Stanford University and anchored on the social interdependence theories of Kurt Lewin and Morton Deutche (Deutche, 1949, Lewin, 1935). Key to the theories propounded is the exploration of the influence of the structure of social interdependence on individual interaction within a given situation which in turn affects the outcomes of that interaction (Johnson & Johnson, 1989).

In cooperative learning, the development of interpersonal skills is as important as learning itself. In the development of social skills in group work, learning to cooperate is key to high quality group work. Thus, many cooperate learning tasks are put to students with both academic and social skills objectives. Numerous of the cooperative learning approaches involve assigning roles within each small group to ensure the positive interdependence of group participants and to enable students to practice different teamwork skills. Equally infused with cooperative learning, work is group processing, a debriefing time where students reflect on how they are doing to learn how to become more effective in group learning settings (Johnson, Johnson & Holubec, 1990).

### 3.10.2. Problem Centered Instruction

Equally related to cooperative learning is problem centred instruction which is built around collaborative learning strategies. Problem centred instruction has roots in the work of John Dewey, a renowned philosopher who endorsed discussion-based teaching and believed strongly in the importance of giving students direct experimental encounters with real world problems. Guided design, cases and simulations are all forms of problem centred instruction which immerse students in complex problems that they must analyse and work through together. These pedagogical approaches develop problem solving abilities, understanding of complex relationships and decision making in the face of uncertainty.

### 3.10.3. Peer teaching

Teacher assistance teams may also apply a co-teaching approach, whereby specialised teachers and other support personnel teach cooperatively with classroom teachers (Tzivinikou, 2015; David, 2014; Miltenienė & Venclovaitė, 2012; Solis, Vaughn, Swanson, & Mcculley, 2012; Murawski & Lochner, 2011; Sileo, 2011; Takala, Uusitalo-Malmivaara, 2012; Taylor et al. 2015; Friend & Cook, 2010). Prior to co-teaching, professionals need to decide on the variation of co-teaching to address the support that students need to function successfully in a general education classroom (Nichols, Dowdy & Nichols, 2010). Several authors, Tzivinikou (2015), David (2014), Miltenienė & Venclovaitė (2012), Solis, et al. (2012), Murawski & Lochner (2011), Sileo (2011), Takala, Uusitalo-Malmivaara (2012), Taylor et al. (2015) and Friend and Cook (2010), defined co-teaching, also known as cooperative teaching or team teaching, as a strategy that involves direct collaboration between the general education and special education teachers or support personnel who combine their expertise and jointly deliver a lesson to meet the needs of a diverse group of students in the same classroom. The above authors argue that for a co-teaching relationship to be successful there needs to be voluntary agreement between co-teachers on instructional planning and presentation time (Tzivinikou, 2015; David, 2014; Miltenienė & Venclovaitė, 2012; Murawski & Lochner, 2011; Sileo, 2011; Taylor et al. 2015; Friend & Cook, 2010).

Equally co-teachers also need to respect and acknowledge each other's expertise, and this can be practiced through good communication and problem-solving skills (Tzivinikou, 2015; David, 2014; Miltenienė & Venclovaitė, 2012; Murawski & Lochner, 2011; Sileo, 2011; Taylor et al. 2015; Friend & Cook, 2010). They need to agree on the physical arrangement of the classroom and on procedures for handling learners' disruptive behaviours (Tzivinikou, 2015; David, 2014; Miltenienė & Venclovaitė, 2012; Murawski & Lochner, 2011; Sileo, 2011; Taylor et al. 2015; Friend & Cook, 2010). They also need to inform parents about their co-teaching arrangement (Tzivinikou, 2015; David, 2014; Miltenienė & Venclovaitė, 2012; Murawski & Lochner, 2011; Sileo, 2011; Taylor et al. 2015; Friend & Cook, 2010). The school administration needs to support co-teaching by making suitable timetables and by allocating convenient times for all professionals to have frequent meetings; (Tzivinikou, 2015; David, 2014; Miltenienė & Venclovaitė, 2012; Murawski & Lochner, 2011; Sileo, 2011; Taylor et al. 2015; Friend & Cook, 2010). Friend and Cook (2010) identified six models of co-teaching that can be used in the classroom and the following section will summarize the possible applications of these six models. Peer teaching has roots in one-room schoolhouse tradition, the process of students teaching their fellow students and is probably the oldest form of collaborative learning in education. Whitman (1988) explains some of the widely adapted peer teaching models:

### 3.10.4. Supplemental instruction

High performing students became Supplemental Instruction leaders and convened sessions at least three times a week instructing other students.Blane, De Burh and Martin (1980) propound that The Supplemental Instruction approach developed as a teaching assistant model by Deanna Martin at the University of Missouri-Kansas City as an alternative approach to capacitate students who were at risk and 30% were either withdrawing or failing in their studies.

### 3.10.5. Mathematics workshops

Mathematics workshops became a popular peer teaching approach in the late 1980s as intensive programmes developed by Uri Treisman of the University of California. Treisman wanted to address the drawbacks of traditional tutoring models, particularly those geared to minority students in academic difficulty. Finding that study groups made a difference in students' success, Treisman created a co-peer teaching approach called the Professional Development Programme. The programme was led by graduate instructors and students were put in small groups focusing on problem solving, with an explicit emphasis on peer teaching. Workshops supplemented regular teaching and discussion sessions of mathematical courses. The intensive small group workshops approach emphasized on developing strength rather than remediating weaknesses and peer collaboration rather than solo competition (Treisman, 1985)

### 3.10.6. Learning communities

Fig 3.7 presented elements of professional learning communities for the teaching and lewarning of mathematics as perceived by Jansen, Cumnock, and Conner (2010) and constituted significant pillars of the designed collaborative model.

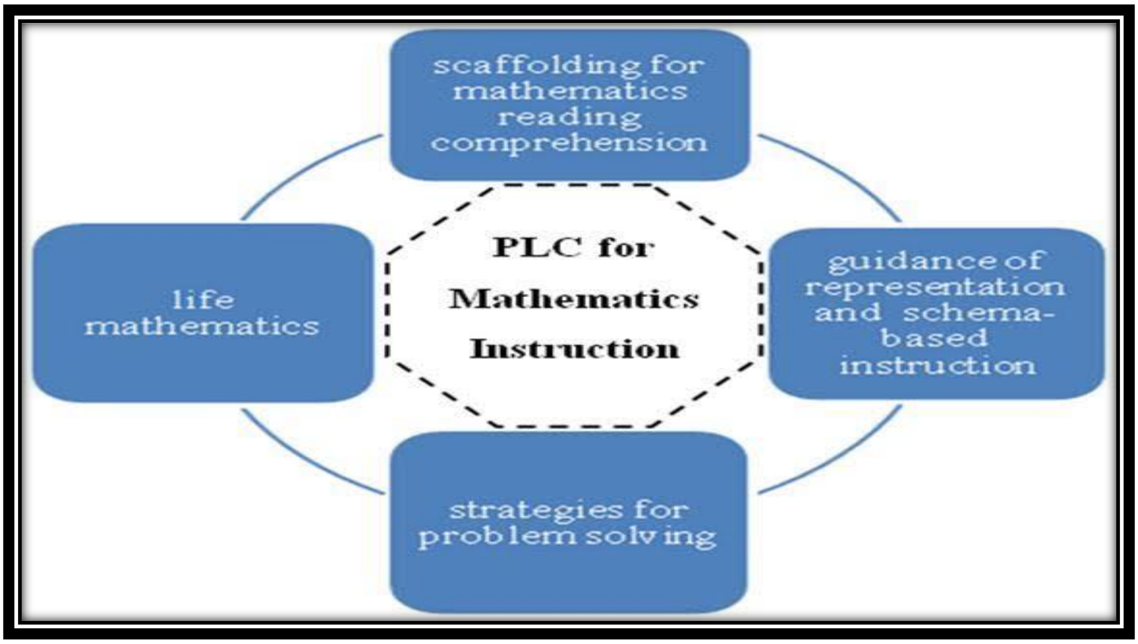


**Fig 3.7 Professional Learning Communities model (Source: Jansen, Cumnock, and Conner (2010)**

Jansen, Cumnock, and Conner (2010) define the concept Professional Learning Communities (PLCs) as the organisations of motivated people sharing learning, vision and new methods and approaches that will enhance the opportunities for learners' learning. Louis (2002) asserts that professional learning communities describe collective people sharing and critically questioning their practice on a continuous basis. This study therefore uses the term "teacher learning community" to describe the group of mathematics teachers who met on a regular basis, as organised by the Department of Education. Teacher learning communities "embody the concept of teacher learning in a setting in which teachers come together over time for the purpose of reconsidering their existing beliefs and practice, gaining new professional knowledge and skills and reconstructing reform agendas that enhance student learning and professional practice" (Chow 2015, 288).

Teachers strongly argue that professional learning communities provide a significant and different type of professional development because they are established within the school districts educational policies and the actual contexts of schools, and the teachers located in schools. From this perspective, McLaughlin and Telbert (2006) contend that professional learning communities can interpret knowledge from the district into an understanding of a particular school's daily practice. In the same vein, Jessle (2007) concurs that developing a professional learning community is one of the key influential strategies to improve learner performance. DuFour, Earker and Many (2006) argue that PLCs should be described as a process rather than as a weekly meeting. On the other hand, Hord (2004) contends that PLCs are platforms where teachers and managers meet to constantly look for and share personal practices and learning, then respond to their learning with the aim of enhancing their efficacy as professionals to benefit their students.

Similarly, DuFour (2007) asserts that schools use professional learning communities to increase the capability to change and improve learner achievement as well as classroom practice. He claims that an increasing number of schools have put into operation professional learning communities as a strategy for ensuring sustainable change that improves quality teaching and learning. McLaughlin and Talbert (2006:4) describe professional learning communities as "organisational structures in which teachers work collaboratively to reflect on their practice, examine evidence about the relationship between practice and student outcomes, and make changes that improve teaching and learning for the particular students in their classes". The 1 + 9 mathematics intervention programme that my study focuses on is a professional development programme that involves senior phase mathematics teachers participating in a professional learning community where teachers join forces and engage with mathematics concepts and challenges experienced with different mathematics topics and work collectively to make sense of the misconceptions that learners have.

Teacher collaboration within a school can be measured by ongoing mutual support, sharing, interaction and professional development among teachers. This often leads to professional learning communities (PLC"s) within a school. Elster (2010) defines a professional learning community as "a group of individuals who share the same set of concerns, problems and interest in a particular topic" (p.2187). This approach on teacher learning differs from other learning models, in that it focuses on teachers working in a community. Lavie (2006) argues that when schools have on-site professional learning communities, teacher collaboration flourishes. This suggests a view that schools should be promoted as learning communities with the purpose of sustaining teacher learning and continuous professional development. It has become evident from various scholars (Friend & Cook, 2013; Kougioumtzis & Patriksson, 2009; Lavie, 2006; Stanley, 2011) that schools need professional learning communities where teachers work together, focusing both on their development and student learning.The study envisages that through collaborative teaching activities, schools can be transformed into professional learning communities.Fig 3.8 illustrated a model of of teacher collaboration and its key components and which contruyction of the study model borrowed some of the components.

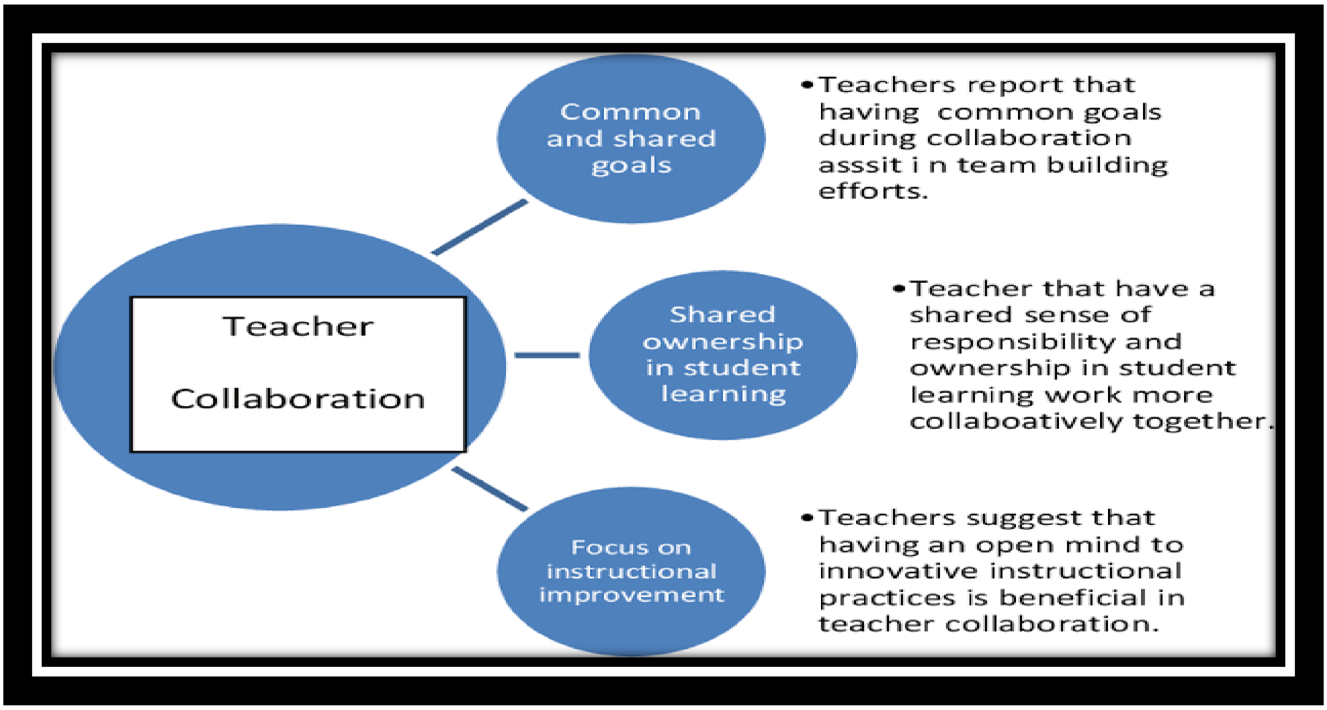


**Fig 3.8: Model of Teacher Collaboration (Researcher creation)**

Stanley (2011:72) identified hunger for collaborative opportunities within schools, where teachers can exchange ideas and best practices for their classrooms. School-based professional learning communities offer an infrastructure for such opportunities. Furthermore, Servage (2010) argues that learning communities allow teachers to reflect on their practices and enhance their collaborative ways of learning. However, these PLC"s must have the following features as outlined by Stoll et al. (2006): (a) Teacher driven: when teachers take initiative for their own learning within a school context (b) A collective responsibility: this entails that each member within a community is responsible for the actions of each member. (c) Reflective personal inquiry: teachers often examine and reflect on their classroom practice through the help of their peers. (d) Collaboration: this involves teachers working together for a shared purpose. (e) Group and individual learning: teachers work and engage in the creation of knowledge together, instead of learning as individuals.

In these professional learning communities, teachers work together, sharing their collective professional wisdom of good practices. Ideas are shared in interaction with each other, expanding each other's knowledge, which is part of their learning experience. Professional learning communities provide a context of collegiality which supports teachers in improving their classroom practices. These collegial relationships require openness, trust, and respect among colleagues (Kelchtermans, 2006). With this, sharing of teaching methods and strategies becomes a trusted and valued practice within a school. In addition, Darling-Hammond, and Richardson (2009), state that professional learning communities deepen teachers‟ knowledge, build their skills and improve instruction. Lavie (2006) further expands on this argument by claiming that the most powerful form of teacher learning, and development occurs in ongoing teams that meet regularly. Through collaboration teachers learn from each other within their learning areas (subjects), departments and respective schools.

The researcher believes that since the practice of collaborative Gabelnick *et al.,* (1990) define learning communities as, "purposeful restructuring of the curriculum to link together courses so that students find greater coherence in what they are learning and increased interaction with faculty and fellow students". Thus, learning communities are a delivery system and facilitating structure for the practice of collaborative learning. Learning community has two intentions which are to provide intellectual coherence for students by linking the class together and building relationships between subject matter or teaching a skill in the context of a discipline. Secondly, they also aim to build both academic and social community for students by enrolling them together in a large block of course work.

Learning communities frequently provide more time and space for collaborative learning and other more complicated educational approaches. Small group workshops and book seminars are examples of learning communities. Peer writing groups and team projects are also examples of cooperative learning. Macgregor (1991) evaluates that these learning communities' programmes provide unique social and intellectual glue for students that results in high rates of students' retention, increased students' achievement, and more complex intellectual development.

DuFour, DuFour and Eaker (2008: 15- 17) outline the following six features of effective PLCs: "shared mission, vision, values, and goals focusing on learning, a collaborative culture with a focus on learning, collective inquiry into best practice and current reality, action orientation: learning by doing, a commitment to continuous improvement, and results oriented". This also resonates with DuFour and Marzano (2011) who explains that through PLCs, teachers form collaborative teams in which the members function co-dependently to accomplish common objectives for which they are equally accountable.

Similarly, Senge (1990) indicates that there is no learning organisation without a shared vision. This view is echoed by DuFour and Eaker (1998) and Senge (1990) who adds that when collaborative team members share a common vision, beliefs, and values, these attributes carry more weight than a mission statement that team members seek to accomplish. They further contend that offering the PLC a vision statement emphatically does not offer the drive to keep the PLC moving forward in accomplishing its objectives. Pankanke and Moller (2007) add that a vision that takes into consideration student learning, has been regarded as the trait of a real professional learning community.

Similar studies conducted by Newmann (1991, 1994, 1996) and Kruse and Louis (1995) correspond with this study. These scholars classify learning communities as an important component of schools aiming to improve the classroom practices and students' academic performance. This resonates with Newmann (1996) who highlights the conditions that encouraged the development of learning communities which include among others the following: the shared governance that enhances teachers authority above school policy and practice; co-dependent work structure, teacher groups that support working together; staff development that increases practical skills in line with the mission of the school; deregulation that offers independence for the school to put into practice a vision of high educational principles; and parent participation in a wide range of school relationships. This corresponds with Kruse and Louis (1995) who point to reflective dialogue, deprivatization of practice, a collective focus on student learning, collaboration, and values and norms that are distributed as the features required for an effective professional learning community. Therefore, collaboration is the central feature of teacher professional learning within the professional learning communities that requires teachers to make goals, approaches, materials, questions, challenges and outcomes known (DuFour, 2007).

### 3.11. Developing a Collaborative model of teaching and learning Mathematics in secondary schools

Proponents of school reform and School Effectiveness like Hargreaves (1999), assert that effective school reform method ought to assemble all stakeholders to figure together collectively guided by common purpose. Teacher professional learning is of increasing interest as one way to support the increasingly complex skills students need to learn in preparation for further education and work in the 21st century. Sophisticated forms of teaching are needed to develop student competencies such as deep mastery of challenging content, critical thinking, complex problem-solving, effective communication and collaboration, and self-direction. In turn, effective professional development (PD) is needed to help teachers learn and refine the pedagogies required to teach these skills.

South African studies on teachers' mathematical knowledge such as that of Pournara et al. (2015) have established that many teachers in South Africa lack subject content knowledge. The research literature and DBE and DHET suggest that collaboration of teachers is a solution to the problem of the shortage of professional development opportunities. This study therefore contributes to this on-going discussion about teacher collaboration by examining the nature of collaborative activities and the types of knowledge that is learnt in a TLC located in a rural part of South Africa. This suggests that finding the solution to perennial drawback of Mathematics underperformance at Sisonke district demands a cooperative approach which will assemble district officers, educators, and learners in finding the matter through sharing ideas and methods in finding arithmetic failures in schools. Jackson and Davis (2000) reiterate that in an exceedingly cooperative culture, members of the varsity community work along effectively and are guided by a standard purpose. Teachers, directors, students, and their families share a standard vision of what the varsity ought to be like. This implies that finding the solution to arithmetic failure is not the responsibility of the teacher alone, nor the principal, however all involved stakeholders whose sole goal is going to be to produce improved arithmetic results in all secondary schools.

Hanford *et al.,* (1997) outline collaboration as exchanging data, fixing activities, sharing resources, and enhancing the capability of another for mutual profit and to realise a standard purpose. The disposition to reinforce the capability of another organisation needs risks, responsibilities, and rewards, all of which might increase the potential of collaboration on a greater scale through involvement in different structured activities. This implies that in an exceedingly cooperative model, establishments, people, and stakeholders work along with one purpose to make sure that performance in arithmetic is improved through sharing resources, expertise, experiences, and time. Collaboration creates a replacement culture inside a company whose mission is to meet set common goals. In an exceedingly cooperative structure, authority is not centralised, however, devolves since their area unit call points to be taken at each cooperative task. Resources also are pooled collectively, secured and products are shared among stakeholders.

Many other types of partnerships will be possible, including experience-based collaborations, culturally based collaborations, geographically based collaborations, community-based collaborative efforts, and innovation-based collaborative efforts. Rudd etal (2004) provide the following explanation for the greater than cooperation rate: The term "competence-based cooperation" refers to a situation in which schools are brought together because of their varying degrees of experience, the goal being for the school with expertise to transfer this knowledge to the other school. In contrast, community-based partnerships are formed when schools are brought together because they share traits or situations, and the emphasis is placed on pooling resources to solve shared issues or difficulties.

Lastly innovation-based collaborations occur where schools are brought together for the purposes of more than sharing expertise but also to focus on innovation and developing new strategies or practices. Thus, the above types of collaborations focus on addressing curricular issues such as improving content of educators, various pedagogical strategies, and practices to achievement of set goals and targets. In the context of the study, the three collaborations will be mixed into one to enable diverse needs of schools offering Mathematics to be addressed.

Rudd *et al.,* (2004) and Wood *et al.,* (2006) summarize that collaboration is undertaken due to the following reasons:

- To share professional expertise and good practice-peer learning and mentoring
- To raise achievement in school subjects
- To enhance school improvement and raise standards of attainment.
- Breaking down barriers amongst schools
- Enriching learning opportunities.

The above aims imply that collaboration focuses on corporation among educators to share their skilled expertise in subjects they teach and the way they need resolved explicit issues in the teaching and learning of arithmetic. Raising the standards of passing arithmetic and providing students with new improved learning opportunities is additionally the crust of collaborations among schools.

Studies on effective collaborations done by Rutherford and Jackson (2006) in Northern Ireland discovered that to induce the best results, cooperative activities got to be managed within the space of funding, coming up with and implementation of programmes. Funding for cooperative ventures that were of a national initiative was provided by the state whereas in decentralized set ups individual schools contributed a pool of resources to implement their cooperative activities. Morris (2007) highlights that schools created their contributions because of the need that they will solely benefit from the initiative and is worthy of the sacrifices. Therefore, the analysis study which is the background of this research evaluated the impact of cluster-initiated matriculation interventions inside the Sisonke district, their funding systems in addition to coming up with and implementation structures. The role of ward managers, principals, Head of Departments, and arithmetic educators within the numerous stages of interventions will be evaluated within the context of whether everyone plays their roles effectively in making certain arithmetic improvement within the district. Collaborations of academic nature leads to advantages to the colleges' academic systems like;

- Raising the standards of achievements in subjects pass rates. Arnold (2006) and Sharpe *et al*., (2002) concur that collaboration among faculties has the subsequent benefits:
- Economic advantages such as sharing resources, accessing new funding streams and economies of scale.
- School improvement and raising standards, including improvement in pupil attainments due to an enhanced curriculum and development of teacher expertise.
- Forging of closer relationships between participating schools and from this outcome, a greater awareness and understanding of other schools. Bringing schools together can break down the barriers so that they can work together in mutually beneficial ways.
- Educators benefit from opportunities to exchange ideas and good practice and expended ideas and good practice. Staff no longer suffer from a sense of professional isolation, instead they had outlets to share and voice any concerns with a larger number of their colleagues.
- Pupils enjoy an enhanced educational experience and improved attainment. Socially they benefit from interacting with pupils from other schools.

In conclusion to the significance of collaborative model; collaborations among schools have multiple advantages to educators and learners collaborating within the activities. The study shall appraise if cluster cooperative programmes in Mathematics inside the Centocow cluster, like Winter and Spring camps in attainment of improved pass rates and teacher development. A recommendation on how they should be organized and implemented will be made as well.

### 3.11.1. Components and Participants in a Collaborative Model of Teaching and Learning Mathematics in Secondary Schools

A cooperative model like alternative models is created from elements that embody establishments, individual teachers, contexts, materials and non-material resources that once placed along ends, up in a posh framework that depicts various characters of stakeholders, experiences and their quest to create improvement in arithmetic performance in the Centocow cluster faculties.The goal of mobilizing stakeholders to rally behind one vision and collectively apply efforts is to create faculty improvement and effectiveness within the performance of arithmetic in secondary faculties. Slater (2005) posits that participants in an exceedingly cooperative model are bonded by a common standard goal, vision and desires and participate either voluntarily or by mandate that's institutionally or cluster prescribed.

This suggests that a cooperative model despite being user systems initiated could also be institutionally obligatory on educators, thanks to pressing demands of constructing faculties responsible to government and alternative stakeholders for the results they manufacture. In an exceedingly cooperative model, people and teams of individuals who are stakeholders in arithmetic education have specific, clearly outlined roles they play, complementary to every alternative target-hunting by an equivalent common goal of up arithmetic performance.

A collaborative model is a stakeholders' model, therein its participants are people, establishments and teams that have interest and expertise to do with Mathematics teaching and learning. Slater (2005) identifies principals, educators, and learners as key participants within the model. Cobb and Jackson (2011) assert that college based skilled learning communities, district arithmetic specialists, arithmetic lecturers and subject advisors, teacher networks and learners represent key participants in an exceedingly suburbanized intervention model geared toward reducing poor performance in arithmetic in secondary schools.

The participants in an exceedingly cooperative model are brought together by common goals that are instrumental within the formulation of cooperative relationships. Little (1990) reiterates that collaboration comes out of relationships that should be engineered as building blocks of collaboration. This suggests that cooperative participants ought to recognize one another and develop the trust and respect that characterizes cooperative relationships. Knowing one another in an exceedingly cooperative relationship suggests that searching for folks, what they possess, what they hold true and pricey and their values, skills, weaknesses, and strengths. From the above citation, it is evident that sturdy relationships among arithmetic educators and above is preponderant in making a culture of trust and openness contributing to professional discourse on up arithmetic performance at the Sisonke district secondary schools.

**3.11.2. Content of a Collaborative model of teaching and learning Mathematics.**

Arends, Winnaar and Mosimege (2017), in their reflection on the Trends in International Mathematics and Science Study (TIMSS) state that many South African mathematics teachers do not fully embrace collaboration with fellow mathematics teacher as a form of support, as generally they are reluctant to do team teaching and lesson observation. Key challenges in implementing a Mathematics curriculum in secondary schools are categorized into pedagogical, professional development, building, and sustaining professional relationships and governance.

Hargreaves (1994) explains that pedagogical aspects of collaboration include team teaching, curriculum planning, conferencing with each other about practice, assessment of students and sharing resources. This implies that the above curriculum processes are key activities that participants engage into in their quest to improve the teaching and learning as well as assessment of a Mathematics curriculum in the Sisonke secondary schools.

Equally related to the above pedagogical category are specific tasks whose purposes are to attain achievement of professional development purposes like peer observation, mentoring, modeling and discussion among educators and other teacher networks with interest in Mathematics. Governance of schools is also a key to effective sustainable and successful teaching and learning of Mathematics in schools. Slater (2005) describes activities related to governance to include school improvement, planning, school organisation, staffing issues and school council. This means that School Management Teams in schools in collaboration with school Governing Bodies and Learner Representative Councils have a critical role of placing suitable and relevantly qualified teachers to teach Mathematics and to set up structures that support and work to improve the teaching and learning of Mathematics in the Sisonke secondary schools.

Additional studies by Oshea and Oshea (1997) found that participants need to possess specific collaborative skills which include communication skills, emotional competencies, decision making and problem solving, conflict management and team building. This means that in order for collaboration to succeed, participants need to be guided by collaborative principles of focusing on shared vision of improving Mathematics achievement guided by the skills that characterize collaborative activities. The study shall seek to create and inculcate the collaborative skills among participants and evaluate the extent to which the participants are responding to the dictates of the model and how it attempts to improve Mathematics' outcomes at the Sisonke district.

**3.11.3. Case Studies of Collaboration**

- ***Case Study 1***

Improving the performance of Mathematics instruction across school rooms, colleges and broader instructional jurisdictions may be a pressing issue for researchers and practitioners. Collaboration among academics, principals, education management officers and skilled bodies is also the cure-all to raising the teaching and learning of Mathematics in South African schools.

Bryk *etal.*, (2010) in studies applied within the United States of America noted that the key to unlocking failure in mathematics involves supporting colleges and broader instructional jurisdictions' development of capability to scaffold academics and others' current learning and development. Colburn (2003) additionally asserts that because of classrooms as part of the broader establishment and community, teachers are ready to sustain modification once there are mechanisms in place at multiple levels of the system to support their efforts. This means those teachers' efforts to boost Mathematics results rests with the support that district officers, subject advisors and teacher organisations provide them by approach of workshops, courses, and moderation feedbacks.

Tutorial enhancements in school rooms need those settings within which academics work be organized to support their teaching and learning to be congruent with the knowledge explosion and growing demands to be in line with fashionable trends in instructional delivery. This means that outside agents together with the user system participants like academics, principals and educators ought to re-organize their practices and support one another to achieve improved arithmetic results.

- ***Case Study 2***

  Other studies within the renewed basic education curriculum (FNBE, 2014), suggested that collaboration is emphasized in various contexts, for instance, between teachers, students, homes, and out of-school actors. Team teaching is regarded as an important approach in meeting the collaborative goals of education. In general, team teaching can be defined as a pedagogical method in which two or more teachers teach a single group of students together, and it can be implemented in various ways (Davis, 1995). Team teaching can be divided into four distinct areas: planning, content integration, teaching, and evaluation (Davis, 1995, Baeten & Simmons, 2014, 93). Collaborative teaching has been found to help teachers learn from one another (Shibley, 2006), and such teaching encourages and motivates teachers´ professional development (Sandholtz, 2000; Birrell & Bullough, 2005). From students´ point of view, team teaching increases the number of opportunities for student-teacher interaction (Wadkins et al., 2006). Also, research indicates that team teaching has a positive impact on student learning outcomes (Little & Hoel, 2011). Teachers and schools that engage in high-quality collaboration have better achievement gains in math and reading (Ronfeldt et al., 2015. The above implies that improvement of Mathematics results should not be left to probability however ought to be deliberate efforts initiated professionally by stakeholders with intentions of capacitating teachers' grasp of content within the subject, teaching and learning ways that are culturally tuned in to the learners geared toward leading to improved and proper arithmetic teaching and learning. The study shall, evaluate the roles played by subject consultative services in capacitating arithmetic educators to boost their teaching pedagogy and content delivery in school rooms.

  Studies by Cobb and Jackson (2011) noted that assessment and responsibility policies in colleges do not seem to be clearly understood as most academics teach to check. Elmore (2006) additionally asserts that some districts face challenges of high numbers of novice academics. Therefore, districts' efforts through subjects' advisors and specialists to support educators to boost their assessment methods and raising the standard of classroom tutorial expertise. The study additionally assessed the effectiveness of subject consultative and district education support services rendered to educators who teach Mathematics in aspects of assessment and improving classroom practice.

Further studies by Darling-Hammond, Wei, and Orphanos (2009) and Franke (2004) highlight that teacher skilled development is additional seemingly to influence room apply once its sustained overtime involving identical cluster of teachers operating along, targeted on problems central to instruction and arranged round the tutorial materials that academics use in their school rooms. This implies that collaboration among arithmetic academics is crucial because it enhances their skills in teaching arithmetic in ever-changing room things and deepening their subject information. Therefore, the analysis can assess if subjects' teachers' workshops and weekend courses undertaken by arithmetic educators completely impact on the teaching and learning of the topic in the Centocow cluster.

- ***Case Study 3***

The nature of workshops that academics attend shall even be a theme of investigation because it might impact on the standard of teacher development and subsequent results of learners within the subject. Cobb and Jackson (2011) assert that a coherent skilled development programme that has the potential to yield positive results ought to integrate development offered to districts for all arithmetic academics and faculty based mostly skilled development initiatives. This means that for collaboration to be effective, academics development of education skills and subject information in Mathematics ought to be done not solely from the highest however, conjointly from user systems in addition in effective ways in which are subsidiary and biological process in enhancing teaching ways and understanding of content.

Corburn and Russell (2008) use the term routines of interaction to elucidate the approach of developing academics through the utilization of queries and tasks that academics neutralize teams and singly distinguishing ways and explaining content to every alternative which may pause challenges in their daily teaching and learning of Mathematics in school rooms and colleges normally. Therefore, the study shall get to judge the character of skilled development of arithmetic educators initiated by the district and subject advisors. The content and techniques utilized in the workshops and the courses shall even be investigated to determine the effectiveness of such efforts on rising outcomes in arithmetic.

- ***Case Study 4***

Additional research studies done in Scotland, Priestley et al. (2011) and Butler, Schnellert and MacNeil (2015) in Canada have focused on TLCs that are outside of the school. These two international studies reported that teachers engaged in TLC activities among other things as a way of sharing ideas and thinking about their own professional development in relation to the education policy. The findings of these two studies appear to suggest that teacher collaboration was characterised by "compulsion" (Hargreaves 1994, 195–196) to meet the policy target, a mandated agenda of the education system. Although the positive results of collaboration are reported in the above-mentioned studies, Chen, Elchert and Asikin-Garmager (2018) highlight that teacher do not always like the opportunity to work together to share teaching practices particularly when collaboration practice is a result of a top-down mandate and tied to staff appraisal.  Horn and Little (2010) expound that school based professional learning communities in which Mathematics teachers at school level meet on a regular basis to work on problems of practice are a central aspect of school-based teacher professional development. This means that teachers at school level face problems peculiar to their learning and teaching environments and thus regular consultative and planning meetings and collaborations may result in improving daily practice and implementation of pedagogical skills and content from district professional programmes.

Further programmes that Professional Learning Communities could do may include calculating Mathematics problems, comparing solutions and strategies, and analyzing students work, these activities are designed to create context-based solutions to the problems faced by teachers and students in the teaching and learning of Mathematics in different classroom environments. The study shall endeavour to find out if schools have staff development programmes or Professional Learning communities and regularly meet to assess and improve their work capacity in Mathematics and how that has an impact in improving the teaching and learning of Mathematics at the Sisonke District.

Establishment of teacher networks may well be a cure-all to developing effective teaching of arithmetic in colleges and schools across Republic of South Africa. Bryke *et al.,* (2010) postulate that networks of skilled relations between arithmetic academics leads to tutorial improvement and creates a coherent tutorial system that develops and supports academics to boost their arithmetic content and adapt their education skills. Additional findings by Frank, Zhao, and Borman (2004) and Spillace and Thompson (1997) assert that effective teacher networks end in trust, mutual responsibility for student learning and access to others' experience area minimum of as necessary as teachers' perceptions of the worth of the development initiative in driving learner achievements in room practices. This implies that academics' social networks are a key to unlocking support for school-wide tutorial improvement and facilitate teachers to deepen their information of arithmetic content and teaching methods.

Coburn and Russell (2008) warn that the extent that a tutor network willing truth supports the collaborating teachers' learning depends crucially on the character of their interactions with each other. This means that there should be a distinction between low in-depth interactions that specialize in surface structures and procedures as hostile high in-depth interactions specializing in underlying education principles of the approach, the character of the arithmetic content and the way students learn. Ultimately effective teacher networks are distinguished by their activities that support tutorial improvement instead of speaking shows. Thus, this study shall investigate the role contended by arithmetic academics in cluster Associations in improving the teaching and learning of mathematics at Sisonke, the character of their programmes and the way they impact on improvement of Mathematics results at matriculation level.

Extra activities might embrace discussing completely different solutions and techniques to arithmetic issues like analyzing student work with the objectives of serving to learners to perceive and luxuriate in learning arithmetic in school rooms and out of doors colleges in their daily lives.

- ***Case Study 5***

  Collaboration with learners who are the most consumers of the schools' course of study product is preponderant because it tackles the challenges, they face in learning arithmetic. Confrey (2011) and Naomi and Allensworth (2009) in their studies on the extent of the intervention programmes for below achieving learners noted that the analysis base on instruction in extra arithmetic categories for troubled learners was very restricted. Existing South African literature on teacher collaboration such as Brodie and Borko (2016) and Bantwini (2018) seem to focus on teacher collaboration through teachers learning in TLCs and professional learning communities (PLCs) that are operating within schools. The findings of one of these studies suggest that "success in establishing sustained teacher collaboration requires that the teachers have a broad range of support personnel, internally and externally, whom they can consult on various issues pertaining to their teaching practices" (Bantwini 2018, 15). Furthermore, collaboration of teachers within schools is also promoted in South African education policy, namely the Integrated Strategic Planning

Framework for Teacher Education and Development (DBE and Department of Higher Education (DHET) 2011). According to this policy, the DBE and DHET envisage that support and resources for teachers, and access to professional development opportunities, "will be enhanced at local level by the establishment of PLCs" (DBE and DHET 2011, 10). Studies done of cluster groups (teacher's groups initiated by DBE for administrative purposes) and teacher learning communities (Graven 2002; Jita and Ndlalane 2009; Jita and Mokhele 2014; De Clercq and Phiri 2013) indicate on the benefits of teacher collaboration. For example, a study on teacher learning communities in a South African context have established that through collaborative learning teachers developed confidence that was essential to their professional development (Graven 2002). This implies that colleges ought to establish low achieving learners and deliberately subject them to further tuition and remedial lessons to capacitate them to grasp troublesome areas of the arithmetic programme.

The study shall investigate the presence and impact of remedial and special desires programmes in colleges, coordinated by the district and subjects' consultative services and monitored by Heads of Department in colleges. The character of the programme and the qualifications of academics will be investigated and evaluated within the context of contribution to rising Mathematical outcomes.

Mathematics coaching and advisory services are an important component of Mathematics improvement initiatives. Studies by Frankel *et al.,* (2007) and Kazem and Hubbard (2008) in the United States of America found out that Mathematics coaching is a means of supporting teachers' learning and districts have created a cadre of full-time coaches who work with individual teachers in classrooms and also with groups of teachers in clusters where they work. The programmes in coaching involve helping teachers to solve their mathematical problems that deal with classroom practice and strengthen the role and foster the effectiveness of Professional Learning Communities which are user-system based and monitored.

Bradley (2007) and Olson and Barrett (2004) highlight that potentially productive coaching activities might include co-teaching and enacting the coaching cycle, then jointly planning lessons (clinical approach to supervision), observing the enactment of a lesson, and then jointly analyzing the lesson. This implies that coaching and advisory services are professional engagements among teachers with the oversight of an expert who is a subject advisor and experienced Mathematics educator. The interactions are active and deliberately planned to improve classroom instruction and capacitate individual teachers in improving Mathematics teaching and learning.

Studies by Borko etal., (2009) and Elliot *et al,* (2009) found that development of relatively accomplished instructional practices was a necessary but not sufficient condition for developing effective coaching practices. This implies that Mathematics coaches and advisors need to be experts in the subject for them to impart knowledge and skills effectively for individual educators in their classrooms. Accomplished coaches are those that are well versed with the pedagogical aspects of the subject and its content and have skills to impart to teachers and learners. The study shall thus evaluate the role of subject advisory and coaching services offered by district-based subjects' advisors of Mathematics. Assessment of the levels of expertise they possess in the subject and how they deliver it to an individual and a group of teachers will also be investigated and analyzed.

- ***Case Study 6***

  Principals and Heads of Departments are the foot commanders in the implementation of curriculum enterprise. Consequently, they play very crucial roles in ensuring that teaching and learning is supervised, and teachers are adequately resourced and capacitated to teach in classrooms effectively. Studies done in South Africa by Zulu and Betrams (2019) on teacher collaboration praxis found that the mathematics teachers share the resources and work together on how to best use resources with their learners. Examples of these resources are books, handouts, five laptops and overhead projectors that they were sharing. This sharing among mathematics teachers seems to be in line with the research literature on teacher learning, which suggests that "developing new ways of working is achieved through collaborative acts of meaning making and ways of envisaging term TLC refers to the group of mathematics teachers this as a mediational tool" (Pirtle 2014, 1). Studies done in America by Finkand and Resmick (2001), Murphy, Elliot, Goldring and Porter (2007), and Robinson, Lloyd, and Rowe (2008) postulate that school leadership has reformed due to demands for accountability moving away from focusing on administration and management to act as instructional leaders in Mathematics and other disciplines. This implies that principals and Heads of Departments should play pivotal roles in initiating effective teaching and learning in Mathematics through understanding Mathematics, students' mathematical learning and teacher learning. (Nelson and Sassi, 2005) cite that effective principal are those who are professionally updated as instructional leaders in subjects taught in their schools, in this case

Mathematics so that they can monitor and assess and distinguish between weak and effective Mathematics teaching and learning.

Studies by Elmore (2006) and Halverson and Diamond (2004) established that leadership practices that are effective involve principals who provide adequate support to teachers, they observe teachers as they deliver Mathematics lessons and provide feedback on areas of improvement and participate in Mathematics Professional Learning Communities. This means through observing instruction and providing teachers with informed feedback, school leaders can both communicate expectations and hold teachers accountable for improving classroom instruction.

Additional studies by Gibbons and Cobb (2010) in the United States of America argued that the development of shared responsibility for instructional improvement appears to be facilitated if school leaders and coaches or subject advisors meet regularly to share their observations about the quality of teachers' instructional practices, discuss how work with teachers is progressing, jointly select teachers with whom subject advisors should work, and plan for future work with groups of teachers. This means that school principals should have deliberate Mathematics improvement strategies that coordinate teachers with subject advisors. The study shall investigate the quality of instructional supervision and leadership and will also be evaluated to ascertain if it is effective and may result in improved Mathematics teaching and learning.

The tradition of schools existing as independent public entities with autonomy and focusing without interference on internal problems with implementation of school curricular can no longer be sustained as it has paved way to current reform processes that advocate twinning among schools at cluster, provincial and sometimes at international levels. Twinning among schools is a collaborative approach whose main aim is to harness collective expertise and skills in solving the curriculum which schools face. In the context of this study, high schools in the cluster, circuit, district, and province are expected to work together to tackle problems they face in the teaching and learning of Mathematics at high school level. Twinning encourages sharing of experiences in schools within the same geographical context and facing similar challenges in implementing a Mathematics curriculum.

Studies by Serrat (2009) postulate that twinning colleges encourages a passion for learning and information sharing among workers' members, developing learning competencies, making opportunities for casual sharing, and activating a subsidiary learning culture among colleges. This means that twinned colleges become learning organisations that specialize in improved learning opportunities that ultimately end in improved outcomes. Communities that apply emerge inside twin colleges and resources, material or human resources are shared among colleges in resolution the common challenges colleges face in implementing a Mathematics curriculum.

Serrat (2009) additionally asserts that twinning colleges conjointly provide a good variety of opportunities for individual and collective learning and development. Learning and development programmes are a unit created on the market to confirm that people and groups develop competencies of reflective apply and cooperative learning. This means that through twinning colleges will unearth common areas of corporation and conjointly assist one another in resolution challenges in improving the mathematics results in high schools. Twinning ultimately leads to reforming colleges into communities of practice through building a network of professional practice among Mathematics teachers. Teachers within clusters share content knowledge, methodologies and resources which could be used in teaching Mathematics within twinned schools.

Other studies done in Massachusetts by Jackson and Davis (2000) noted that colleges operating collaboratively were target-hunting by a standard purpose and share a standard vision of what they must seem like in their action cultures. Such schools set up along and set common goals guaranteed by an analogous vision. Twinning conjointly leads to shared leadership and higher cognitive process and offers rise to operating groups who enable educators to collaborate on challenges they face as hostile operating in isolated school rooms while not interactions with their colleagues. Thus, academics in twinned and booming colleges move to debate concepts, share practices, and conjointly set up lessons that they deliver in school rooms. The study can get to search out if schools at Sisonke are twinned within the cluster, ward, or circuit and in what programmes in arithmetic are academics concerned in and the impact of these programmes in improving Mathematics outcomes at the Centocow cluster.

The role of schools as centres of social group excellence put aside for grooming learners to settle on career methods which will end in them conducive to economic process have light-emitting diodes that high stress on instructional standards, continuous improvement and responsibility by academics and principals that area geared toward creating colleges high activity profit creating organisations that are learner friendly and accommodative. Ultimately, poor Mathematics outcomes demand new capacities for colleges and new orientations for educators to tackle the perennial below performance within the subject. Lachat (1994, 1999) postulates that the challenges of the twenty-1st century create a replacement mandate for colleges and never have colleges been asked to confirm that each one student deliver the goods in public outlined standards of learning and think about higher order skills as core skills to be non-inheritable by all students. This means that colleges are pressured to reform and match the realities of latest lifetime of discourse societies.

Mathematics achievement globally is non-negotiable as scientific headed careers demand passes in arithmetic and Sciences without which one cannot pursue a significant career. Hargreaves (1997:22) reiterates, "What is value fighting for in our colleges is ultimately meeting the educational desires of all students and caring for them effectively. Whereas these instructional desires are nearly unaltered and universal, responding to them effectively within the complicated postmodernist age creates challenges". This implies that Mathematics teachers ought to endeavour to diagnose the issues long faced by learners and initiate sensible, practicable interventions that may end in learners passing arithmetic.

### 3.12. Diagnostic Analysis and Intervention Strategies towards Improving Mathematics Outcomes in Secondary Schools

Boaler (2016) asserts that Mathematics assessment practices should change so that they focus on improving understanding. Boaler (2016:149) reminds us that mistakes can present a powerful learning opportunity which teachers can take advantage of by providing feedback on the actions and how this could be improved instead of focusing on the learner characteristics. Black, Harrison, Lee, Marshall, and William (2004:14–15) further state that classroom dialogue, exercises and peer groups are forms of formative assessment, which are useful ways of helping students change from behaving as passive recipients of the knowledge offered, to becoming active learners who take responsibility for their own learning. Clark (2008:12–13) suggests that the use of a variety of teaching and assessment methods can stimulate learners' achievement, while pointing to the importance of specifying success criteria and learning intentions in any assessment settings.

Diagnostic tests are designed to unearth students' weaknesses and specific mistakes in attempting certain specific concepts. Bretts *et al.*, (2011) noted that Mathematics diagnostic testing helps in providing feedback on the readiness of scholars to proceed to a given course within the next school year and appraise teachers' skills to deliver their lessons in apprehensible approaches effectively. Attempts to seek out the real causes and nature of issues faced by learners in Mathematics, school rooms are done through many approaches, among them item analysis and conducting diagnostic tests for troubled learners.

Bretts (2011) asserts that diagnostic testing results in specific interventions and additional correct grouping supported specific weaknesses and strengths discovered within the testing. This suggests that diagnostic testing has twin functions of distinguishing learner wants and placement into teams that suit their performance. Post placement is then followed by acceptable learner–tailored interventions and programmes to boost Mathematics teaching and learning. It should not be used to downgrade the student emotional where the learner feels discriminated against due to a natural cause: delayed or poor performance in mastery. This is not collaborative and its punitive and discourage other learners to proceed with difficult subjects. Therefore, the diagnostic results should be used to improve and not to grade the class of the student. Bretts *et al.*, (2011) argue that on a comparative basis each Voluntary Testing and Obligatory Testing had similar effects and no variations in terms of increase in looking at sampled learners.

The fact that the scores were used for placement functions into subsequent grade might need motivated students to figure more durable to boost their looking at scores. The study shall administer standardized tests and use their results as diagnosing in making a cooperative model. Equally integral to the study was to seek out if re-testing when re-teaching can be incorporated in assessment as a remedial tool in improving Mathematics action in schools. This means the Provincial directive to administer centralized testing to underperforming schools should be accompanied by an additional curriculum support to capacitate educators pedagogically. The interventions should be done by subject advisors and Mathematics experts either in individual schools or to a group of teachers with the sole aim of increasing teachers' content grasp and pedagogical competency.

Other findings by Bretts *et al.*, (2011) contend that tests administered by the district as diagnostic might become more effective if teachers are scaffolded and provided with post testing and analysis feedback on the tests and professional development on how to adapt their teaching methods in response to tests results. The study will thus evaluate the extent to which subject advisory at district level assists educators in diagnosing Mathematics problems and providing appropriate pedagogical interventions to improve the teaching and learning of Mathematics at the Centocow cluster.

State accountability in tackling poor Mathematics outcomes is also one grey area that has not been tacked globally and locally probably because no one has identified the real missing link in addressing the problem. Bretts *et al.,* (2011) explain that states should provide teachers with the capacity of conducting formative testing during the school year that is testing designed to diagnose how well students could have mastered the material taught and tested. Leaving teachers alone in classroom to come out with solutions regarding the underperformance of learners in Mathematics is not effective enough as it has not yielded desired results. A responsive system that capacitates and scaffolded educators on how best they could teach individual concepts and conducts proper assessments will be ideal and may be the long-awaited solution to poor Mathematics outcomes. State testing which is formative, and diagnostic would assist teachers in their day-to-day teaching, learning, and testing of individual concepts and unearth learners' strengths and weaknesses in helping teachers pinpoint how they failed in classroom teaching of concepts.

The complexity of handling classroom variables demands high levels of collaboration between a teacher and learners to result in effective instructional delivery. Due to the changing nature of Mathematics content and subsequent pedagogies, current research favours co-teaching or team teaching where two or more teachers teach the same class at different times, different concepts in the same subject. The above approach decentralizes accountability to not only one teacher but to different professionals.

Studies by Wendy (1994) done in the United States of America outlined that co-teaching as a tutorial delivery approach within which general and special educators share responsibility for designing, delivery and analysis of tutorial techniques for a group of scholars. The educators add a co-active and coordinated fashion that involves the joint teaching of academically behaviorally heterogeneous teams of scholars in integrated settings. This suggests that in co-teaching educators collaborate in teaching one cluster of learners,' put together tributary experience in information and skills of information implementation in arithmetic.

Wendy (1994) and Lawton (1999) explain that co-teaching can take the following models:

- One teaching–one observing where one educator teaches while the other observes to see the curriculum implementation in play, intervenes in some situations to meet the needs of learners.
- Station teaching where both teachers have a specific role to play in the classroom.
- Parallel teaching where a class is divided into two and is taught at the same time by two different educators.
- Alternative teaching where focus is on re-teaching in small groups of students.
- Team teaching where there is shared responsibility in teaching and planning and results in creative freedom for educators.

Thus, co-teaching as associate intervention strategy realizes the ability of collaboration among educators and learners and maximizes interaction and designing of room activities with the aim of providing most instructional attainment.

Additional studies by Syh-Jong Jong (2006) in Taiwan on effects of team teaching found that collaborative teaching provided different ways of solving Mathematics problems giving them the opportunity to learn to think differently. This implies that team teaching exposes learners to a plethora of learning tools, strategies, and teaching aids from both teachers in the classroom and results in boosting their final examination performance. Additionally, it was found that teaching was simplified by regrouping students with similar mathematical abilities together in a new class. Teachers also added extra materials suitable for students and that grouping according to mathematical abilities was very enjoyable to learners.

On the contrary Syh-Jong Jong (2006) found that the team teachers deferred in their approach to handling the management of the class and delivery of content which in some cases resulted in confusion among learners. The study shall, therefore, seek to evaluate the models of team teaching used by teachers in the Centocow cluster and evaluate their effectiveness in improving performance in Mathematics. Focus will be the team-teaching model used by teachers during annual winter school programmes, and challenges faced by the project will also be of interest to the researcher as they may contribute to poor performance in Mathematics. Perceptions of teachers on the project will also be captured and analyzed in the context of the research project.

### 3.12.1. Conditions Necessary for implementing a Collaborative Model

#### 3.12.1.1. School Management and Teaching

Schools as social establishments are basically mandated to develop data and skills in learners. It prepares learners for a life with skills and competencies to assist their countries to notice solutions to rising challenges. Effective leadership is critical to effective programme implementation for modification and sustaining the intervention (Smith and Edwards, 2008). A collaborative school culture is defined as "the existence of high levels of collaboration among teachers which is characterised by mutual respect and trust, openness, shared work values and cooperation among teachers" (Erikson, Minnes, Brandes, Mitchell, & Mitchell, 2005:788). This means that the context of a school is crucial when teachers engage in collaborative teaching activities. Johnson (2003) further argues that although teachers‟ different values, skills and personalities affect their ability to collaborate, the context of the school is important for successful collaborative teaching activities. This implies that school structures should enable teachers to share and learn from each other spontaneously. From the above views, schools cannot improve without teachers working as a unit.

The concept of collaborative teaching has a variety of meanings, with notions such as networking, mentoring, joint work, and teamwork in which teachers engage in a school. This means that a collaborative school culture provides conditions for collaborative teaching to succeed, thus transforming a school into a learning community. From the above discussion it is evident that collaboration and collegiality are essential for collaborative teaching activities. I, therefore, argue that collaboration and collegiality help to develop a working consensus conducive to teachers helping one another. Through various forms of collaborative teaching, a shared school vision among teachers can be developed. Literature suggests that schools that are characterised by a collaborative culture are "places of hard work, strong commitment, collective responsibility and dedication" (Munthe, 2003: 806). Therefore, a school's culture impacts on collaborative teaching activities and teacher learning and development.

Therefore, institutions of higher learning including secondary schools should create them as effective organisations that are ready to fulfill their social functions. In the collaborative model suggested and proposed by the researcher, it shall not be the duty of the principal to improve and equip classroom but teachers and students the same (Fullan, 2004: 16) should implement reform that results in proper improvement in students' achievement". Leaders ought to possess high educational expertise and talent to encourage educators and learners in the face of challenges in implementing a Mathematics programme. The study shall examine the effectiveness of faculty leadership in implementing an arithmetic programme.

**3.12.1.2. School Management and Leadership**

Another finding by Southworth (2005) cites that schools should be led as business organisations whose sole purpose is to form and lead a setting that enhances and supports learning. Harris *et al.*, (2005) concur that the present leadership stems from the necessity to deal with discontinuous fast modification. This means that schools as a part of the ever-changing social contexts are incessantly ever-changing their data profiles, human resources, nature of learners and discourse factors. Thus, school leaders implementing a Mathematics programme ought to be ready to initiate and propose solutions to high failure rates in Mathematics specially and sciences generally.

Another key condition to victorious programme implementation is for schools to be led by tutorial leaders instead of a principal or Head of Department. Tutorial programme principals are those who are well versed in room observation, they will teach, evaluate, arrange, and supervise teaching and learning in their schools and do not seem to be armchair theorists who solely use position power and are empty in skilled power residing in disciplines instructed in their schools. Analysis findings by Lambert (2002:37) asserts that, "the days of the principals as a lone academic leader are over, previous model of formal, one-person leadership leaves substantial skills of academics mostly untapped." This suggests that current academic leadership ought to be a shared method wherever the principal's role is to supply an acceptable and accessible educational setting wherever information is effectively and professionally shared. Consultations with School Management Teams ought to be the characteristics of recent school leadership wherever all skills are controlled for the good of schools.

#### 3.12.1.3. School Management Teams and Partnership.

Other studies by Day *et al.,* (1993) done in the United States of America found that making and setting for whole school participation in programme development and implementation is significant for victorious schools. Manthey (2004) concurs that leadership that matters is that the leadership that's sustained which needs that it's distributed to others. This means that victorious context for implementing a mathematics programme is wherever all academics and stakeholders inside the school community are concerned in initiating and implementing solutions to info challenges in order that they conjointly own the innovations and participate in class programmes designed to search out solutions to issues sweet-faced in establishments. Consequently, solutions to arithmetic failure in schools ought to be initiated from schools by educators, Heads of Departments, principals, and learners in order that they become intellectual property and effective.

Additional findings by Edwards and Smit (2008) found that provision of teacher support in implementing topic programmes are the key to effective teaching and learning of arithmetic. Academics as foot troopers in implementing information want further skilled or information support in terms of teachers' guides and learner materials that are culturally sensitive to the contexts within which learners are instructed. The findings from earlier studies cited above have implications on the role of subjects' advisors in implementation of an arithmetic education in high colleges. The study shall measure the role of subject advisors in aiding schools and individual educators solve the challenges they face in implementing an arithmetic programme.

Teaching strategies and models represent a key condition to facilitate effective teaching and learning of mathematics in high school. Effective teaching practices guarantee effective learning takes place that successively leads to freelance, self-driven learners. Studies by Corburn and Russel (2008) discerned that there are five teaching models that enhance learning within the room and people embrace inductive teaching that develops students thinking skills, deductive teaching that focuses on ideas, synectic teaching that promotes the concept of staring at a well-recognized idea from a replacement perspective, thought attainment teaching that explores and develops ideas, and at last artist teaching which inspires students to use data, skills and important thinking processes.

#### 3.12.1.4. Subject Educators and Mathematics Learning

Teachers should not be mere disseminators of mathematical data however, ought to consciously interact their learners guided by data of teaching and learning. The study shall measure effectiveness of teaching strategies used by academics in teaching mathematics within their school rooms and correlate with learners' performance in the subject.

Other analysis studies on effective skilled development practices by Borko *et al.,* (2009) and Elliott *et al.,* (2009) suggest that in teaching arithmetic, educators ought to first interact in routines of interactions wherever they interact supporting facilitators in developing Mathematics teaching skills through distinguishing key Mathematics ideas in set tasks, distinguishing aspects of the tasks that may be unknown to some students and anticipating students` solutions to explicit tasks. The higher than explains the reciprocal role that clusters coordinators and subject advisors in arithmetic ought to play in raising the standard of teaching and learning in colleges. Mathematics educators in class will not effectively afford confronting challenges alone, however, can solely do through consultation with their colleagues and subject advisors in order that they conjointly strategize and notice solutions to the teaching and learning of Mathematics in schools. Skilled development observation makes educators to be assured in their material and improve their content grasp which ends in positive teaching and learning of Mathematics. The study shall measure if the present structure and observation of Mathematics teaching in schools is an accessory of skilled development of educators and the way that has wedged in Mathematics outcomes.

The roles of cluster coordinators and subject advisors in enhancing skilled development of academics also will be evaluated within the context of its contributions to Mathematical accomplishment and making optimum conditions for teaching and learning Mathematics in secondary schools. Glenn (2000:8) maintains: Better Mathematics and Science teaching is grounded first raising the standard of teacher preparation and in creating continued skilled education.

Contemporary school reform literature and academic trends favour a humanized, decentralized management partnership and community orientating culture as opposed to hostile historically rigid and officialdom school systems. This suggests that implementing a collaborative model needs a contributory, co-operative, competitive skilled setting receptive to changes. Studies by Tacon and Atkinson (2004) contend that making the correct climate for modification needs a crucial think about the final word success of latest the cooperative strategies. This means that an environment of trust, support, openness and inquisitive to hunt solutions culture could be a requisite to implementing a cooperative model of faculty improvement. The study shall investigate if the conditions of implementing an arithmetic programme in colleges are mutual and contributory for collaboration which ends in effective and improved arithmetic outcomes.

Findings by Isopod (2005) found that effective collaboration demands that academics sought to move on the far side ancient norms of school of thought isolation and autonomy to a co-operative and inspiring unlocking of every other’s leadership potential and foster skilled growth. Operating cooperatively within the classroom and at the total college level with an unbroken specialization in student achievements could lead to valuable outcomes for academics and students concerned within the collaborative project. The higher than implies that ever-changing teacher attitudes and mindsets is that place to begin the creation of favourable conditions to implementation of the model, because it demands that academics be pro-active in seeking solutions to poor arithmetic outcomes through moving out of their school rooms and networking with others within the subject, through distinguishing issues and suggesting solutions not as isolated people however, as groups that have a joint vision of rising arithmetic outcomes.

**3.12.1.5. Mentoring and Coaching as Teaching and Learning Mathematics Supportive Systems.**

Another study done by inventors, Fullan and Muller (2000) in the United States of America cited that academics ought to ask for new approaches to mentoring that are rooted in social equality and evolve naturally out of private want. This means that during a cooperative model the teacher must re-invent his skilled role and assume that of a co-mentor and womb-to-tomb learner inside a secure, democratic house within which academics become co-learners who encourage, support and critique one another through shared inquiry into their observations. Mathematics academics as foot troopers within the programme implementation processes got to imbibe the spirit of collaboration and conceived finding solutions to learner issues in arithmetic as not a personal task however, a team task for professionals who face challenges conjointly, in groups and willing to share personal experiences with the final word goal of rising performance in Mathematics. The study sought to assess the perceptions on operating in groups with their skilled colleagues to find solutions to Mathematics underperformance in high schools.

Partnership with oldsters within the actual teaching and learning of Mathematics constitutes a key condition in implementing a cooperative model. Studies by Newman (1995) discerned those partnerships between academics and oldsters ought to transcend consultations to levels wherever academics open their school rooms to folk and work brazenly and honestly with them as some way of building parental trust, commitment, and support for academics and teaching. This suggests a shift from oldsters enjoying and observer standing within the education of their children. They ought to currently get into school rooms as key collaborators and play accessory and motivating roles in support of efforts by academics and learners to find solutions to Mathematics poor performance. The presence of oldsters in Mathematics school rooms as collaborators can infuse a culture of collaboration, teamwork, consultative work and build an environment of openness and trust that is significant for improvement in arithmetic. Isopod (2005) reiterates that so as for folks to figure collaboratively with alternative stakeholders in colleges, they ought to be inspired to embrace all learners not simply their own children need. They have a broad vision of them guiding their input into decisions and choices created in class complimenting that of educators. This means that colleges ought to open and permit parental contribution to the ideas which will lead to improved performance in learner scores.

Findings by McRherson and Crowson (1994) in Austarlia found that the role of the principal is completely different during a cooperative context which there ought to be a modification of skills, data and behaviours needed for cooperative leadership. This means that principals are needed to try to inspire a culture of teacher leadership and direction through acting as hero manufacturers instead of heroes, (Barth, 2001). Thus, school management not solely needs a new compendium of skills, however, must additionally adopt new mind sets or ways which feature addressing ambiguity, empowering others and maintaining modification momentum inside an increased responsibility context.

Other studies by Jackson and Davis (2000) found that colleges that embrace a cooperative culture ought to adopt shared leadership and deciding wherever management isn't centralized, however many folks than directors have the knowledge and therefore, the power to form to form choices and enact changes. Rather than one or two individuals creating choices alone, groups create choices by accord, finally participants have voiced their opinions and support for modification. This means that principals and Heads of Departments become team members beside educators in subjects' committees, and skilled engagements geared toward resolution program failures are done and each party equally contributes to the discourse that leads to rising college performance. The study shall seek evaluate the roles of Mathematics educators in shared leadership and the way they interact in skilled discourse on resolution of poor performances in Mathematics.

Creation of cooperative groups that specialize in managing modification is essential in enhancing a cooperative culture in colleges. Analysis studies by Stewart (1996) found that victorious colleges produce structures that enable Mathematics to collaborate on the challenges they face. Rather than operating in isolated school rooms alone while not interacting with their colleagues and educators in victorious schools move to debate ideas, share practices and arrange programmes. This suggests that in facing Mathematics' low performance, schools ought to deliberately produce task groups that change in size, purpose and length of the time they work along. Groups might be tutorial groups that are employed for several years whereas study teams could also be discovered to achieve specific tasks. The study intends to search whether schools have cooperative groups mandated with seeking solutions to boost Mathematics performance. These groups might be arithmetic academics associations inside school and clusters. The impact of the groups and therefore, the level of support from the faculties, Heads of Departments and principals as was also be investigated.

### 3.12.2. Dynamics and challenges of implementing a Collaborative model of teaching and learning Mathematics.

Research has established that the educational system within which Professional Development occurs has implications for its effectiveness. Specifically, conditions for teaching and learning both within schools and at the broader system level can inhibit the effectiveness of PD. For example, inadequate resourcing for PD—including needed curriculum materials—frequently exacerbates inequities and hinders school improvement efforts. Failure to align policies toward a coherent set of practices is also a major impediment, as is a dysfunctional school culture. Implementing effective PD well also requires responsiveness to the needs of educators and learners and to the contexts in which teaching and learning will take place, Darling-Hammond, Hyler and Gardner (2017).

Earlier studies done in India by (Chiriac & Granström, 2012; Hämäläinen & Vähäsantanen, 2011) identified several problems that teachers encounter when applying CL in the classroom. We explain two problems affecting CL effectiveness: organisation of collaborative activities, and assessment of learning. First, teachers often face challenges while structuring collaborative activities such as monitoring students' on-task behaviour, managing group-work time, providing relevant materials, assigning individual roles, and establishing teamwork beliefs and behaviours (Gillies & Boyle, 2010). A study by Ruys, Van Keer, and Aelterman (2012), which analysed preparation of collaborative activities of pre-service teachers, revealed insufficient attention of teachers to organising collaborative work such as determining group norms and facilitating activities. Furthermore, research demonstrated that many primary and secondary school teachers often place students in groups and let them work together without preparing students to perform collaborative activities productively (Blatchford et al., 2003). Second, teachers frequently find it difficult to assess students' performance and achievements as they implement CL in classrooms at all levels of education (Strijbos, 2011). For example, teachers at some primary and secondary schools showed uncertainty and ambiguity about what and how to assess (Frykedal & Chiriac, 2011). Also, a study by Chiriac and Granström (2012) reported that the criteria or rules for assessment lacked transparency and concreteness. Furthermore, the lack of assessment tools to measure collaborative performance of every group member may cause student disappointment about the transparency and evenness of the assessment (Strom & Strom, 2011).

Key challenges in implementing an arithmetic programme in secondary schools are classified into education, skills development, building and sustaining skilled relationships and governance. Hargreaves (1994) explains that education aspects of collaboration encompass team teaching, programme designing, conferencing with one another, assessment of scholars and sharing resources. This suggests that the top of programme processes are key activities that participants have interaction in their quest to enhance the teaching and learning moreover as assessment of a Mathematics programme in the Sisonke district secondary schools.

Equally associated with attainment of quality Mathematics education are specific tasks whose functions are to achieve accomplishment of skilled development functions like peer observation, mentoring, modeling and discussion among educators and different teacher networks with interest in Mathematics. Governance in schools and colleges are additionally a key effective to property and booming teaching and learning of Mathematics in schools. Woodlouse (2005) describes activities associated with governance to incorporate college improvement, planning, college organisation, staffing problems and faculty council. This suggests that college management groups in colleges in collaboration with School Governing Bodies and Learner Representative Councils have an essential role of inserting appropriate and relevantly qualified educators to show arithmetic and to line up structures that support and work to enhance the teaching and learning of arithmetic in the Sisonke secondary schools.

### 3.12.3 Barriers to collaborative teaching

#### 3.12.3.1 School culture and structural barriers

Research has proven that a school culture can impact on teacher collaboration (Spillane, 2000). Bush and Middlewood (2005:69) define structure as "the physical manifestation of the culture of an organisation" and Mkhwanazi (2014:44) defines school culture as: "A place where teachers are socialised to the existing organisational norms through the policies and procedures that give direction of the organisation and, control how personnel in these organisations conduct themselves".

There are numerous elements that may hinder collaborative teaching activities within a school such as limited access to professional development, lack of administrative support. For instance, schools focus more on what Maloney and Konza (2011) referred to as „operational procedures‟. These include examination curriculum, participation in staff meetings, syllabus coverage, and submission of workbooks, homework, and supervision of learners. These procedures do not consider teacher development, thus hindering engagement in collaborative teaching activities.

Kougioumtzis and Patriksson (2009) argue that collaboration in schools is not only scarce but difficult to promote and sustain. Provision of time is one of the powerful tools in supporting collaborative teaching activities. Expanding on this argument, Datnow (2011:152) states that allocation of time for instructional planning meetings is considered "sacred". However, the way timetables are arranged hinders collaborative teaching in most South African schools. Some schools are characterised by teacher shortages and diversity in the curriculum, leading to timetables being arranged to maximise teachers‟ teaching time.

School timetables do not permit teachers to meet and discuss challenging classroom practices or plan and prepare lessons together. In other words, timetables do not promote collegiality among teachers. Leonard and Leonard (2003:7) argue that "teachers still complain that the scarcity of opportunities to collaborate is promulgated by decreasing time availability and increasing work demands". It is still difficult for teachers to have time together to engage in collaborative teaching activities. Kennedy (2011:34) contends that teachers "view their non-contact time as their time for marking and preparation, relaxing before the next period". Moreover, teachers are given extra supervisory work to do, which further limits opportunities for collaborative teaching activities. This is confirmed by Brodie and Borko (2016) who contend that teachers have heavy workloads, which limit their time to engage in meaningful collaborative work.

In secondary schools, the division of teachers into departments and subject learning areas also hinder teacher's ability to work together. This culture emphasises teacher autonomy rather than collaboration. As a result, this hinders attempts for teachers to regularly talk with and observe one another. This is in contrast with Stoll et al. (2006) principle of collective responsibility. Failure to hold collective responsibility for student learning can impede teachers‟ professional growth. From the above argument, schools still need to adapt practices to encourage teacher learning and development.

Limited access to resources e.g., books, instructional materials, laboratory material and computers make it impossible for teachers to carry out effective teaching. Austin (2001) argues that sharing teaching methods and collaboration in the classroom becomes much easier where teachers have access to resources. From my teaching experience, I have witnessed schools where more than two learners must share a book and teachers must improvise when they must do experiments as there is no laboratory equipment in the school.

#### 3.12.3.2 School leadership

Research has proven that school leadership's role in nurturing teachers‟ professional growth, is of paramount importance when teachers engage in various collaborative work activities (Hord, 2004). The necessity of supportive conditions offered by school leadership is further reiterated by Spillane (2004) who asserts that the school management monitors teacher learning of its teachers and lack of teacher development opportunities.

Surprisingly, one of the barriers to collaborative teaching in a school is the School Management Team (SMT). Schools are characterised by few opportunities of professional development activities and lack of a supportive role from the school management (Chassels & Melville, 2009) which further results in teachers having difficulty in implementing their teaching practices. The above views imply that teachers experience minimal support from the SMT or lack thereof to engage in collaborative teaching activities.

The school leadership's role has been redefined to that of instructional leadership. Instructional leadership promulgates that the school management should encourage sharing of expertise among teachers and create opportunities that encourage collaborative teacher activities (Parise & Spillane, 2010). However, Kingsley's (2012) findings revealed that the school leadership is not supportive of collaborative teaching activities. This may be due to their lack of understanding of how collaborative teaching works. Expanding on this argument, I have observed that the school leadership fails to set up opportunities for teachers to plan lessons together and evaluate their classroom practice. The focus is much more on management and other administrative tasks.

Austin, (2001) contends that teachers need more support to increase subject knowledge to refine their teaching skills. However, school leadership's focus is on managerial duties such as learner discipline, parental involvement, and public relations. This kind of leadership fails to encompass teacher collaborative activities that influence instructional practices and other teacher professional development activities that may enhance teacher learning and learner performance.

Rytivaara and Kershner, (2012) assert that secondary school teachers still work alone with limited support and guidance from the school management. Furthermore, Maistry, (2007) in a South African study argued that often, teachers receive little or no encouragement to experiment with new teaching techniques. Moreover, school leadership fails to promote teacher professional growth that includes encouraging positive relationships amongst teachers, time for reflection and assistance regarding teachers' classroom practice. Maistry, (2007) further argues that school leadership's focus is on ensuring the execution of administrative tasks by teachers, for example, syllabus coverage. These kinds of settings deter teachers from engaging in meaningful collaborative teaching activities.

#### 3.12.3.3 Mathematics Teachers as barriers themselves

School micropolitics are another factor that hinders teacher collaboration in schools (Fullan, 2007). I believe secondary school teachers often resist participating in discussions and evaluation of practices that result in improved teaching and professional growth. There is evidence in some schools of a negative attitude of some teachers to collaborative teaching activities (Rytivaara & Kershner, 2012). They further elaborated that teachers lack commitment towards these activities. Similarly, Thibodeau (2008) talks about „lazy‟ teachers who wish to avoid extra work and those that find it difficult to work collaboratively, preferring to work alone. These teachers view their individuality and creativity as being restricted by collaborative work.

Teaching is also grounded in teachers' backgrounds, biographies, the types of teachers they have become, as well as their skills. Mkhwanazi, (2014) argues that teachers' collaborative work activities are influenced by their past experiences which have an impact on their learning and classroom practice. These encompass how teachers themselves were taught both at school and teacher colleges. As teachers bring along their own teaching attitudes and values, this influences their decision to engage in any collaborative activities within the school. In some South African schools, unwilling novice teachers pose a barrier to collaborative teaching. Ono and Ferreira, (2010) allude to the fact that novice teachers resist working collaboratively with experienced teachers as they prefer to stay in their own comfort zones. They regard engaging in these activities as an encroachment of their valuable time.

Schools are often characterised by dynamic relationships between teachers who have diverse personalities. These relationships can also impede collaborative teaching activities. Tensions often emerge because of differing personal experiences, expertise, knowledge, authority and values, and approaches to collaborative teaching (Kougioumtzis & Patriksson, 2009). This resulted in what Kingsley, (2012) refers to as pseudo-collaboration. The impact of teacher collaboration "is further corroborated by studies showing that competition between teachers or collaborative groups has negative effects on the success of collaborative teaching" (Kelchtermans, 2006:229). The implication of this is that unhealthy competition among teachers often results in a level of "ill feelings" among colleagues. However, De Clercq and Phiri (2013) maintain that a competitive spirit among colleagues is important in teachers‟ continuous learning to develop their knowledge, skills, and competencies.

Another barrier to teacher collaboration is the existence of cliques among colleagues. This often defeats the purpose of successful collaborative teaching activities in schools. Kelchtermans (2006) confirms that close personal ties among members of a team often inhibits collaboration and professional learning. Expanding on this argument, Camburn (2010) states that friendships or animosity between teachers makes it difficult for teachers to collaborate in an effective way. These kinds of relationships work against teachers acquiring new skills and knowledge as they avoid all forms of collaboration that could possibly threaten bonds within these cliques. Hargreaves (2003) warns that such collaboration can be comfortable, cosy, and complacent.

A study conducted by Nel, et al. (2016) also discovered that teachers with or without additional short courses in learner support were not confident in the knowledge that they have acquired because they were trained in the curriculum that used the medical deficit model to view learners with learning barriers. According to Nel et al. (2013; 2016) teachers felt that referring learners to the DBST was time consuming as they had to fill in forms daily and contact parents and some were not happy with the services they received (Nel et al., 2013; 2016). Committees introduced by DBST demand a great deal of paperwork such as drawing up policies and involvement of the School Governing Bodies, who are not always available. The school syllabus changes regularly therefore teachers find it difficult to find time to attend to this (Nel et al., 2016). Therefore, if teachers do not change their attitudes, then collaboration will be inadequate. To address attitudinal barriers teachers and other professionals need to focus on the interconnectedness of various participants in their school settings and they will then realise the need to collaborate (Taylor et al., 2015)

Additional studies by Oshea and Oshea (1997) found that participants ought to possess specific cooperative skills that embrace communication skills, emotional competencies, deciding, and drawback finding, conflict management and team building. This suggests that for collaboration to succeed, participants ought to be guided by cooperative principles that specialize in shared vision of high Mathematics accomplishment guided by the abilities that characterize cooperative activities.

#### 3.12.3.4 Mathematics Conceptual barriers

Conceptual barriers are expectations professionals in schools possess about how things should be done (Taylor et al., 2015; Richards et al., 2016; Mulholland & O'Connor, 2016). General education teachers and special education teachers may have developed their own ideas of how their school should operate, including their roles, those of other professionals, families, and learners (Richards, 2016; McLean, 2012; Florian & Black-Hawkins, 2011; Walton, 2016; Geldenhuys & Wevers, 2013; Green & Moodley, 2018; Dreyer, Engelbrecht & Swart, 2012; Avalos-Bevan & Bascope, 2017). General teachers may be comfortable with the practice of taking learners with special educational needs to a resource room for a considerable time (Richards, 2016; McLean, 2012). The challenge might arise with the introduction of a particular form of collaboration form such as co-teaching, where they will be expected to plan and deliver the lesson together (Richards, 2016; McLean, 2012). According to Engelbreccht and Hay (2018) a challenge might arise when professionals who were regarded as experts struggle to accept that teachers are experts who are their partners and who will participate in decision making. However, Richards (2016) cautioned us that it is worth noting that collaboration skills take time, therefore, substantial changes in teachers' roles and how the school operates need time to develop and improve. According to Zangona, Kurth, and MacFarland (2017), the lack of knowledge on how to support learners with significant learning disabilities may affect general as well as special education teachers' abilities to implement inclusive practices successfully. Lack of training and previous experience has been reported by Ajuwon, Lichtenberger, Griffin-Shirley, Sokolosky, Zhou, and Mullins (2012) as the reason for the gap in knowledge. Nel et al. (2013) conducted a study in two provinces in South Africa and discovered that most teachers did not understand the concept of collaboration; only the minority understood collaboration as working together as teams. Their understanding, according to Nel et al. (2013), lacked important characteristics of collaboration such as effective communication between team members, and mutual recognition of every team member's skill. The study shall seek to create and inculcate the collaborative skills among participants and evaluate the extent to which the participants are responding to the dictates of the model and how it attempts to improve Mathematics' outcomes at the Centocow cluster.

### 3.12.3 .5 Pragmatic barriers

Pragmatic barriers in collaboration, such as scheduling time, large caseloads and competing responsibilities, are considered the most important (Taylor et al., 2015; Richards et al., 2016; Florian & Black-Hawkins, 2011; Geldenhyns & Wever, 2013; Walton, 2016; Dreyer, Engelbrecht & Swart, 2012; Suc, Bukovec & Kapljuk, 2017). Walton (2016) made an example that "some teacher might be willing, and others might not be willing to work extra hours after school to collaboratively plan when no time is provided during the school day or week. Some professionals might experience a challenge when scheduling time for planning as they might be allocated to more than two different schools to support, so they will have to travel in between schools and might not make it to planning meetings (Richards, 2016; Dreyer et al., 2012). To overcome these challenges, Dreyer et al. (2012) suggests that the school principals and district administrators should make sure that time is scheduled for collaboration, and this must be part of the school culture. Walton (2016) added that barriers for planning time can be diminished in several ways including "split schedules for teachers, use roving aides to cover classes, and providing financial incentives". a lack of time for formal communication. They added that schools can use any type of collaboration if planning time is scheduled by their administrators (Walton, 2016; Dreyer, Engelbrecht & Swart, 2012; Suc, Bukovec & Kapljuk, 2017). The sad reality of some schools is the fact that their administrators do not support inclusion therefore they do not see the need for planning time, so they do not make time for professional to meet for planning (Walton, 2016).

A study conducted in Sweden and in Chile by von Ahlefeld Nisser (2017); Avalos-Bevan and Bascope (2017); Mulholland and O'Connor (2016); Murawski (2010); Sharma, Loreman and Forlin (2012); Shakenova (2017) and Collinson and Cook (2013), respectively discovered that principals and administrators did not schedule enough planning time for teachers to collaborate, therefore teachers were unable to collaborate with their colleagues and other professionals. Similarly, in some South African schools Hargreaves, Nakhooda, Mottay, and Subramoney, (2012) discovered that teacher and occupational therapists did not have time to meet, as teachers had full teaching schedules and occupational therapists had sets of therapy times for the learners.

## 3.13. Chapter Summary

A Collaborative model is a collection of models tested and instituted before, a lesson learned from the established interventions aimed at improving teaching and learning of

Mathematics. It was clear from my analysis of all literature and case studies, that the collaborative and cooperative approach to teaching and learning is promising to establishing a community of practice. This chapter evaluated literature and outcomes. The chapter describes distinct research endeavors. The chapter analyzed modern math education programs, validated, or questioned outcomes, and contrasted study settings. Professional development approaches are reviewed. Differentiated professional development programs, techniques, PEEL, STEP, Discovery, MSSI, Learning for Sustainability Project, CEER, and professional development schools were discussed.

Professional development models as proposed by Bell and Gilbert (1996) and Loucks-Horsely *et al.*, (1990) were described. Comments on these professional development approaches were made. Similarities between these professional development approaches pertaining to their limitations were identified. Recommendations by several authors on measures to enhance professional development were reviewed. Significant positive effects on the teachers' increase in knowledge and consequent changes in their classroom practice were described. The recommended features of professional development activities as formulated by Desimone *et al.*, (2002: 83) which have significant positive effects on the teachers' knowledge and classroom practice were reviewed. The framework for the design of a professional development model and its key features that relate to developing a Collaborative model is discussed in the next chapter (Chapter 4).

# CHAPTER FOUR: THE RESEARCH FOR AND DESIGN OF A COLLABORATIVE MODEL FOR TEACHING AND LEARNING MATHEMATICS IN SECONDARY SCHOOLS

## 4.1. Introduction

The framework for the design of a professional development model introduced in the previous chapter and its key features that relate to developing a Collaborative model were discussed in this chapter.

The chapter presented an extended literature review aimed at creating an in-depth comprehension of the theoretical foundations of the Collaborative model for teaching and learning Mathematics in secondary schools which the research study sought to construct. The information and data found in the first section of this chapter led the researcher to construct a framework for the collaborative model of teaching and learning Mathematics in secondary schools as stated in the main aim of this study in Chapter Two.

Darling-Hammond, Hyler and Gardner (2017) advises that designing and implementing an effective professional development of teachers demands a holistic model that is based on principles of co-operative learning with the practical application of skills and knowledge within a coherent framework of professional learning. Consequently, the Collaborative Model for teaching and learning Mathematics in secondary schools was designed and developed based on:

- The theoretical and conceptual frameworks of social constructivism and network theories
- Loucks-Horsely *et al.*, (1998)'s design framework for professional development of science and mathematics educators
- Principles of effective professional development.

## 4.2 Developing the Theoretical Framework of the study.

Grant & Osanloo (2014) define a theoretical framework as the blueprint for the entire dissertation inquiry. It serves as the guide on which to build and support your study, and also provides the structure to define how you will philosophically, epistemologically, methodologically, and analytically approach the dissertation as a whole. Eisenhart (1991) further perceived a theoretical framework as a structure that guides research by relying on a formal theory, constructed by using an established, coherent explanation of certain phenomena and relationships. Thus, a theoretical framework comprises the theories expressed by experts in the field into which you plan to research, which you draw upon to provide a theoretical coat hanger for your data analysis and interpretation of results. Put differently, the theoretical framework is a structure that summarizes concepts and theories, which you develop from previously tested and published knowledge which you synthesize to help you have a theoretical background, or basis for your data analysis and interpretation of the meaning contained in your research data, Swanson (2013).

The theoretical framework offers several benefits to a research work. It provides the structure in showing how a researcher defines his/her study philosophically, epistemologically, methodology and analytically (Grant & Osanloo, 2014). Ravitch and Carl (2016) concur that the theoretical framework assists researchers in situating and contextualizing formal theories into their studies as a guide. This positions their studies in scholarly and academic fashion. Moreover, the theoretical framework serves as the focus for the research, and it is linked to the research problem under study. Thus, the theoretical framework consists of the selected theory (or a theory) that undergirds your thinking with regards to how you understand and plan to research your topic, as well as the concepts and definitions from that theory that are relevant to your topic. Therefore, the theoretical and conceptual frameworks of the study were informed by the theories of constructivism and network, respectively. The following sub-sections detailed how the two theoretical constructs informed the design and development as well as recommend implementation principles of the model.

**4.2.1. History of Constructivism**

Owusu (2015) defines constructivism as an epistemological perception of knowledge acquisition which places significance on knowledge construction as opposed to transmission and the recording of information conveyed by others. Hageman-Smith (2003) concurs that it is a philosophical theory which attempts to explain how human beings acquire knowledge through processes of cognition, assimilation, and accommodation as they interchange views and ideas about a social and physical setting. This means that in a constructivist classroom, knowledge is constructed or generated through an active engagement between the learner, learning process, content and learning context. Thus, in constructivist philosophy a learner is active, interacts with others and the setting and in the process constructs, a lasting reality of his or her world.

Constructivism has three interrelated conceptual frameworks namely exogenous, endogenous, or cognitive and dialectical or social constructivism. Owusu (2015) explains that exogenous constructivism holds that reality is constructed as new knowledge and is formulated through mental structures that develop to reflect the external organization of the world, whereas endogenous or cognitive constructivism holds that knowledge acquisition is internal and is only stimulated by internal cognitive conflict as a learner strives to resolve mental disequilibrium.Piaget (1977), a proponent of cognitivism, posits that learners construct own knowledge through individual and socially mediated discovery-oriented engagements.

Equally influential, Brown, Collins and Duguid (1989) explain dialectical or social constructivism as a theory of knowledge construction through social intersection of people, engagements that involve sharing, company and debating among learners and their mentors. This implies that in social constructivism learners construct personal knowledge, exchange ideas in group settings and knowledge are mutually constructed through dialogue and sharing of individual perceptions of reality. Noddings (1990) highlights that constructivism is underpinned by the following tenets:

- All knowledge is constructed by the individual, that is, it must be found in the mind and cannot simply be acquired by direct, mediated transmission,
- All knowledge is constructed from pre- existing knowledge structures and is recursive and dynamic,
- Knowledge construction is inherently found in nature,
- Dialogue plays a significant part in knowledge construction,
- Knowledge construction is contextually situated.

Fig 4.1 shows a summary of related concepts and tenets of constructivism. A synopsis of the tenets in Fig 4.1 suggested that in constructivist discourse, knowledge is both a mental and social product of an active process engaged in by the creator of knowledge within a context where others scaffold or help in the generation of ideas, refining concepts, and enabling permanent transfer of knowledge into reality and experience.

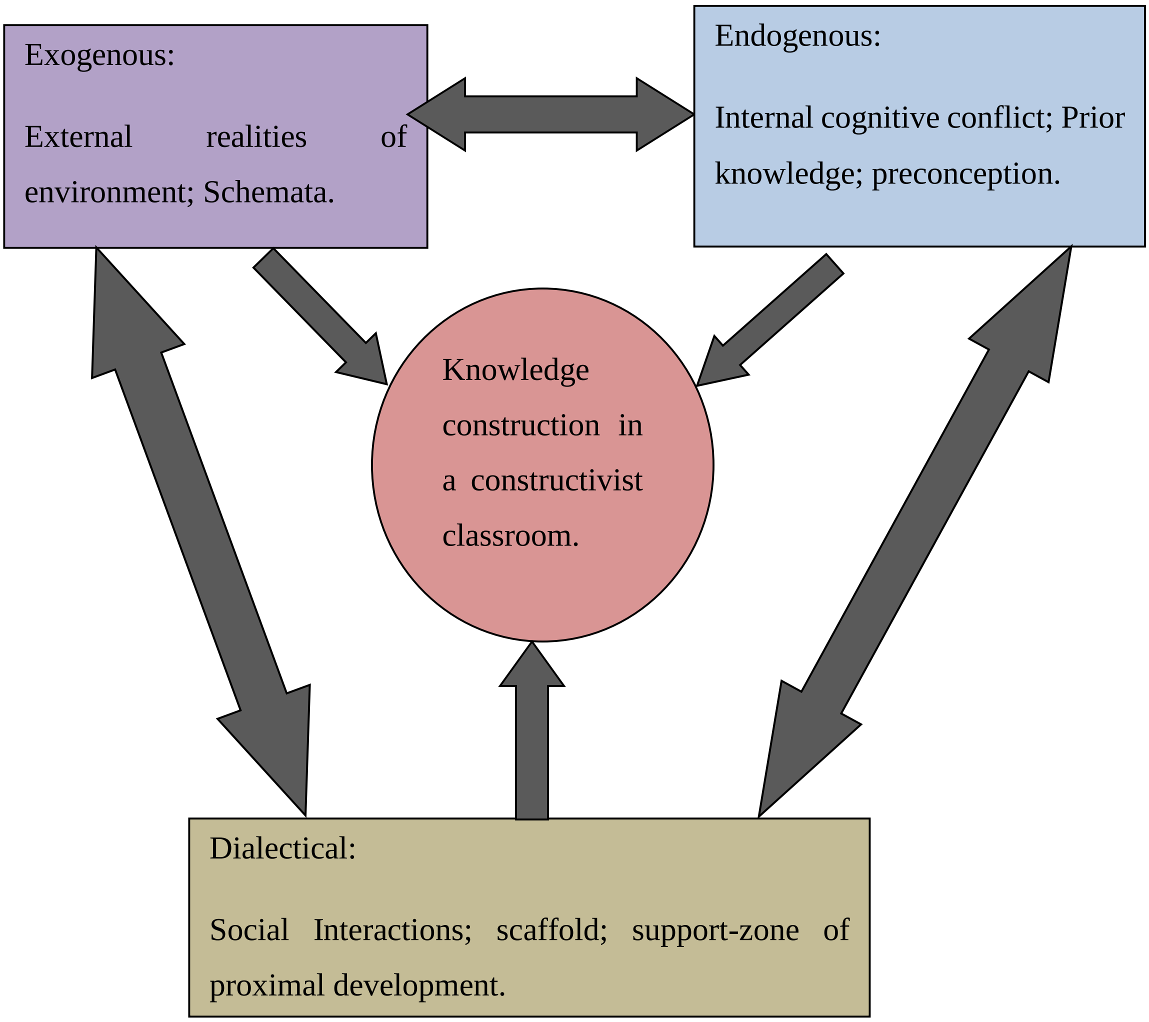


**Fig 4.1: Elements of Constructivism: Adapted from Owusu (2015)**

Van Lakerveld (2005) propounds that social constructivism acknowledges the important role played by others and the exchange of views in a dialogue as it results in exploring, explaining and validation of own knowledge. Vygotsky (1978), unlike Piaget (1983), argued that learning cannot be separated from its social context in that all cognitive functions originate from the social contexts as products of social interaction and that learning is essentially a process by which learners are integrated into a knowledge community.

Additionally, social constructivism puts greater emphasis on context and also highlights the important role of culture and how knowledge derived from social processes also exist within cultures (McMahon, 1997; Schunk, 2000). Culture becomes a great influence into not only what patterns of social processes can emerge within a context but also how they emerge (Rogoff, 2003). Additionally, the notion of teachers as learners calls us to define what it is we feel that teachers need to know. An increasingly globalized and complex world has propelled a movement toward a vast array of skills that fall under the label of the 21st century. Most frameworks focus on various types of higher-order skills such as complex thinking, communication, collaboration, and creativity also known commonly as the 4Cs,Dede, 2010; Saavedra and Opfer, 2012; Soulé and Warrick, 2015). These skills are increasingly being recognized as the gold standard for student abilities, as well as requirements to meet the demands for success in work and life, (Binkley et al., 2012).

In the context of teaching and learning, Wenger (2009:1) defines communities of practice as, 'groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly". In designing the Collaborative model, Mathematics educators will create Mathematics communities of practice within schools and within the communities. They will share, discuss, and provide practical solutions to challenges they meet. Commenting on school based communities of practice, Owen (2004) states that individuals interact and learn from observing each other sharing ideas through oral and written language and analysis of students' tasks, and teachers are engaged in professional learning everyday all day long. Schools and classrooms become the stage where teamwork skills are developed on a daily basis and that translates the teaching and learning of Mathematics into a socially–shared activity that both educators and learners enjoy.

In designing the model, the researchers also improved knowledge from more recent adult learning theories that explain how adults create knowledge and learn from each other within communities of practice and situated learning. Duncombe and Armour (2003) counsel that educators are encouraged to develop their learning communities of practice where they learn from each other and share common professional and personal experiences. Quality professional development can lead to important qualitative outcomes such as the creation of a positive school culture, citizenship, improvement in individual teacher skills, and development of opportunities for peer learning (Willemse, Dam, Geijsel, van Wessum, & Volman, 2015).

The research was premised on the constructivist learning theories of Jerome Brunner (1968), Jean Piaget (1983), John Dewey (1964) and Lev Vygotsky (1978), among early theorists. The theorists hold the view that meaning is socially constructed by individuals through shared social interactions within a social context among community members. Bognar, Gajger, & Civic (2015) posit that learning is a process of interaction between what we know and what we still need to learn. Key concepts in social constructivism and learning are that in the learning process the previous knowledge and students' cognitive structure have to be taken into account. Learning is a social process – is not in leads, but in relations between people, learning is a situational process that is participation in certain social and cultural circumstances. Learning is a metacognitive process which includes the understanding of the skills and strategies that enable successful resolutions of the problems, and to use these skills and strategies in order to learn effectively. Learning is based on the students' activity and autonomy. The concept of Collaborative Learning Environment (CLE) is a system specially developed to support the participation, collaboration, and cooperation of users sharing a common goal. CLE design should take into account social factors to discover and describe existing relationships among learners, existing organisational structures, and incentives for collaborative action Alzahrani and Woollard (2013). Consequently, Fig 4.2 depicts the collaborative networking and interactions among school variables that include teachers, learners, curriculum content and pedagogical factors among key variables that shape curriculum implementation.

## 4.2.2 Network Theories

Fig 4.2 presents a school network that showed an interaction among school stakeholders who include educators and students as well as the curriculum. Deductions from the social constructivists' theories suggest that fruitful collaborations take place within well-established social networks.

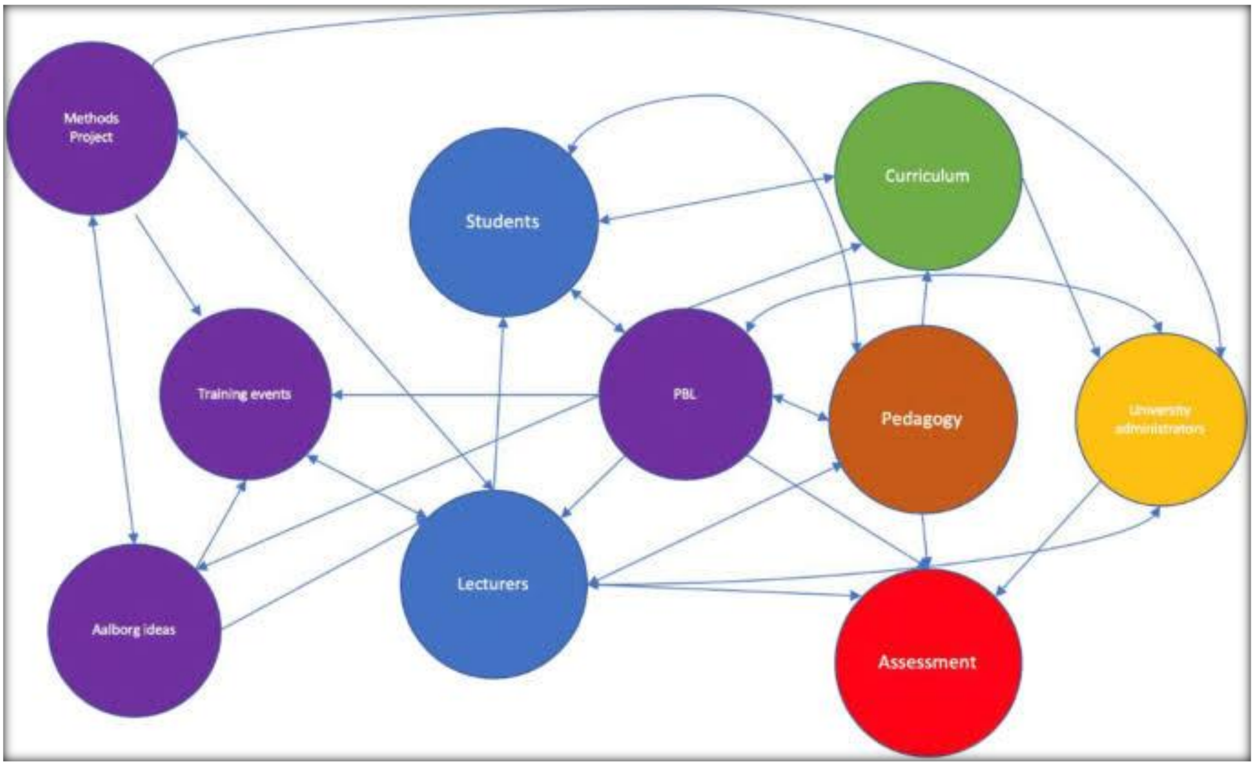


**Fig 4.2: Concept of a school network (Resaearcher creation)**

West and Ainscow (2010) explain that these continuous professional development networks are characterized by regular contacts between staff across schools and from all levels of school hierarchy and relationships based on the view that all schools in the network have valuable contributions to make. Thus, in designing the Collaborative model, teacher networks in the schools and clusters will form the core of the mathematics curriculum change and innovation based pedagogical-content knowledge strategy. Educators from schools in the cluster will collaborate as networks aimed at reforming Mathematics teaching and learning in the cluster. Hadfield *et al.,* (2006:5) define a network as, "groups or systems of interconnected people and organisations whose aims and purposes include the improvement of learning and aspects of well-being known to affect learning.'' This means that schools and individual educators who teach Mathematics will constitute learning community networks whose aims would be to improve the teaching and learning of Mathematics through shared *experiences* and activities designed by the network.

The constructivist view of the organisation is connected to Vygotskian views of learning. Vygotsky posited that co-operation lies at the basis of learning, through the way in which interaction leads to scaffolding that allows actors to achieve more than they would be able to do individually (Vygotsky, Vygotsky, & John-Steiner, 1978). Knowledge for Vygotsky, like for Piaget (Piaget & Inhelder, 2000), is embodied in actions and interactions with the environment and others. In this sense, organisations are most likely to be effective learners where they form communities of practice in networks or other collaborative arrangements and are engaged in a process of social learning that occurs when actors who have a common interest in some subject or problem collaborate to share ideas, find solutions, and build innovations. This view of collaborative ventures as communities of practice therefore presupposes that new knowledge emerges as groups work together towards the achievement of joint goals (Borgatti & Foster, 2003). Constructivist organisational theory can clearly be linked to moves towards creating schools as learning communities, in that, from the constructivist point of view, this effort may be more successful if carried out by schools collaborating in a network rather than by schools acting alone. School networks can therefore be said to fall within this model when they are formed primarily with the goal of knowledge creation and are constructed in such a way as to allow optimal openness and collaboration, Daniel Muijs , Mel West & Mel Ainscow (2010).

In attempting to contextualize the concept of networks, Hargreaves (1998) propounds the concept and vision of knowledge creating schools as central to school improvement. They enhance sharing of knowledge within and among schools in a cluster with the sole aim of creating new professional knowledge. Thus, in the study, the schools in the Centocow cluster were transformed into Mathematics knowledge-creating schools with the intention of creating a platform for educators and learners to share activities, pedagogical approaches, and experiences. Conceptually related to Barnes' (1954) views on the impact of the construction of social networks, Durkheim (1972) argued that networking within and among schools in the community is crucial in assisting the schools to face contextual challenges. Thus, schools in the research cluster participated on a mutual, equal basis using a bottom-up approach where classroom educators who are the chief curriculum implementers were at the centre of Mathematics teaching and learning in secondary schools. Katz and Earl (2010) summarise the key features of networked learning communities as:

- Purpose and focus of the programme must be clear and contextually responsive to the history, needs and challenges of participating schools (Chapman & Allen, 2006)
- Willingness of individuals to work together in a climate of mutual trust and respect as well as developing collaborative relationships (Allen & Cherry, 2000).
- Collaboration is an intense interaction that makes educators open their beliefs, views, and practices to investigate and debate issues (Katz & Earl, 2010). In collaborative engagements educators work out solutions to challenges they face in teaching and learning contexts.

Devolved leadership, creating networked learning communities is enhanced upon well-coordinated and directed programmes that form shared and distributed leadership where positions are shared to enhance effective communication. Both formal (principals and Heads of Departments) and innovation leaders (teachers' leadership involved in a network) should work together encouraging and supporting one another (Katz & Earl, 2000). Daniel Muijs, Mel West & Mel Ainscow (2010) In educational practice, network goals as they currently appear to exist can be broadly defined as being about: School improvement; broadening opportunities (including networking with non-school agencies such as social services or business); resource sharing. Sergiovanni (1999) counsels that leaders in education must have a strong moral compass that enthuses and permeates the organisation and drives improvements and staff commitment to the goals of the school (Loucks-Horsely *et al.*, (1998)

### 4.2.3 Rationale for choice of Constructivism and Network theories as frameworks of the study

The theoretical and conceptual foundations of both Constructivism and Network theories as outlined above provided a working and pragmatic framework within which a Collaborative model was conceived, designed, and constructed. Combined underpinning tenets of the above theories are summarily outlined below and how the study exploited them:

- Knowledge construction is a by-product of social interaction among individuals in a social context.
- In working together for a common purpose, individuals share information positively in a collaborative manner.
- In the process of interaction individuals collaboratively communicate their ideas, beliefs, and attitudes towards social processes.
- In professional, collaborative networks, educators within and across schools engage in co-planning, co-teaching, and co-construction of best practices in teaching and learning contexts.
- Networks of professional educators provide opportunities for exchange of successful practices, strategies, problem solving techniques and best pedagogical approaches.
- Networks of educators regularly make planned contacts among themselves within and across schools in clusters to engage in practices that result in improved Pedagogical Content Knowledge of their subjects. Fig 4.3 presents the midwife role of constructivism in professional development and quality teaching and learning in education.

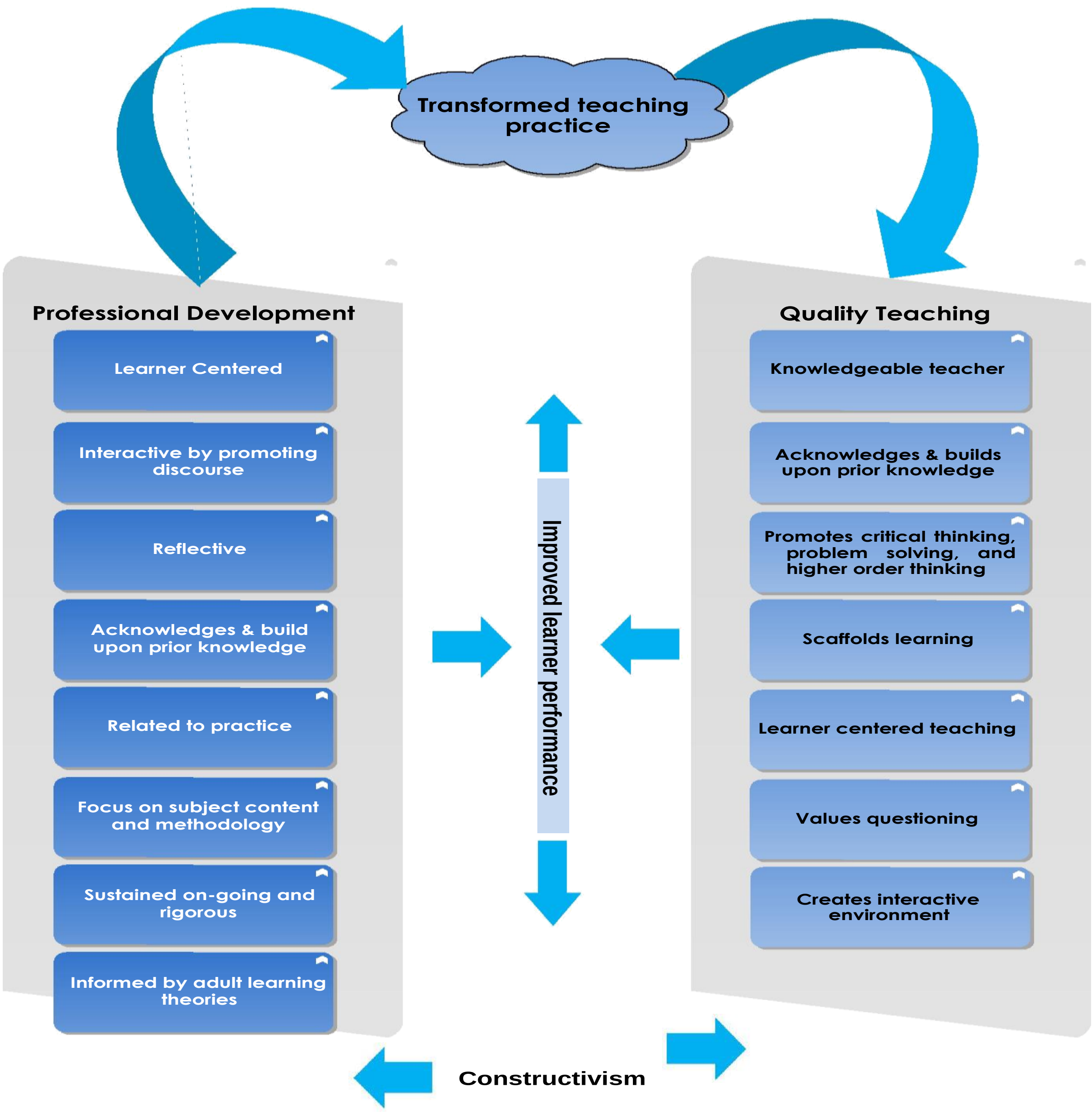




**Fig 4.3 Constructivism as midwife between Professional development and Quality teaching**

In this study, a collaborative model was conceived, designed, and constructed underpinned by the above tenets, Mathematics educators in grade 10 working as networked learning communities (Katz & Earl, 2010) were coordinated together with subject advisors and learners to provide data on the feasibility of constructively engaging one another collaboratively through sharing ideas, beliefs, best practices, experiences and resources in teaching and learning of Mathematics in secondary schools. Each of the stakeholders in a collaborative network were assigned specific responsibilities which, if dutifully done, may contribute to improved Mathematics outcomes as outlined in Fig 4.9, where collaborative two-way communication is highlighted as key to the success of teaching and learning. In the model, teacher isolation and confinement to the classroom is replaced by a collaborator, scaffolder, mediator, communicator, and researcher within a school's ecological context.

### 4.3. Design frameworks for Professional Development in Science and Mathematics

Teacher professional learning is of increasing interest as one way to support the increasingly complex skills students need to learn in preparation for further education and work in the 21st century. Sophisticated forms of teaching are needed to develop student competencies such as deep mastery of challenging content, critical thinking, complex problem-solving, effective communication and collaboration, and self-direction. In turn, effective professional development (PD) is needed to help teachers learn and refine the pedagogies required to teach these skills. Desimone (2011), Loucks-Horsely *et al.*, (2003) and Ingvarson *et al.*, (2005) concur that due to increased financial investment in professional development, policy makers have increased their search for evidence on the effectiveness of professional development programmes on teachers' knowledge, teaching practice and student learning.

Teacher learning can take place in different ways; it can be formal or informal and planned or incidental (Bertram, 2011). Formal learning is seen as learning that occurs in a controlled environment, with structured activities and specific outcomes, (Govender, 2016). Teacher learning occurs in social contexts such as groups, subject committees and departments, workshops and on school verandas. Collaborative teaching can be regarded as informal learning, as it may occur spontaneously and also as formal learning as it can be planned for learning to be successful. Scholars Hoekstra, Brekelmans, Beijaard and Korthagen, (2009); Kennedy (2011) and Wilson and Demetriou (2007) argue that both these forms of learning cannot work successfully in isolation, then they are essential in teacher learning. Likewise, Datnow (2011:152) defines teacher collaboration as "sharing of expertise in delivering a lesson, solving a problem or working together on a project". From these definitions, one can conclude that teachers agree to work together, sharing their teaching advice while using their varied expertise. Collaborative teaching is a strategy that has been used across different countries in the world.

Historically, collaborative teaching has been seen as a panacea for student learning (Roth &Tobin, 2005). More recently, collaborative teaching has been situated in the context of school improvement. Collaborative teaching was introduced to teachers to encourage them to work as a unit, thus enhancing their development (Rytivaara &Kershner, 2012). Studies by Ranamane (2006) and Kingsley (2012) revealed that teachers were motivated to use collaborative teaching as a model for teachers learning to become knowledgeable about teaching and improve their teaching practices.

The professional development of Science and Mathematics teachers globally and, particularly in South Africa, is a critical subject that draws public interest as it affects educators pedagogical- content knowledge which in turn impacts on learner performance. Concerns in the policy and public domains emanate from failure to measure if the professional development initiatives and programmes are worth the huge budgets from the taxpayers. In the study, Loucks-Horsely`s (1998) design framework was the cornerstone of the Collaborative model design and structure and recommendations for its implementation due to its theoretical and empirical applicability in the South African context of education.

Wei *et al.,* (2009) defines professional development as the processes and activities designed to improve teachers' knowledge, the practice of instruction and learning outcomes of students. Gordon (2004:5) further elucidates that professional development is, "Experiences that empower individual teachers, educational teams and organisations to improve curriculum instruction and student assessment in order to facilitate growth and development." Therefore, professional development is broadly learning programs designed to capacitate educators and take different forms which include coaching, mentoring, study groups, action research, observation of teachers, in class practices and enactment of curriculum in classroom among others. Fig 4.4 depicts the concept of continuing professional development which constituted the key variable underpinning of the designing the collaborative model for mathematics teaching and learning.


**Fig 4.4 Concept of Continuing Professional development (Gray (2005)**

Gray (2005) and Diaz-Maggioh (2003) explain the concept of Continuous Professional Development as ongoing improvement of individual teachers' professional knowledge and skills in an evolving process aimed at improving how work is done and involves reflection and improvement. In the South African context, the term CPD is a highly priced professional engagement of educators in improving their work practices and is referred to as in-service training (INSET) and the South African Council of Educators, the statutory body policing registration of educators, encourages educators to participate in such programmes in order to be relevant to the ever-changing teaching and learning contexts.

### 4.3.1. Outline of Theoretical and Conceptual framework for designing a Professional Development model in Science and Mathematics

The design was infused by the continuous reflection during implementation which is anchored on the outcomes of the program to re-evaluate and further improve the staff development model. The model design framework is adapted from Louck-Horsely *et al.,* (1998) which will be a guide to the process of developing the model. Loucks-Horsely *et al.,* (1998) contend that in developing a professional development model it is important to draw upon "practitioner wisdom" implying that the design is a product of discussions with prominent professional developers, Mathematics and Science educators, and integrates elements from different models. Loucks-Horsely and Matsumoto (1999) further assert that teachers' knowledge be included as a mediating variable between professional development and student learning since it shapes both teaching practice and educators` pedagogical–content knowledge.

Supovitz (2001) contends that the logic behind professional development is that high quality professional development will transform classrooms and ultimately result in increased and improved learners' achievements. The availability of collaboration, time, long term commitment, and resources are important for the successful implementation of professional development (Maria & García, 2016). Many believe that the level of intensity of participation in professional development activities are partially a function of the sort of backing that teachers get to participate in them or the type of barriers they encounter (Avalos, 2011; Jurasaite-Harbison & Rex, 2010; Mahmoudia, & Özkana, 2015).

Loucks-Horsley *et al.*, (1998) presented a comprehensive theoretical design framework for Mathematics and Science professional development models for the United States of America educational system where student learning was the ultimate goal. Teachers were portrayed as the main level for students through which that goal could be achieved. The design framework emphasizes the continuous and circular design permeating the implementation of professional development programmes.

The study used as guidance the professional development design framework for Mathematics and Science education reform described by Loucks-Horsley *et al.*, (1998:16–24). The framework is presented in the form of a figure (see Figure 4.5). A generic planning sequence which consists of four elements - goal setting, planning, doing, and reflecting is at the centre of the framework. This is referred to as the implementation process. In the next three chapters it was shown how this process was applied in the development of the collaborative model. The circles (see Figure 4.5) represent important inputs into planning and goal setting. These helped to facilitate informed decisions by pointing professional designers to the wide repertoire of existing professional development strategies as well as the critical issues that Mathematics and Science education reformers are most likely to encounter. Both the goal setting and planning processes are influenced by the programme designer's understanding of the unique features of his/her own context and the knowledge base (knowledge and beliefs).

Reflection can influence every input which, in turn, affects the creation of a new and better design. This is elaborated on later in the chapter which deals with the construction of the model and intervention guidelines in using the model. Finally, Figure 4.5 indicates multiple feedback loops from the reflect stage to illustrate how the design continues to evolve as practitioners learn from doing.

**4.3.2Key features of Loucks-Horsley *et al.*, (1998) Framework for Designing Professional Development model for Science and Mathematics**

Fig 4.5 presented the underpinning framework that was used to develop the Collaborative model of the study. In the sections below, the views of Loucks-Horsley *et al.*, (1998:16–24) on each of these elements are discussed as a prelude to the researcher's views on the design framework and its application in designing a collaborative model for teaching and learning Mathematics in secondary schools.

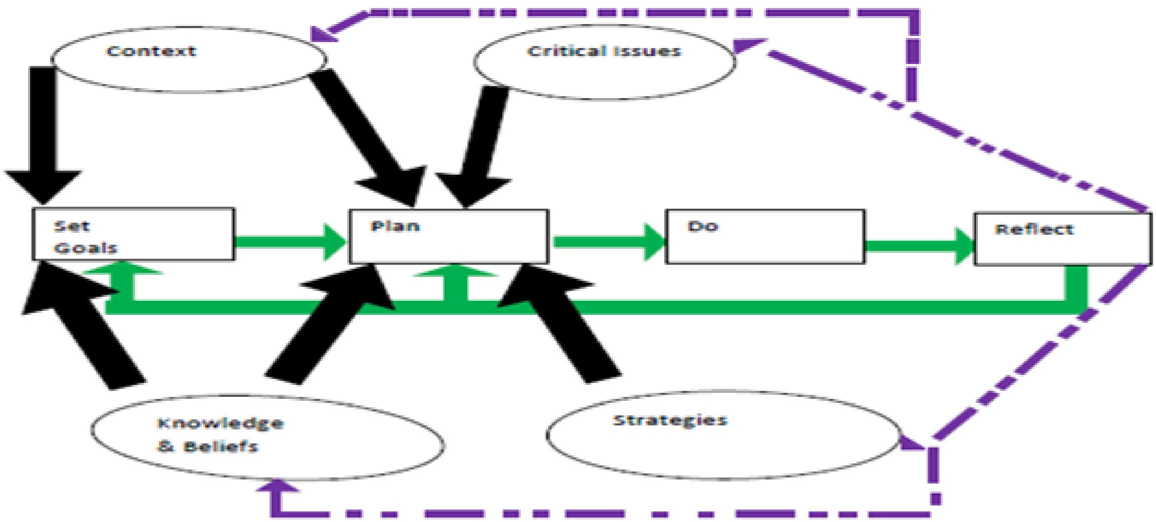


**Figure 4.5: Framework for Designing Professional Development model (Loucks-Horsley et al., 1998:17)**

**4.3.2. Knowledge and Beliefs**

*"How long did it take you to make that pot?'' Someone asked a potter. "A lifetime", the potter replied. –Source unknown*

Designing a professional development model for Science and Mathematics requires in-depth underpinnings from a pool of knowledge evolved over many years of research and practice (Loucks-Horsley *et al.*, 2003). Tapping from past research and experiences in practice enables designers to avoid reinventing a wheel or trotting the wrong path, which may be costly and embarrassing.

Knowledge and beliefs constitute two key variables that form the pillars of designing a professional model. Knowledge and beliefs comprise the programme designer's knowledge base that can help him or her to make informed decisions. They will be discussed separately together with other framework variables which are as follows:

- Context critical issues
- Set goals.
- Plan, do, reflect.
- Knowledge and beliefs
- Strategies

**4.3.3. Knowledge**

The work of the professional programme designers is informed by five distinct but related knowledge bases, namely knowledge about:

- Learners and learning in general.
- Teachers and teaching
- The nature of the disciplines of science
- The principles of effective professional development
- Change and the change process.

**4.3.4. Beliefs**

Beliefs are pieces of knowledge embraced by professional developers as their own. They are, therefore, the ideas people are committed to, also referred to as core values, fundamental choices or mental models. Beliefs shape one's ways of perceiving and acting (Loucks-Horsley, 2003). If designers clarify and articulate their beliefs, these beliefs become the conscience of the programme which shapes the goals, drives decisions, creates discomfort when violated and stimulates ongoing critique. Beliefs are regarded as a critical input into goal setting and planning (Loucks-Horsley *et al.*, 1998:18). Thus, beliefs anchor designers' vision, goals, and purpose of designing a professional development model and bring life into the activities they will be engaged in various processes of programme development and implementation.

### 4.3.5. Strategies for professional development in Mathematics

Programme designers are in a much better position to come up with a workable strategy or combination of strategies after a repertoire of strategies has been considered. Multiple strategies could be used in a single programme with the aim of meeting the different needs of programme participants. Strategies constitute key inputs by which goals for the programme are implemented and sustained over the implementation process. Through programme strategies developers can enable change agents who are teachers to imbibe and embed professional learning into their daily lives (Loucks-Horsley *et al.,* 2003). Table 4.1 presented Loucks-Horsley *et al.,* (2003) presents eighteen strategies for professional learning as follows:

**Table 4.1: Aligning and Implementation of Curriculum**

| Aligning and Implementation of curriculum | Collaborative structures | Examining teaching and learning | Immersion experiences | Practicing teaching | Vehicles and mechanism |
|---|---|---|---|---|---|
| Curriculum alignment and instructional materials selection | Partnerships with scientists and mathematicians in business, industry, and universities | Action research | Immersion in inquiry in science and problem solving in Mathematics | Coaching | Developing professional developers |
| Curriculum implementation | Professional networks | Case discussions | Immersion into the world of | Demonstration lessons | Technology for professio |

| | | | | | |
|---|---|---|---|---|---|
| | | | scientists and mathematicians | | nal development |
| Curriculum replacement units | Study groups | Examining student work and thinking, and scoring assessments Lesson study | | Mentoring | Workshops, institutes, courses, and seminars |

The Table 4.1 presented the strategies that address specific issues and concepts that developers focus on and as such a triangulation of the various strategies in pursuit of quality professional development may result in real change in the teaching and learning of Mathematics in secondary schools.

**4.3.6. Context**

Context is also complex, composed of many interconnected and dynamic influences events and beliefs, among other aspects. Therefore, when one is designing a study, one must clearly understand the context. Loucks –Horsley *et al*., (2003) propound that skilful designer should have one foot planted firmly in theory (knowledge, beliefs, and strategies) and the other in reality. Designers of research must make sure that they understand the context in which they are working. However, they are also part of a community within which they must design a programme. They must be influenced by their vision of what Mathematics teaching, learning and professional development should ideally be.

Firstly, planners should clearly determine who the learners and teachers are. They must ensure they are well informed with the state of practice including curriculum statements, assessment, and the learning environment. They must be well acquainted with current policies and the state of available resources such as time, money, the expertise of the professional designers and community support. A description of the context within which the study must be designed is not enough. In my opinion based on the writing of Loucks-Horsley et al., (2003) reformers of Mathematics should address context (Loucks-Horsley et al., 1998, p. 20). The following are key context issues that the mathematics professional development programme developers must be mindful of:

- Students’ standards and learning results.
- Teachers and their learning needs
- Curriculum, instruction, assessment
- Practices and the learning environment
- Organisational culture
- Organisational structure and leadership
- National, state, and local policies of education
- Available resources
- History of professional development
- Parents and the community.

Contexts of implementing a Mathematics curriculum are complex, interconnected, and dynamic and as such, professional development models must consider contextual factors in the innovating schools so that the envisaged change will be well accepted and makes a positive impact on the quality of teaching and learning in secondary schools. Mathematics, as highlighted in Chapter 1, is a critical subject characterized nationally and provincially by under-performance, hence that context is paramount in crafting a Collaborative model.

#### 4.3.7. Critical issues

Loucks–Horsley *et al.*, (1998) examined professional development programmes in the USA. Common issues which seemed to be critical to the success of such programmes regardless of the context were identified. According to Loucks-Horsley *et al.*, (1998:21), these issues are equity and diversity,professional culture, leadership,capacity building for sustainability,scaling up,public support of the innovation,effective use of standards and frameworks,time for professional development and evaluation and assessment.The above critical issues served as elements that provided checks and balances regarding activities of educators involved in professional development that is performance indicators they were expected to imbibe as a result of engaging among themselves with the aim of improving their professional competency in mathematics.

### 4.3.8. The Implementation Process

Before starting to develop a professional development programme, designers needed a structure for planning and decision making. In general, they determined who will make the decisions, who has input into the decisions, what decision makers need to know and be able to do to carry out their role effectively, how decisions are to be made and how designers will communicate with stakeholders and build support for the plan.In the centre section of figure 4.6, the four aspects of the generic planning process are shown. These elements, goal setting, planning, doing, and reflecting will be referred to as the implementation process.

#### 4.3.8.1. Set Goals

In the South African context this corresponded to the outcomes outlined in the National Curriculum Statement (Department of Education, 2001b). Goals for teachers flow directly from goals for learners.

Once the structure of decision-making is in place, goals were set. Two kinds of goals are necessary if professional development is to be linked to learner achievement goals for students and goals for teachers. If designers set their goals for student learning, they must have knowledge about teaching and learning as well as knowledge about the nature of science treated explicitly in the national and some state standards (Loucks-Horsley *et al.*, 1998:22).

If learners must "develop a set of understandings, skills and predispositions", teachers need to know what to do to accomplish these outcomes for learners. Goals for teachers are also informed by referring to the standards and data about teacher performance needs and support available from stakeholders (Loucks-Horsley *et al.*, 1998:22). In the South African context, it is given, amongst others, in the *Norms and Standards for Educators* (National Educational Policy Act 1996).

### 4.3.9. Planning

In this phase planners scanned their context and uncovered important factors which they considered as they tailored their programme to their own circumstances.Planning is central in any innovation as it gives direction on processes. To plan is to sketch out your design. All the other inputs including critical issues, knowledge, beliefs, and strategies come into play in the planning phase. They may even decide to do more research on learning, teaching, Mathematics or Science, professional development, and change. Planners must consider how to confront critical issues such as scaling up, evaluation or leadership. Furthermore, during planning, professional designers think strategically about which strategy or combination of strategies to use, (Loucks-Horsley *et al.,* 1998:23).

**4.3.10. Doing**

"*The devil is in the details of implementation"- Unknown source.*

What programme designers know is that for fundamental change to happen, "teachers need to experiment with new behaviour and gain new understandings, which takes time. After making decisions, programme designers, according to Loucks-Horsley *et al*., (1998:23) move from the "sketching" to "painting" – the actual implementation of their plan.

This is the phase where they draw on their skills and knowledge as change facilitators and knowledge about implementation and the change process. Teachers will move through predictable developmental stages in how they feel and how they are using new approaches. However, the teachers' feelings, which can be unpredictable, must be taken into consideration. Programme implementation is prescriptive with specific activities and processes, but expertly monitored just like a patient who has previously undergone a medical operation and is under the care of a medical specialist. Programme designers invest their expertise to see the successful implementation of their innovations.

**4.3.11. Reflect**

It is rare for an entire programme to be carried out exactly as planned. As the action unfolds, designers discover what works and what does not. The designers can go back to the drawing board" after some feedback has been given. Programmes change when a better way has been discovered or when conditions change. None of the inputs remain static over time. The knowledge base is constantly growing. As professional designers learn from their experiences, they become active contributors to the knowledge base. As their needs and interests change, they look to research for new ideas." Beliefs can also change, while "critical issues are just as dynamic. New issues can arise as deeper understandings and insights are gained on the issues being struggled with. After designers have reflected by using the feedback they received, they can refine the programme and start with revised goals, planning, doing, and reflecting again. Therefore, designing professional development is a continuous interactive and cyclic process (Loucks-Horsley *et al.*, 1998:23-4).

### 4.4. **Interpretation and Application of the Design Framework in Designing the Collaborative Model**

"*The task of education can no longer be seen as a task of conveying ready-made pieces of knowledge to students, not in Mathematics education, of opening their eyes to an absolute mathematical reality", Von Glasersfeld (1990).*

The persistent underperformance in Mathematics and Science education as highlighted in chapters 1,2 and 3 demanded a paradigm shift in pedagogical approaches, conception of the learner and teacher, assessments, teaching and learning materials used in classrooms. Conception of the learner as a blank slate, passive and only an absorbing recipient of the teaching and learning process with the teacher as an expert and transmitter of eternal knowledge has been overtaken by contemporary activity-based, learner-centred, interactive, and empowering pedagogies.

Prawat (1992) posits that constructivism offers a paradigm shift in the focus of teaching and learning by putting the students' own efforts to understand at the centre of educational enterprise. Ginsberg and Seo (1999) concur that constructivism helps the teacher to focus on both the child's constructive process and the Mathematical content underlying the child's thinking in order to support children's progressive mathematisation of self constructed ideas. This implies that through employing constructivist pedagogies learners create their knowledge through active participation in planned activities in groups, pairs, and individuals interactively.

Rosenthal (1995) further contended that most Mathematicians agree that the best way to learn Mathematics is by actively doing Mathematics, by discussing it with others and by synthesising major ideas. This means that in a constructivist classroom the teacher intercedes, mediates between the learner, content and learning process and that results in the generation of mathematical ideas and understandings as learners engage in discussions, projects, assignments and models that are ultimately imbedded in their minds as permanent reality of their world.Prideaux (2007) reiterates that the essence of constructivism is that it birthed active learning also known as learning by doing, learning by experience, learning through action, student centred learning, peer, and collaborative and corporative learning.

In support of using constructivism as a conceptual framework in Mathematics education discourses, Owusu (2015) summarises the following as benefits:

- Children learn more and enjoy learning more when they are actively involved rather than being passive learners.
- Education works best when it concentrates on thinking and understanding than on rote memorisation.
- Constructivist learning is transferable.
- In constructivist classrooms learners create organising principles that they can readily transfer to other learning settings.
- Constructivism gives ownership of what they learn since learning is based on learners' questions and exploration and other learners have a hand in designing the assessment as well.
- Constructivism promotes social and communication skills by creating a classroom environment that facilitates collaborative interaction and exchange of ideas.

Therefore, as has been highlighted above, the researcher followed a constructivist orientation mainly because it presents a reformist, paradigm shift from traditional teaching and learning processes to progressive and empowering pedagogies that are fronted by a reformed classroom, reformed teacher and reformed pedagogical approaches that promote effective learning of Mathematics and subsequent improved students' performances which is the thrust of the study. In the constructivist theory of learning, teaching focuses on the learners' understanding, while keeping in mind that knowledge is a network of conceptual structures which cannot simply be transferred by the use of words. It cannot exist in some complete form outside the learner and be internalised, stored, and reproduced at some later time. Knowledge must be constructed by each individual learner.

Teaching is a social activity which involves others whom the teacher intends to influence. Although learning is a personal activity in the sense that it must take place in the learner's own mind, teachers must guide learning and will have to have some notion of the concepts the learners already have and how they are related (Von Glasersfeld, 1992:33).

- ***Knowledge-:*** In the following sections the researcher gives views on knowledge about learners and learning; teachers and teaching; the nature of Science and Mathematics;

principles of effective professional development and the knowledge base of change and the change process. Some of these views are in line with the views of Loucks-Horsely *et al.*, (1998), the originators of the conceptual framework for designing the Collaborative model.

- ***Learners and learning***: -When learners' conceptions are investigated, insight is gained into their ways of thinking about and their understanding of Science and Mathematics. Learners and learning are, therefore, entities which are difficult to separate (Duit, Treagust & Mansfield, 1996:17). To understand learners' ways of thinking, the following aspects are distinguished:
- ***Learning is influenced by what learners know***-What learners know influences what they learn. According to Ausubel (1968), the most important single factor influencing learning is what the learner already knows. Ascertain this and teach accordingly (Ausubel, 1968: v). For example, if a learner has a specific picture in his mind about the concept probability of a soccer match outcome, this picture influences any additional learning about this topic, even if his/her conception is inconsistent with accepted knowledge. Learning is, therefore, influenced by the learners' existing knowledge and it is often difficult to change his/her conception and to build a new understanding. Therefore, all learning should spring from the known to the unknown knowledge of the learners.
- ***Knowledge is constructed by learners:*** -Learners construct their knowledge using their own processes. The process of creating meaning is the construction of links between new ideas and what the learner already knows. This could be done by creating ideas for the first time, making sense of their intuitive ideas, or extending existing views. No one can do it on their behalf. In addition, personal reflection is also an aspect of the process of learning. Learners must be "able to monitor their own ideas". This can be done through processes such as comparing or contrasting their views with other views, or providing reasons why one viewpoint is more acceptable than another. Thus, learning is a "personal activity" "embedded" in "social interaction" (Loucks-Horsley *et al.*, 1998:28).
- ***The construction of new knowledge is a process of change:*** -Hewson (1996:132) describes learning as a process in which a person changes his or her conceptions by capturing new conceptions, restructuring existing conceptions or exchanging existing conceptions for new conceptions. Only dissatisfaction with existing conceptions can prompt a learner to change them. Learners must have reason to believe that their current knowledge is inadequate. Therefore, learning is a process of construction not only involving additions to knowledge,

but sometimes involving remodelling of existing knowledge. Mathematics learners thus must be inquisitive and knowledge thirsty to sustain interest in the subject.

- ***New knowledge comes from experience: -***There are different types of experiences which contribute to the construction of a learner's knowledge. For example, in Mathematics there are problematic situations, reflecting on one's own ideas and thoughts and indirectly using resources like books, television, radio, or by having a conversation. Therefore, learning is greatly influenced by others and is not self-contained (Loucks-Horsley *et al.,* 1998:30).
- ***All learners are capable of understanding and doing Science***: All learners have the capability to understand and do Science "regardless of race, culture and gender". This ability is rooted in their curiosity about natural phenomena and their desire to inquire into and make meaning of Science (Loucks-Horsley *et al.*, 1998:30).
- ***Reflective practice and Meta cognition:*** Learners actively construct knowledge. However, these learning processes need to be facilitated. Reflective practice helps learners to develop metacognitive strategies which promote the understanding of the learning process and the development of responsible lifelong learners. According to Gunstone and Northfield (1994:526), metacognition means having an informed and self-directed approach to recognizing, evaluating, and deciding whether or not to reconstruct. Learning of Science and Mathematics can be promoted when laboratory experiences are integrated with other metacognitive learning experiences such as "predict-explain-observe" demonstrations and when they incorporate the manipulation of ideas instead of simply materials and procedures (cited in Lunetta, 1998:251).
- ***Teachers and teaching-:*** To break away from the view of teaching in a typical classroom where teachers "provide authoritative explanations and expect learners to memorise", a broader view on teachers and teaching is captured under the following concepts, (Loucks-Horsley *et al*., 1998:30):
- ***Teaching must facilitate learning***: -Globally, emphasis is being shifted from teacher-centred to learner-centred approaches. "Changes from previously implemented practices to those required for constructivist teaching/learning approaches do not take place all at once" (Hand, 1996:212). When teaching is based on a constructivist view of learning, the teacher is a neutral facilitator who does not intervene or tell the students any Science. In teaching based on a constructivist view of learning, the teacher interacts with the students' thinking and facilitates the students' thinking and learning (Bell & Gilbert, 1996:55). The teacher is involved in ways such as explaining the Science to learners but does not tell the Science to

learners immediately. He/she would rather ask questions or suggest some activities to stimulate them to think. Therefore, learning lies at the heart of teaching. This implies that teachers must know what level the learners are, where to start, ensure that the work they teach is in line with the present curriculum and presented in such a way that the learners can grasp it. Fittingly, the researcher carried out a baseline study (Chapter 6) to ascertain the mathematics learners' levels of performance. On the other hand, learners also have a responsibility to make the connections between where they are and where they intend to be. Learning is the sole responsibility of the learner, and if he/she does not intend to learn, no learning will take place. For this reason, teaching does not imply learning and it cannot be said that "without learning teaching did not happen" (Loucks-Horsley *et al.,* 1998:31).

- ***Professional teachers have specialised knowledge:*** **-**Loucks-Horsely *et al.*, (1998) emphasised the following: Excellent Science and Mathematics teachers have a very special and unique kind of knowledge that must be developed through their professional learning experiences. Pedagogical content knowledge – that knows how to teach specific scientific and Mathematical concepts and principles to young people at different developmental levels– is the unique province of teachers and must be the focus of professional development. Knowledge of content, although critical, is not enough, nor is knowledge of general pedagogy. There is something more to professional development for Science and Mathematics teachers than generic professional development opportunities can offer. (Loucks-Horsely, *et al.,* 1998: xviii). Furthermore, Shulman (1987) has outlined categories of knowledge from which teachers draw during their teaching.
- Content knowledge
- General pedagogical knowledge with specific reference to those broad principles and strategies of classroom management and organisation that appear to transcend subject matter.
- Curriculum knowledge, with particular grasp of the material and programmes that serve as "tools of the trade" for teachers.
- Pedagogical content knowledge, that special subject content and pedagogy that is uniquely the province of teacher, their own special form of professional understanding.
- Knowledge of learners and their characteristics
- Knowledge of educational contexts, ranging from work in groups in classroom, the governance and financing of school district, to the character of communities and cultures in which they work.

- Knowledge of educational ends, purposes and values, and their philosophical and historical grounds (Shulman, 1987:8). However, teachers as professionals should realise that their learning about teaching does not stop after they have obtained their teaching qualification. They are expected to learn continuously throughout their teaching career through participation in appropriate professional development learning opportunities. Only then would they succeed in achieving an uninterrupted improvement of their teaching capabilities (Loucks-Horsley *et al.*, 1998:32). Fig 4.6 displays an interaction among key factors that create and sustain teacher quality in mathematics teaching which are a possession of right attitudes torwards the teaching of the subject professional skills and abilities, professional knowledge and understanding as well as pedagogical knowledge of Mathematics.

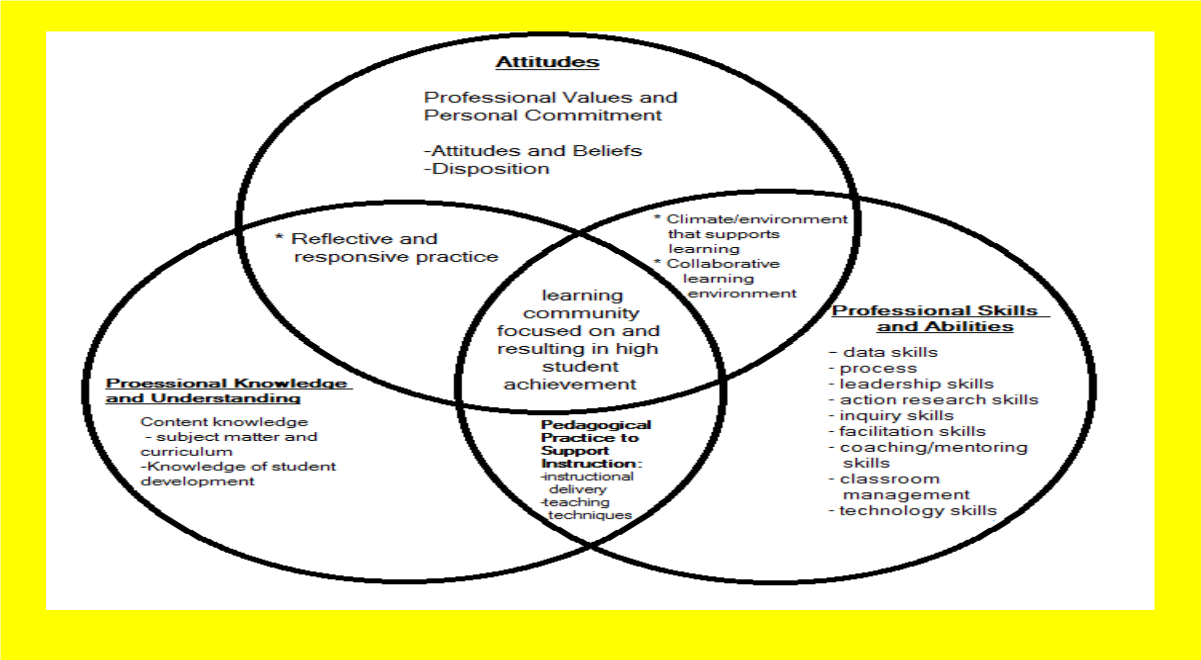


**Figure 4.6: Professional Development Key Features in Ensuring Knowledgeable and Effective Teachers of Mathematics in Secondary Schools**

### 4.4.1. Nature of Mathematics knowledge

Mathematics is defined as a definite body of knowledge and involves the study of quantity, structure, space, and change (Ndlovu, Pournara, & Mwakapenda, 2019). The nature of mathematical knowledge is defined in various ways such as: the absolutist and fallibilist nature of mathematical knowledge (Ernest, 1991), pure, impure, and im/pure nature of mathematical knowledge (Luitel 2013) and so on. Teachers' experiences of learning and teaching mathematics, beliefs towards mathematical knowledge, attending conferences, workshops or teacher training programs play an important role in constructing different natures of mathematical knowledge. The absolutist view of mathematical knowledge consists of fixed, certain, or unchangeable truths whereas, fallibilist view of mathematical knowledge consists of mathematical truth as fallible and corrigible and is always open for revision and change, Luitel (2020).

Acquiring Mathematical knowledge about how the world functions does not necessarily lead to an understanding of how Mathematical concepts are acquired. Neither does knowledge of the philosophy and sociology of science alone lead to a scientific understanding of the world. The challenge for teachers is to integrate these different aspects of Mathematics in such a way through creative planning of their teaching that they reinforce one another. Both the teachers' and students' experiences towards the nature of mathematics directly or indirectly affect their teaching and learning mathematics., Luitel and Pant (2019) argued that teachers' understanding of mathematics curriculum is different and it matters a lot to select the pedagogy. Constructing with interviews of mathematics teachers, they identified different images of mathematics curriculum namely, curriculum as a format for the textbook author, students' experience of learning, interactive process of teaching and learning, jack of all trades and masters of none. These images of mathematics curriculum reflect their understanding of the mathematics curriculum based on their curricular practices. These types of understanding of mathematics teachers towards mathematics curriculum really affect teaching and learning mathematics either positively or negatively and construct different natures of mathematics.

Mathematics knowledge is dynamic since our understanding of the world is constantly changing. Through the practicing of Mathematical concepts, it is attempted to build a picture of the real world in terms of concepts, principles, theories, or constructs that can be used to explain what has been observed and predict what has not. In the Mathematics classroom, the question does not stop at "what do we know?", but "how do we know it?". This can stimulate social dialogue between learners, between learners and teachers, between learners and the natural world, with the ideas of experts as well as within themselves. Through dialogue the learners can construct new meanings and formulate arguments which contribute towards their development as critical thinkers (Loucks-Horsley *et al.*, 1998:34). Hua (2015), teachers who are guided by practical interest can succeed in maintaining an educative relationship between teachers and students as well as teachers and their colleagues with mutual understanding. On the one hand, everyone such as teachers, students, and other stakeholders put their opinion without fear. On the other hand, they respect each and everyone's thoughts. Students can learn and enjoy the embodiment of local as well as global wisdom such as freedom of expression, togetherness, happiness, sense of friendship, and so on. Through mathematical games, collaborative activities and real-world problem solving and so on. The above cited interactions call for new, socially derived pedagogical approaches in teaching and learning of Mathematics in secondary schools hence the collaborative model that was developed in the study.

### 4.4.2. Principles of Effective Professional Development

Through working collaboratively, teachers can create communities that positively change the culture and instruction of their entire grade level, department, school and/or district. Uses models of effective practice: Curricular models and modeling of instruction provide teachers with a clear vision of what best practices look like. Teachers may view models that include lesson plans, unit plans, sample student work, observations of peer teachers, and video or written cases of teaching. Provides coaching and expert support: Coaching and expert support involve the sharing of expertise about content and evidence-based practices, focused directly on teachers' individual needs. Offers feedback and reflection: High-quality professional learning frequently provides built-in time for teachers to think about, receive input on, and make changes to their practice by facilitating reflection and soliciting feedback. Feedback and reflection both help teachers to thoughtfully move toward the expert visions of practice. Is of sustained duration: Effective PD provides teachers with adequate time to learn, practice, implement, and reflect upon new strategies that facilitate changes in their practice, Darling-Hammond, Hyler and Gardner (2017).

#### 4.4.2.1 Collective Participation

A critical feature of high-quality PD mentioned in several studies, Borko et al., 2010; Desimone, 2009; Garet et al., 2001; Guskey, 2003) is that programs should be organized around collaborative learning environments, and that groups of teachers from the same grade, subject, or school should participate in the PD together. PD programs that are designed for groups of teachers are believed to have several advantages in comparison with those designed for individual teachers (Garet et al., 2001). Firstly, these kinds of professional learning communities enable interaction and discourse among colleagues. Secondly, teachers from the same school or grade level are more likely to share common curriculum materials, course offerings, and assessment systems. Thirdly, teachers teaching the same students can engage in discussions around needs across grade levels and classes. Fourthly, the collective participation of teachers from the same school may support the development of a shared professional culture and a common understanding of instructional goals, which in turn may help sustain changes in practice over time. At the same time, studies have shown that even in communities where teachers are given time to work together, significant gains in student achievement are not present (Kennedy, 2016; Timperley et al., 2007; Vescio, Ross, & Adams, 2008). What and how teachers discuss, and the support they are given, must also be taken into consideration. To begin with, the participating teachers need to be willing to openly discuss the issues they encounter in practice (Cobb & Jackson, 2011). Further, the discussions should be focused around investigating relationships between instructional practice and student learning (Vescio et al., 2008). Finally, these discussions often benefit from the support of external expertise, such as researchers within the field (Blank & de las Alas, 2009; Timperley et al., 2007.

### 4.4.3. Change and the change process.

*"The crux of change is how individuals come to grips with reality" (Fullan, 1991:30).*

All real change involves loss, anxiety, struggle and even resistance. To change is not an easy process. It takes time and persistence. Research on teacher change indicates that changes in attitudes often result when teachers use a new practice and see their students benefiting. Active engagement with new ideas, understandings and real-life experiences seem to cause fundamental changes (Loucks-Horsely *et al.,* 1998:38-39). In designing the Collaborative Model, Mathematics educators were subjected to a change process which sought to bring about pedagogical shifts from Socratic, traditional methods to interactive, collaborative pedagogies.

The new paradigm for professional development requires teachers to engage in inquiry, work collaboratively, share knowledge and skills, observe, discuss, and evaluate their own and others' teaching, expand their perspectives beyond their particular classroom, and accept new leadership roles. Such a shift requires major changes in practice for which teachers have no tradition and little preparation (Collinson and Ono, 2001:234). Contrary to teacher change, educational changes are far-reaching and comprehensive. Such changes imply changes affecting every teacher, school, and tertiary institution and even the design of the professional development programmes. The domino effect of educational change is easily noticeable.

For example, in the classroom, new or revised materials will have to be used, new teaching approaches, for example, new teaching strategies or activities will have to be implemented and beliefs or programmes will have to be altered such as pedagogical assumptions and theories underlying particularly new policies will possibly have to be assimilated. All these changes are necessary because together they represent the means of achieving a particular educational goal or set of goals. Therefore, to improve teaching, change is unavoidable. Professional development of teachers is an indispensable mechanism to effect change and, as such, professional development is a critical component of Mathematics education reform. To facilitate the implementation of change, professional development programmes should, therefore, also provide opportunities for the preparation and motivation of teachers to accept change.

### 4.4.4 Influences of Content Knowledge on Teaching

It is the researcher's belief that the greater grasp of content a teacher has, the more open he/she is to innovative teaching approaches. Such teachers are more confident and are eager to go to class and to engage in a wider range of professional practices. Generally, they are much more positive in their approach to teaching. The following authors also support the view that teachers' knowledge of content influences their teaching. Brophy (1990) states that, "Where [teachers'] knowledge is more explicit, better connected and more integrated, they will tend to teach the subject more dynamically, represent it in more varied ways, and encourage and respond fully to student comments and questions. Where their knowledge is limited, they will tend to depend on the text for content, de-emphasize interactive discourse in favour of seatwork assignments, and in general, portray the subject as a collection of static factual knowledge" (cited in Fennema, 1992:15).

Fennema (1992) reported that her research showed that content knowledge influences the decisions teachers make about classroom instruction. "The nature of the impact and the impact on their students' learning was less clear". However, in the area in which the teacher was more knowledgeable, instruction and subsequent learning were richer (Fennema, 1992:149).

Carlsen (1989) maintained that a high level of teacher content knowledge resulted in fewer questions asked by the teacher and more questions asked by the learners. This resulted in higher levels of learner participation. On the other hand, low levels of teacher content knowledge, seemed to relate to insignificant learner participation levels and to low-level teacher questions (cited in Fennema, 1992:153).

According to Jane Butler-Kahle (1999), research funded by the National Science Institute of America showed that improved teacher content knowledge might change teaching practices and improve student learning...when teachers cover topics about which they are well prepared, they encourage student questions and discussions, spend less time on unrelated topics, permit discussions to move in new directions based on student interest, and generally present topics in a more coherent way–all strategies described as standards-based teaching. However, when teachers teach topics about which they are less well informed, they often discourage active participation by students, keep any discussions under tight reign, rely more on presentation than on student discussions and spend time on tangential issues (Kahle, 1999:3).

In her review of research on Effective Teaching of Science in Scotland, Harlan (1999) found that, "studies lead to the conclusion that, although the research leaves little room for doubt that increasing teachers' own understanding is a key factor in improving the quality of teaching and learning in Science, there are other factors which have to be considered as to why understanding is needed, not so that teachers can convey factual information didactically to pupils". Rather it is so that they can ask questions that lead children to reveal and reflect on their ideas, so that they can avoid "blind alleys", so that they can provide relevant sources of information and other resources, to identify progress and the next steps that will take their learning further (Harlan, 1999:80).

Lockheed and Verspoor (1991:62) also maintained that effective teaching was determined by the individual teachers' knowledge of the subject matter and mastery of pedagogical skills. Taylor and Vinjevold (1999) elaborated on the South African situation that teachers' poor grasp of the knowledge structure of Mathematics, Science and Geography acts as a major inhibition to teaching and learning these subjects, and this is a general problem in South African schools (Taylor & Vinjevold, 1999:142).

#### 4.4.5. Relationship between Professional Attitudes and Teaching

The teaching of mathematics in South African schools is amongst the worst in the world. In 2011, the Trends in International Mathematics and Science Study (TIMSS) showed that South African learners have the lowest performance among all 21 middle-income countries that participated. A recent CDE report further underlines the issue as it found rapid increases in enrolments in private extra mathematics classes, which was partly in response to poor teaching in public schools,' (McCarthy & Oliphant, 2013: 3).

Attitude is a central part of human identity. Everyday people love, hate, like, dislike, favour, oppose, agree, disagree, argue, and persuade. Attitude as a concept is concerned with an individual's way of thinking, acting, and behaving. It has very serious implications for the learner, the teacher, the immediate social group with which the individual learner relates, and the entire school system. Attitudes are formed as a result of some kind of learning experiences students go through, Ngeche (2017). This is mimicry, which also has a part to play in the teaching and learning situation. In this respect, the learner draws from his teachers' disposition to form his own attitude, which may likely affect his learning outcomes, (Yara 2009).

Teachers', especially prospective teachers' attitudes—not only towards mathematics, but also towards teaching of mathematics—are important because there is a significant relation between teachers' attitudes towards teaching mathematics and their practice in teaching mathematics. As a result, they have a powerful influence on the students' attitudes towards mathematics, Tabuk (2018). For Zan and Martino (2007), attitude towards Mathematics is just a positive or negative emotional disposition towards Mathematics. Neale (1969), however, defines attitude towards Mathematics as an aggregated measure of a liking or disliking of Mathematics, a tendency to engage in or avoid Mathematical activities, a belief that one is good or bad at Mathematics, and a belief that Mathematics is useful or useless. Similarly, Hart (1989) considers attitude towards Mathematics from multidimensional perspectives and defined an individual's attitude towards Mathematics as a more complex phenomenon characterised by the emotions that he associates with Mathematics, his beliefs about Mathematics and how he behaves towards Mathematics. Attitude towards Mathematics includes the tendency to be fearful of and anxious about Mathematics.

An understanding of how attitudes are learned should establish a connection between teachers and students' attitudes, and attitudes and performance. Bridget, Vemberg, Twemlow Fonag, and Dill (2008) studied how the teachers' attitude contributed to students' academic performance and behaviour. The study unveiled, among other things, that students with more devoted teachers were regarded by their peers as helpful to victims of bullying relative to students with less devoted teachers. The study also disclosed that students with devoted teachers had the courage and determination to face difficulties in school life. Teachers were recognised as those who provided support, encouraged students and their value for love eradicated unwanted behaviour in students. Teachers are, invariably, role models whose behaviours are easily copied by students. What teachers like or dislike, appreciate and how they feel about their learning or studies could have a significant effect on their students, Teachers' beliefs about Mathematics such as the usefulness of Mathematics, the way Mathematics should be learned, the difficulty or ease of Mathematics, as well as gender ability and beliefs also affect their attitude towards the subject and impact on students' performance, Ngeche (2017).

Kirsten and Clive (2012) argue that the challenge facing teachers is how to negotiate their dual role, that of teachers-aslearners in PD as well as teachers of children, amid pressures associated with high workloads, expectations to teach across all curriculum areas, and competing and constantly changing desires and demands of policy makers, parents/caregivers, principals, and students. This challenge is accentuated in PD programmes by developers and deliverers that appear to position the students as the learners and convey to the teachers that their own learning is not central to the process, that they are simply conduits for change.

Yara (2009) confirms that teachers with positive attitudes towards the subject likewise stimulate favourable attitudes in their learners. Henderson and Rodrigues (2008) and Quinn (1997) regard the main source of negative learner attitudes toward mathematics as inappropriate teaching practices and teacher attitudes. Ma and Wilkins (2002) finally put the vital role of teacher attitudes and beliefs into perspective, when they posit that learners who believe that teachers have high expectations of them tend to have a more positive attitude towards mathematics.

**4.5 Theoretical links between theoretical frameworks, professional development framework and collaborative model design**

In the study theoretical frameworks of social constructivism and network theories built the thesis foundation, conceptualized the study, and provided a reference point for interpretation of findings, (Merriam and Simpson, 2000). The theoretical frameworks were pillars, the structure, and the scaffolding frame through which the existing theories that underpinned the study were developed. Construction of Mathematics by educators and the learners within a social context resulted in effective teaching and learning in schools and classrooms in Centocow cluster.

Nooteboom (2004) posit that schools through purposive action can also network in the way business often do to save material and staff costs and share expertise on pedagogical approaches for the provision of more effective and scalable Continuing Professional Development activities, Hadfield (2005).Thus, interconnected schools and groups of educators working with common aims and purposes to improve learning and teaching Mathematics constitute the pillars of the Collaborative model design and implementation. Collaboration, communication and networking among schools, educators and learners will result in creation of Mathematics learning communities in a network which was the ultimate output of the collaborative model.

Designing a collaborative model for teaching and learning Mathematics in secondary schools was a professional initiative hence underpinned by a Professional Development framework of Lockes-Horsely *etal.*, (1998) Apparently both the Professional Development framework (PD)and the collaborative model are brainchildren or are underpinned by Social Constructivism and Network theories as common concepts of socially interactive learning, collective utilization of expertise, resources, sharing and increasing the flow of information, creating social capital through innovative and contextually responsive pedagogical approaches were evident in the designing, construction and refining the Collaborative model. The Professional Development framework (Fig 4.6) and its concepts was further utilized in Chapter 6 as the research activities and processes frame in the implementation of the baseline study at Centocow cluster the research site of the study. Fig 4.8 below presents the relationship between theoretical frameworks, Professional Development framework and the collaborative model, the ultimate product of the study.


**Fig4.7**

**Relationship among theoretical frameworks, Professional Development Framework and Collaborative model**

The convergence of the twin theories of social constructivism and network theory is summarized in Figure 4.8. These two theories are responsible for providing the frameworks that support the pillars of the research investigation. While in the classroom, students as well as teachers need to collaborate on designing the model and share their knowledge, expertise, and best practices in mathematics with one another. Additionally, students need to collaborate with one another and do mathematics rather than simply listen to mathematics being taught by teachers and others.

### 4.6. Summary of the Collaborative Model Design Features and Implementation Processes

In the light of the above discussion the researcher believes that a collaborative holistic approach must be followed in the construction of the collaborative model. The teachers' content knowledge and Pedagogical Content Knowledge (PCK), professional attitudes and teaching approaches cannot be separated. Therefore, the Collaborative model must be constructed in such a way as to provide for the simultaneous development of these dimensions. If a holistic approach is followed, teachers' content knowledge may be improved without developing their skills to transfer the knowledge to their learners. On the other hand, concentrating on the teaching method and classroom skills and neglecting content knowledge may also render teaching efforts less fruitful.

#### 4.6.1. Strategies

A combination of strategies enriches the professional learning of teachers. Therefore, a decision had to be made about which strategies the best to follow when are planning the Collaborative model, because different strategies are used to fulfil different purposes. Loucks-Horsely *et al.*, (1998:42) regard a strategy as a learning experience that has identifiable characteristics that make it recognisable when implemented. In this study the aim was of constructing the Collaborative model to simultaneously improve Mathematics teachers' content knowledge, the way they teach and their professional attitudes. To achieve these aims the following strategies were employed:

#### 4.6.2. Mathematics Study Guide

The study material was proposed primarily for improving conceptual understanding, allowing teachers to experience an inquiry approach to Mathematics and improving their cognitive and experimental skills. It will also provide different teaching approaches that were inquiry based and provided examples of a learner centred approach. Furthermore, the teachers' knowledge would be developed in a unique way by integrating content knowledge, pedagogy, and pedagogical content knowledge. The study material will be composed in such a way that it also developed metacognition, that is, awareness on and reflection of the teachers' own learning and teaching. Worked out examples of mathematical concepts, activities and revision tasks are to form part of the proposed study material or textbook.

#### 4.6.3. Workshops

Teachers usually teach following the example of how they were taught. The best way to stimulate teachers to change their teaching is to convince them that the new way of teaching is better. According to Eick and Reed (2002:410), evidence suggested a strong influence between teachers' beliefs about teaching and learning and how they taught Mathematics. Their data and others suggested that a teacher incorporated his or her preferred learning style, based on learning history, into their approach to teaching. The workshops were incorporated in the planning of the model to help teachers to learn new behaviours, to develop conceptual understanding and to demonstrate teaching and practical skills in Mathematics.

#### 4.6.4. Journal writing

The journals or work diaries were compiled by the teachers to reflect on their own teaching and learning. They had to reflect on what they learned from their study material and what effect it had on their classroom practice, as well on ways in which they could change their classroom practice. Therefore, this strategy has been chosen primarily for reflecting and secondarily for building knowledge.

#### 4.6.5. Context

A specific professional development programme is distinguished from other similar programmes by the context within which it is implemented. Specific characteristics of situations influence the success of a programme. Seven context factors that influence professional development design are discussed below.

- ***Learners-***The personal and professional growth of teachers probably has the greatest impact on the skills development, self-confidence, and classroom behaviour of their learners. "When teachers stop growing, so do their learners" (Barth, 1980:147). The main goal of education, therefore, is to improve teaching and teachers for the benefit of the learners. Thus, to determine the growth path of teachers, careful stock has to be taken of the state of the learners; how they are performing, what do they know? Only once their shortcomings have been identified can professional development for teachers be steered in the right direction. The state of performance of the South African learners in Mathematics and Science is unsatisfactory. They also compare unfavourably with international standards like the TIMSS and as revealed by World Bank reports. Their (educators) lack of grasp of the content is the cause of great concern. The language of teaching and learning Mathematics has also been cited as a reason for their weak performance.

Only 23% of the learners who participated in the TIMSS (2001) test were proficient in Afrikaans or English (language of the test) while 77% indicated that they seldom or never spoke the language of the test. However, the performance of learners from other developing countries also participating in the TIMSS test did not seem to be hampered by having to write the test in their second or third language (Howie, 2001:91). The reason for underperforming, therefore, seems to be much deeper than mere shortcomings in language proficiency. The bridging of the gap between where the learners are and where they ought to be, therefore, still remain the question to be answered. The researcher holds the view that equipping the teachers better through in-depth Mathematics content knowledge and pedagogical approaches could improve the outcomes.

- ***Teachers:*** Teachers should be devoted to keeping up to date with new educational technologies, new teaching methods, new learning and assessment methods, and new curriculum policies and innovations within the subject/learning area. It is a career journey which starts with initial teacher training and ends when a teacher retires. At different stages of teachers' careers different development needs arise. Teachers must have good subject knowledge and have to be equipped with contextually responsive pedagogical strategies in order to teach the subject in such a way that the learners can make it their own. A range of problems is being experienced with Mathematics teachers in South Africa (see Chapter 1). Few of them are suitably qualified. Furthermore, 88% of learners are taught by teachers younger than 40 years, which indicates that teachers are in an early stage in their careers (Howie 2001:105). Both nationally and internationally there appears to be a link between mature and experienced teachers and learner achievement in Mathematics and Science (Howie, 2001:97).

However, very often the conditions under which teachers work are underestimated. Some teachers must teach more than 300 learners per day, have to deal with large classes and consider themselves overworked. According to the White Paper on Education (Department of Education, 1995:10), the learner-teacher ratio for any given class in secondary schools should be 35:1. The average number of learners in Science for Grade 8 is 49 per class while the international average is only 31 learners (Howie, 2001:108). In addition, the teachers must carry a full load of extra mural activities and have to attend teachers, parents, and in-service meetings. Still, teachers are the greatest single factor influencing students' learning and therefore, should be the primary clients of professional development.

- ***Available resources:*** The South African government currently spends billions of rands on education (5.5%) of the Gross Domestic Product (see chapter 1), but the country's Science and Technological infrastructure that promotes the teaching and learning of Mathematics remains poor as highlighted below:

  Most schools that offer Mathematics and Science have a serious problem about facilities such as laboratories and equipment to promote effective learning and teaching. The teaching of science remains at a theoretical level without any experiments to enhance understanding and application of knowledge (Department of Education, 2001:13). According to Howie (2001), the shortage of instructional material such as textbooks and the state of other facilities such as heating, cooling, and lighting is reported by South African principals as worse than what their international counterparts are experiencing. They also complained about the lack of computers and computer software for both Mathematics and Science and a shortage of school buildings and grounds. Although inadequate facilities and insufficient instructional material are easily defined problems, some scholars regarded their impact on teaching as not that severe. Lewin (2000) shows that…investment in facilities and equipment cannot be shown to have a direct relationship to improved learning outcomes (Lewin 2000:37).

  Similarly, Taylor and Vinjevold (1999) agree that external resources do not have the impact that better school management and teaching practices have. Thus, improved pupil results do need external resources such as textbooks and laboratories, but with or without additional resources, better school management and teaching practices are also required, and there are many examples that demonstrate how these factors can make a significant difference on their own (Taylor & Vinjevold 1999).
- ***Parents and Communities:*** Disrupted family units are fairly common in the South African society, especially amongst the country's rural population typical of where the study is undertaken. The average international figure for both parents living with their families is 81%. In 87% of South African families only the mother lives permanently with their families while in only 60% of the cases both father and mother live permanently with the family. In 42% of South African families, grandparents are part of the family unit, and in 43% other relatives are also included, compared to the international figures of 24% and 16% respectively. On average, a South African family consists of seven people living in one home (Howie, 2001). The geographic location of schools is important and the influence on

the achievement of the learners in the different parts of the country of the 50 percent of South Africa's population that live in rural areas, only 8% of South African learners have three learning aids, such as a dictionary, a study desk, and a computer in their homes (Howie, 2001:13). The international average is 41%. Parental education is often linked to learners' achievement. Only 15% of the Grade 8 learners who took part in the TIMSS test in South Africa reported that their mother or father had studied further at a university or technikon while 12% of learners did not know what the educational levels of their parents were (Howie, 2001:92). Thus, parental involvement despite not a study variable was observed to play an influential role as the teaching and learning of Mathematics extends to homes in the form of homework tasks.

- ***Critical Issues:*** From the list of critical issues developed by Loucks-Horsely *et al.,* (1998:21), the researcher addressed the following: the need for equity for teachers from a previously disadvantaged background, the development of a professional community and building of capacity for sustainability.
- ***Equity:*** Due to South Africa's history and the nature of the South African society, the Collaborative model was mainly developed for capacitation of teachers from a disadvantaged background. In so doing the researcher could contribute towards equity in a diverse society where the gap in education between the rich and the poor is huge.
- ***Developing a professional community:*** The Integrated Strategic Planning Framework for Teacher Education and Development defines PLCs as follows: PLCs are communities that provide the setting and necessary support for groups of classroom teachers, school managers and subject advisors to participate collectively in determining their own developmental trajectories, and to set up activities that will drive their development. (ISPFTED, p.14) McLaughlin (1996) observed the following: Classroom practices and conceptions of teaching "emerge through a dynamic process of social definition and strategic interaction among teachers, students and subject matter in the context of a school" (Cited in Loucks-Horsely*et al.,* 1998:195). Therefore, initiatives must be designed to equip teachers to become leaders and build their own professional communities. Teachers must learn new skills and strategies and are expected to return to their schools and teach others the same skills and strategies. This could be done by initiating dialogue about what they have learned and encouraging others to participate in similar complementary learning experiences. However, Gray (1999) found in his 30 years of work in science education in a developing

world context, those teachers in even the most difficult circumstances are capable of amazing things.

If any degree of professionalism is to emerge, then the responsibility for ongoing professional development of teachers needs to be shifted fairly and squarely on teachers themselves, with the authorities and outside agencies playing a secondary, supportive role, (Gray 1999). Therefore, opportunities must be facilitated for teachers to work collaboratively to break down isolation through coaching and mentoring, workshops, and networks. This could equip teachers with tools and techniques to build and maintain supportive professional communities in their schools and districts. Thus, the Collaborative model was aimed at developing teachers by improving their content knowledge, providing them with both information on and practical experience in different teaching approaches and strategies in order to build their professionalism and self-esteem.

- ***Building Capacity for sustainability:*** This critical issue is addressed to help the teachers to learn for themselves. They must be able to search and access the other resources to improve the development so that they can assess their own level of understanding and become aware of their shortcomings.
- ***Implementation Process:*** The implementation of the design process is described in the following three chapters. In Chapter 4 the baseline study and the design and development of the Collaborative model and the conditions for implementing the model and the international benchmarks for its evaluation and guidelines for implementing the model are outlined. In each of these chapters the knowledge and beliefs, context, strategies, and critical issues influencing the design of that intervention programme are spelt out. After setting goals, planning, and doing by implementing the planning process for each phase, the results were analysed. This will have an influence on the process of reflection and change that will take place.

### 4.7. Design and construction of the collaborative model

The construction of the collaborative model was premised on a number of features that have a bearing on the nature and quality of the intervention model. The features that affected the construction of the model were context factors, knowledge and beliefs of educators and learners, critical issues, and strategies to be used in the model.

### 4.7.1. Contextual Issues and Factors

Educational programmes and interventions are influenced by specific characteristics that are peculiar to a geographical context where the intervention is implemented. Five contextual factors that influenced the design and development of the Collaboration Model are discussed below:

- ***Mathematics Educators:*** Five educators from the rural Centocow Cluster of KwaZulu-Natal province participated. All the educators taught Mathematics in Grade 10, and all had varying teaching experiences, professional qualifications, and different professional training backgrounds.
- ***Learners:*** Mathematics learners in Grade 10, the root grade in Further Education and Training phase were sampled and twenty formed the sample, four from each of the sampled schools participating in the research. The method of sampling and the population are given in the following chapter where the research methodology is discussed.
- ***Curriculum:*** CAPS curriculum, recently modified from Outcomes Based Education was in use. Emphasis of the new Curriculum is on content rather than processes. Thus, Mathematics educators were expected to demonstrate a reasonable competency in Mathematics content knowledge.
- ***Learning and Teaching Materials:*** The Centocow cluster being a deep rural geographical location is typical of a cluster of schools in developing countries where learning and teaching resources are scarce. The schools have shortages of textbooks, laboratories and classrooms as some learners learnt in temporal, movable classrooms. Of particular interest to the researcher was the presence of different types of textbooks that are from different publishers, implying that schools do not a have a prescribed, standard textbook for use in their classrooms. Textbooks choice was haphazardly done either by subject educators or Head of Department.

  Educators have makeshift staffrooms, often packed with unused teaching materials in the form of outdated textbooks and past examination papers. As earlier alluded to, there were no Mathematics and Science laboratories and classrooms are filled to capacity with an average of fifty learners per classroom compared to the Department of Education recommended 1:35 teacher–learner ratio.
- ***School Community:*** The school communities were rural, poor, and underdeveloped and most learners were orphaned and left in the care of foster parents and grandparents. In

relation to educational support to learners, the community offered little or no support at home as most parents and guardians did not go beyond primary education, hence secondary Mathematic was far beyond their educational levels especially on the following key variables of the research study:

- Pedagogical and content knowledge of Mathematics educators.
- Beliefs and attitudes of educators and learners about trading and learning of Mathematics in secondary schools.

#### 4.7.2. Educators and Learners Test and Assignments

As part of the content workshops, educators will undertake series of tests and assignments to test their grasp of Content and Pedagogical approaches that could be used in Mathematics classrooms. The rationale for educators' tests and assignments is to deepen content and practice of teaching specific concepts in Mathematics.

The test and assignment will be designed to include planning lesson activities that could be used in classrooms, and how learners' challenges and difficulties they faced would be addressed in the classrooms. Pragmatic approaches to learning and teaching Mathematics where both the educator and learners will be learners will be the thrust of the model and hence educators will be expected to think creatively in designing teaching and learning aids.

Equally important will be learner tests and assignments which will complement those of educators. After every Content and Pedagogical workshop, learners will be given either a test or an assignment jointly designed by the five cluster educators to evaluate the attainment of objectives of the workshop. Key to these tests and assignments would be the need to enable Mathematics learners to inculcate the thinking that Mathematics is an activity-based discipline and as such they need to engage in a variety of activities designed to help them understand and grasp the given concepts. Upon administration of a test or assignment the educators will conduct in-depth item analysis of the test items and marks analysis of the performance in the test or task.

#### 4.7.3. Critical Issues in constructing a collaborative model of teaching and learning Mathematics.

As alluded by Horsely*et al.,* (1998), critical issues in developing a professional development model are significant as they constitute the ultimate vision of the programme to be designed.

Thus, for this study the promotion of qualitative and equitable teaching and learning of Mathematics in previously advantaged community drives the success of the construction of the Collaborative Model. Mathematics educators, capacity building and scaffolding is the vehicle through which the performance of historically disadvantaged black learners will be addressed and unlock their potential to contribute through Mathematics and Science to the development of South Africa.

Additionally, Mathematics educators were encouraged to demystify the belief that Mathematics is difficult and raise a generation of Mathematics learners that enjoy Mathematics through maximum involvement in activities that are interesting and stimulating. Developing reflective educators of Mathematics is the ultimate aim where changing contexts of teaching Mathematics requires an adaptive and quick-thinking Mathematics educator.

#### 4.7.3.1. Mathematics Study and teaching guide

Learning materials constituted a major variable in the quality teaching and learning of Mathematics in secondary schools. A variety of textbooks are used in schools depending on the choice of teacher and available resources.

The sampled schools in the Centocow Cluster used the following textbooks in teaching and learning Mathematics in Grade 10:

- Platinum Mathematics Teachers and learner’s books
- Study and Master Teachers and learner’s books
- Focus on Mathematics Teachers and learner’s books.

The variety of textbooks used implies that teachers use different activities and approaches prescribed by the publishers in dissemination of concepts. Variety also implied that quality varies from textbook to textbook. For standardized concepts development in Mathematics at Grade 10, the researcher proposed a standard study and teaching guide that is designed to deepen educators’ Content and Pedagogical Knowledge and enable learners to enjoy the learning of Mathematics in a socially supportive classroom environment.

The study guide was unique in that it will include teaching skills, content and Mathematics skills intertwined and embedded in specific concepts under a major theme or topic. Key Mathematics skills regarded as essential in Mathematics will be discussed in detail in the study guide.

#### 4.7.4. Strategies Used in the Collaborative Model of Teaching and Learning Mathematics.

The collaborative model, a product of the social constructivist school of thought was developed within the context of face-to-face educational interactions among Mathematics educators, learners and curriculum supervisors and advisors. One of the core features of the Model was the Workshop Model of staff development of educators where regular planned capacity building workshops are held within the cluster aimed at improving Content and Pedagogical Knowledge of Mathematics concepts.

Dissemination of learnt content and pedagogical knowledge in the classrooms through involving learners in active learning of Mathematics formed a crucial stage in the model. Mathematics learners will play vital roles in designing, presenting and peer teaching Mathematics concepts under the supervision of their educators. Thus, the following strategies were chosen for the development and construction of the Model:

##### 4.7.4.1. Staff Development Workshops

Staff development workshops were identified by the researcher as the main vehicle of change as they will be the platform where educators under the guidance of subject advisors will interact face to face and provide solutions and suggestions to teaching of Mathematics concepts in different classrooms.Workshops focusing on content and pedagogical approaches enabled Mathematics educators to clarify sections of the syllabi where they needed assistance in developing conceptual understanding in their learners. Additional workshops provided educators with experiential knowledge of using cooperative learning in teaching different Mathematics concepts. In the workshops, educators further shared their various classroom experiences and provided suggestions on how emerging trends and issues could be best handled. Evaluation and reflection on suggested pedagogical approaches, teaching aids and assessment strategies were also discussed and improved in the content and pedagogical workshops.

##### 4.7.4.2. Project and Investigation

Project and investigation tasks are a familiar feature in the teaching and learning of Mathematics in secondary schools. However, despite featuring in informal and formal assessments, the project tasks are rarely qualitatively done, due to poor project and research skills possessed by both learners and educators.In the collaborative model, learners carried out a project as an avenue of deepening their knowledge of applying Mathematics skills in solving problem in given context.The projectas done in groups following cooperative learning guidelines and aimed at exposing learners to social constructivists pedagogical approaches that enabled them to participate actively in learning activities and apply Mathematics skills. Key Mathematics topics were the focus of project topics and learners applied their specific Mathematics skill in project tasks.

#### 4.7.4.3. Goals of Constructing a Collaborative Model

Construction of a collaborative model was informed by the desire by the researcher to develop a unique, adaptive, and user-friendly model for teaching and learning Mathematics in secondary schools.

The following goals were set for the model:

- To deepen and capacitate Mathematics educators' conceptual understanding and to present different pedagogical approaches during staff development workshops.
- To determine the changes in education content and pedagogical knowledge, beliefs, and professional attitudes towards Mathematics at the end of the programme.
- To develop an integrative, user-friendly study guide which incorporates pedagogical content knowledge of Mathematics, learners' activities that are varied and challenging, as well as easy to follow concept development steps that make Mathematics interesting and easy.
- To determine the reasons for unprofessional attitudes and negative beliefs held by educators.
- To suggest various improvements that could change educators and learners' negative attitudes and beliefs about Mathematics in secondary schools.
- To propose various approaches to enable learners to participate actively in a variety of Mathematics activities in groups to experience socially beneficial Mathematics learning approaches.
- To suggest different assessment approaches and activities that result in improved Mathematics outcomes that makes Mathematics learning interesting and beneficial.

#### 4.7.4.4. Collaborative Model Implementation Plan

The Collaborative Model design framework was informed by Loucks–Horsley, Hewson, Love and Studies (1998), framework for professional development. Planning was a key element of the intervention programme which constitutes the construction of the model taking into consideration the indepth exposition of the research methodology found in the next chapter.

The planning of the model used five Mathematics educators, two Mathematics advisors and twenty Grade 10 Mathematics learners from five sampled schools in Centocow cluster. The Model design and construction was a theoretical task as the testing of the Model will not be done in this study so is the reflection, evaluation, and improvement of the designed model. The researcher used the baseline data on the pedagogical-content knowledge of educators, beliefs and attitudes of learners and educators towards Mathematics education and improving assessment and remedial education in Mathematics education in secondary schools.

#### 4.7.4.5. Do: Processes and Activities in the Collaborative Model

The third planning sequence of the Loucks–Horsely *et al.,* (1998) Model design was doing which constitutes laying out the processes and activities within the intervention model. Key activities and processes identified are staff development workshops, tests and assignments for educators and learners, Mathematics study guide, and projects and investigation for students and educators.

#### 4.7.4.6. Mathematics Study Guide/Material

Effective Mathematics teaching in secondary schools is a product of effective uses of textbooks that cater for learner differences and present clear concepts development for both educators and learners. The researcher propounds that study materials for teaching and learning Mathematics should incorporate inquiry and problem-solving approaches to teaching Mathematics as well as integration of Content and Pedagogical knowledge. The majority of textbooks used in schools varied as testified by findings of the Research methodology. The study material for the model included all steps to teaching specific concepts, practice and practical learners' activities and worksheets that were used in teaching Mathematics lessons. Planned lessons per topic and sub-concepts were done in detail specifying teaching skills strategies and pedagogical content in order to broaden and capacitate teachers' approaches.

Equally important and integral to the study guide was the inclusion of integrated learners' activity-based activities per topic. Integrated activities reflected real life applied situations in Mathematics classrooms. Festus (2013), a Nigerian academic observed that teaching as being practiced today in Mathematics using the lecture method has been found to be ineffective. The teachers do not give learners the opportunity to think and contribute to the learning process.

Therefore, the study guide incorporated activity-based learning activities where students were involved in activity more than listening, less emphasis was placed on transmitting information and placed more on developing students' skills, especially higher order skills such as analysis, synthesis and evaluation. Okwudishu (2011) summarizes that activity-based learning offers the following benefits:

- Reinforces lesson content,
- develops team building skills,
- enhances learners' self-esteem,
- promotes participatory learning,
- allows for creative problem solving,
- promotes the concept of discovery learning.

Thus, in activity-based learning, which is a component of a collaborative learning, learners were energized to participate, strengthen bonds, allows for practical application of learnt concepts, enhances communication with diverse learning, and offered an enjoyable and exciting learning environment that improves retention and motivation.In the study guide learners were given leading questions where the students touched felt, participated, discovered, reasoned, deduced and infered facts and ideas in the learning processes. The followi was the layout of the study guide for teaching and learning Mathematics in secondary schools:

Topics:

- Aims of the topic
- Materials to be used.
- Teaching approaches
- Learner activities
- Assessment activities
- Revision activities.

#### 4.7.4.7. Staff Development Cluster Workshops

Staff development is fundamental in improving the pedagogical-content knowledge, and beliefs and attitudes of Mathematics educators. Therefore, cluster workshops on a weekly basis in the afternoon lasting two hours where educators meet face to face to capacitate each other in conceptual understanding, appraise each other on different teaching approaches, teaching and learning aids per topic and remedial strategies that could be used to help struggling learners. Baseline data revealed that the majority of educators are not good in the subject knowledge and as such workshops will focus on content to capacitate them. Organised workshops will look into each topic, concept, and subsequent sub-concepts, develop them, and enable educators to be on par with their counterparts.

#### 4.7.4.8. Developing Pedagogical Approaches

Pedagogical approaches used by educators in teaching Mathematics are a key variable that needs to be attended to if the Collaborative Model has to succeed. Social constructivists teaching methods that the model will use are discovery learning, appropriate practical work, cooperative learning or small group learning and discussions. Details on each of the pedagogical approaches are outlined below:

#### 4.7.4.9. Discovery Approaches of Teaching

The discovery approach is a method where a learner is guided to discover Mathematics facts and formulae through observation and organise activities. In the method the teacher provides a variety of learning aids and as a means to an end, leads the learners to carry out some activities, which leads learners to arrive at new knowledge. Learners could engage in the activities individually or in groups. In this method, learners discover knowledge on their own through active participation in lessons. Contrary to the lecture method or telling method discovery learning enhances active learning in Mathematics classrooms. Thus, teachers should not just tell the learners the formulae in Mathematics and give examples on topics, rather they should create activities for students to discover Mathematics facts, formulae, and concepts on their own.

#### 4.7.4.10. Appropriate Practical Practice (APP)

Practical work, even though not frequently used in teaching and learning Mathematics, provides the most effective means of understanding Mathematics especially in secondary schools. Absence of practical application of concepts robs learners of forming patterns and establishing meaningful relations among the stimuli and link with their previous related experiences.

The Chinese in their proverbs assert that “What I hear I forget, what I see I, remember, what I do I understand”. This implies that the learners should be afforded an avenue of engaging in practice of concepts so as to understand them fully. Ukeje (1979) explains that “A poor teacher tells, an average teacher informs, a good teacher teaches; an excellent teacher inspires”. Thus, Mathematics educators must inspire learners to think and create ideas. This can only be done through designing and engaging students in meaningful Mathematics activities that allow learners to transfer and apply learnt skills in practical life situations.

#### 4.7.4.11 Small Group Learning and Cooperative Learning

Social Constructivism, the backbone of the Collaborative Model, recognises cooperative learning as the best practice that results in active learning in modern classrooms. Cooperative learning creates a learning environment that encourages students to engage in their learning in meaningful ways. Group work stimulates discussions which are beneficial to learners as they make learning deeper, meaningful, and active effective processes.

#### 4.7.4.12. Discussions in Class

Discussions in class are one of the most common and effective teaching strategies that promotes active learning. McKeachie (1986) expounds that, to promote long term retention of information, to motivate students towards further learning, to allow students to apply information in new settings, or to develop students thinking skills, then discussion is preferable to lecture. Educators must engage students in guided discussions towards achieving the objectives of the lesson. Discussions generate new ideas and result in active learning in the classrooms. Johnson, Johnson, Roy, and Zaidman (1986:307) postulate that, “the low and medium ability students especially benefit from working collaboratively with peers from the full range of abilities. There is also evidence that high–ability students are better off academically when they collaborate with medium and low ability peers than when they work alone”. Series of discussions among educators in the cluster staff development workshops were carried out to familiarise educators with use of activity-based learning approaches in teaching Mathematics in secondary schools.

#### 4.7.4.13. Developing Professional Altitudes and Positive Beliefs on Mathematics

Beliefs and attitudes of educators towards Mathematics play a pivotal role in effective teaching and learning of the subjects. Furinghetti and Pehkonen (2000) expound that learning outcomes of students are strongly related to the beliefs and attitude about Mathematics. This implies that students’ performance in Mathematics is correlated to their beliefs and attitudes towards the subject, educators' beliefs, and attitudes as well as impact on forming students' beliefs. How Mathematics educators teach and reach out to their students is directly derived from beliefs and attitudes about Mathematics. Thompson (1992), in her research on beliefs found that changing teachers' pedagogical approaches are dependent upon changing their beliefs and attitudes about Mathematics.

#### 4.7.4.14. Educators and Learner Tests and Assignments

Assessment of workshops participant constituted a major innovation in the teaching of Mathematics in secondary schools. Baseline data obtained from a comparative test written by educators and learners revealed that there is a thin difference between educators' performance and that of their learners. Item analysis done revealed numerous mistakes in concepts grasped by both learners and educators which suggests that much has to be done to capacitate educators in Mathematics content.

Therefore, intervention workshops for educators are designed to expose them to content and pedagogies that are modern and suitable for 21st century Mathematics learners. Workshops as alluded to in previous sections were content based and also focused on how the content was taught to learners (Pedagogical approaches) that encouraged collaboration among learners in the classroom. In order to enhance in-depth understanding of learnt concepts, educators were given assignments and tests, pretests, and post tests to measure if there was a change in understanding of a learnt concept and skills. Each topic taught in Grade 10 Mathematicswas thoroughly done and conceptually followed by tests and assignments as means of consolidation of what has been learnt. Comparative analysis of scores obtained by both learners and educators as  done and analysed.

#### 4.7.4.15. Projects/Investigation Tasks

Projects and investigation or researched tasks constitute an integral part of developing learners' abilities to use Mathematics skills in solving contextual problems. Despite project and investigation tasks constituting formal assessment in Mathematics, there has been little effort to capacitate teachers on how to teach and assess projects.

In staff development workshops in the cluster, educators were grounded on the rationale for projects in Mathematics, how to teach learners skills to write projects and assessing learners' projects. Several projects from Mathematics topics were designed for learners and educators using workshops guidelines will supervise and assess learners' work. In employing the project method of teaching Mathematics, learners were exposed to teamwork, cooperative learning, and use of Mathematics skills in solving day to day problems.

## 4.8 Conceptualization of the Collaborative Model: Processes, Activities and Features of the Model

Figure 4.8 illustrates the collaborative model processes, activities and envisaged outcomes, need improvements in the critical issues of educators` pedagogical content knowledge, educators` and learners` beliefs and altitudes towards Mathematics enhancing learners' participation in lessons, effective assessment in Mathematics and effective remedial intervention in Mathematics education.

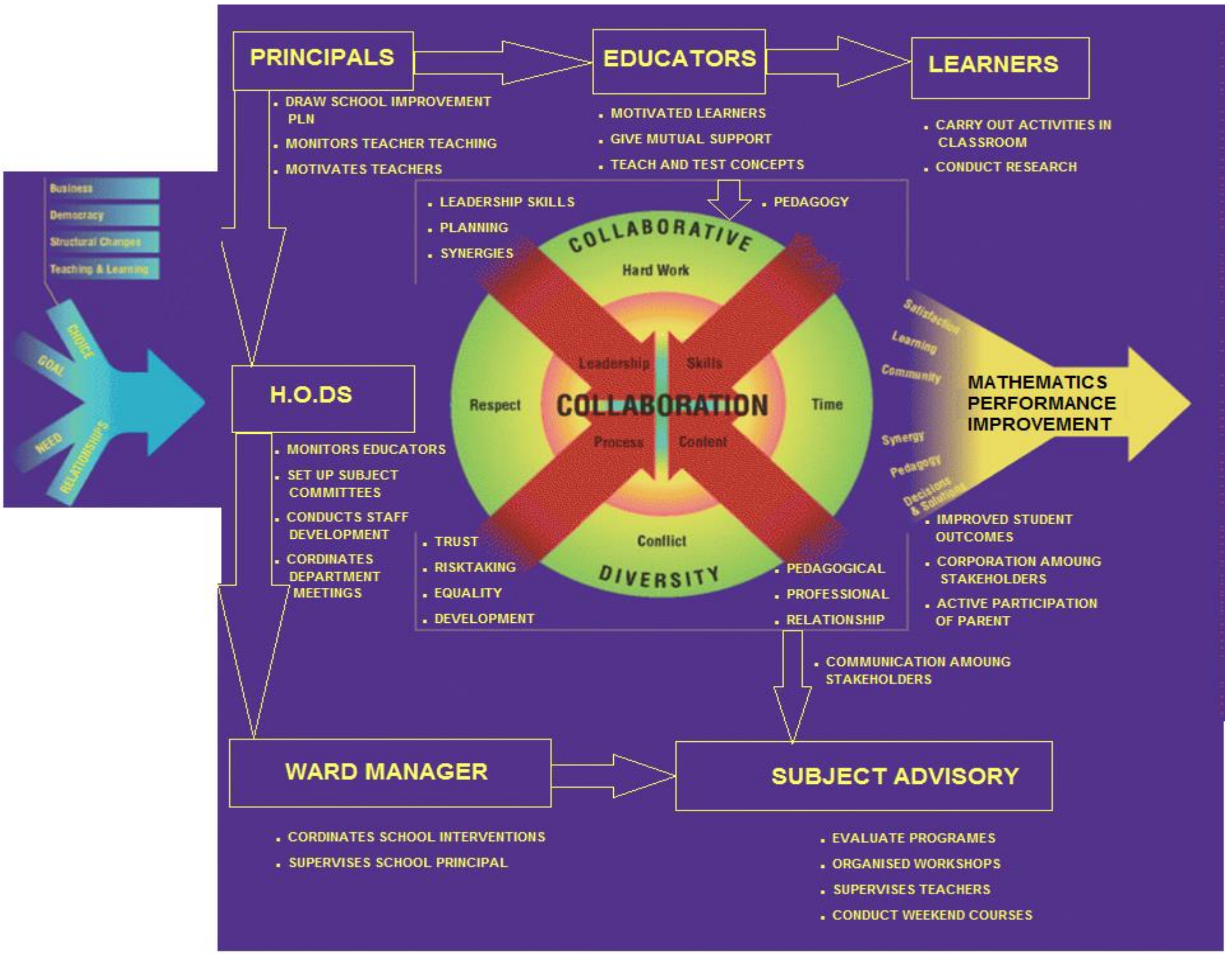


**Figure 4.8: Conceptualizing Collaborative Model. Processes Activities and Features of the Model.**

#### 4.8.1. Collaborative Model: Improvement Strategies

##### 4.8.1.1 Improvement of Educators Pedagogical Content Knowledge of Teaching Mathematics

In the constructed model, Mathematics educators are at the centre of bringing change in the teaching of Mathematics. Therefore, pedagogical content knowledge which, according to the next chapter, was not at satisfactory levels needs to be improved through the model.

Erasmus, Loedolff, Mda and Nel (2015) posit that the professional development programme should be relevant to the participants' and the institutions' needs. The authors further note that it should be structured with clear timelines, activities, and topics to be covered, focusing on theory, practical activities and knowledge and skills acquisition. It is vital for the facilitators to determine, in advance, the instructional strategies to be used in the training, ensuring that they identify the appropriate combination of methods and techniques, sources and materials to be used (Koert, Borgen & Amundson, 2011, Erasmus et al., 2015). Staff development workshops as earlier alluded to in the chapter will enhance pedagogical and content knowledge of educators in that through the workshops educators will explore the concept of collaborating with other educators in deepening conceptual understanding of Mathematics concepts.

Vygotsky (1978) further explained that through team teaching knowledge is collaboratively constructed between individuals from where it can be appropriated by each individual. Team teaching, a collaborative model component will be explored as means of broadening educators' knowledge of Mathematics. Team teaching gives teachers the opportunities to act on their ideas and reflect in and upon their actions (Bayer, 1990). This implies that Mathematics educators at the Centocow cluster will be encouraged to embrace the team teaching approaches as part of a collaborative teacher partnership at the cluster.

Cook and Friend (1996) suggested five forms of variations in co-teaching namely:

- One teaching and one assisting: a technique in which one teacher takes an instructional lead while the other assists students.
- Station teaching: dividing the class content and room arrangement with each teacher working on a specified part of the curriculum and classroom, so that students rotate from one station to the other.
- Parallel teaching: both teaches plan instruction but divide the class into two halves,

- Alternative teaching: organising a classroom into one large group and one small group, where one teacher is able to provide main instruction, the other to review a smaller group of students.
- Team teaching: teachers take turns in leading discussions or both playing roles in demonstrations.

  Team teaching will play an integral part in enhancing educators pedagogical content knowledge as professional growth will be improved, collaboration increased, and experimentation with new teaching strategies encouraged. Furthermore, observation of colleagues in a natural teaching setting will be enabled and collegial analysis of instruction will be fostered. Ultimately teaching and learning of Mathematics is envisaged to become interesting and socially rewarding to both educators and learners.

Improvement of teachers and learner beliefs and attitudes towards Mathematics constitute a key variable that can affect the teaching and learning of Mathematics in secondary schools. Teachers' beliefs towards Mathematics may affect their teaching. A negative attitude may affect teachers Mathematics` pedagogies in either a positive or negative way. Ajzen and Fishbean (1975) in their Theory of Reasoned Action postulate that attitudes towards Mathematics are a result of direct experiences with the subject and beliefs attached to those experiences. This implies that the teaching and learning context in Mathematics classrooms creates either positive or negative experiences that have far reaching impacts on the teaching of Mathematics. Educators must, therefore, create accommodative, positive environments in Mathematics classrooms.

Results from related studies revealed that educators consider Mathematics very useful in life and in choosing careers, but most learners are not Mathematics oriented hence low performance in the subjects. Studies by King (2006) on the contrary, found that teachers who enjoyed Mathematics and felt that it is important were not fearful of it and encouraged their learners to do well in the subject. In other studies, by Wilkins (2002) on the correlation between attitudes and teaching methods used by teachers, it was found that positive attitudes had a significant effect on teaching methods chosen by educators. Teachers with positive attitudes were more likely to believe in the effectiveness of reform-oriented instruction. Thus, in the Collaborative model, through staff development workshops and subsequences of team-teaching engagements, educators built positive attitudes towards Mathematics which in turn had a spill off on new and adaptable methods of teaching Mathematics.

Equally related to teacher attitudes and beliefs about Mathematics are students' beliefs and attitudes which are a product of the classroom contextual impact on learners. Students' attitudes play a central role in Mathematics learning and achievement (McLeod, 1992). Students' attitudes are a very critical factor which could lead to success or failure. Gillham *et al.*, (2001) explain that positive attitudes form the basis for optimism. Optimism is the assignment of favourable interpretation to actions and events. This implies that educators should create friendly, sympathetic, and motivated classrooms that create optimism in learners and demystify the belief that Mathematics is a difficult discipline. Trujillo and Hadfield (1999) highlight that negative attitude can enhance Mathematics–anxiety. Feelings of anxiety lead to fear, panic, helplessness, and loss of ability to concentrate which ultimately results in poor student outcomes and achievement in Mathematics.

Students' attitudes are influenced by pedagogical approaches used by their teachers in the classroom (Duatep-Pasksu& Ubuz, 2009) and choice of teaching methods is guided by a theory of learning and nature of the subject matter to be taught. Therefore, in teaching concepts in Mathematics, teachers must use pedagogical approaches that target learners' affective domains as attitudes relate to emotions. Teaching methods such as drama and group work lead to positive interactions and experiences in the teaching and learning of Mathematics. In the Collaborative model, educators were capacitated in using pedagogical approaches that expose learners to interactions such as problem solving, drama and investigations, and class discussions, among others.

#### 4.8.1.2. Improving Assessments in a Collaborative Model of Teaching and Learning Mathematics.

Assessment in Mathematics is fundamental as it gives feedback on the attainment of set objectives of the lesson. Understanding of taught concepts is revealed through their response to informed and formal assessments. Effective assessment practices will be the core of the model in that it supports Mathematics instruction that produces improved students` performance.

Due to the changing nature of contemporary Mathematics, assessment in a standard-based environment requires that students be judged in terms of Mathematics literacy, understanding of concepts and procedures, and the application of mathematical knowledge in a problem-solving situation. Computing Technology for Mathematics Excellence (2006) proposes that these assessment strategies can be classified as diagnostic, formation or summative. Students` achievement is correlated with the quality of assessment. Diagnostic assessment strategies are focused on assessing student's prior knowledge, strength, weaknesses, and skills levels.

Formative assessment is directed at providing immediate feedback and evidence of students' performance. Summative assessments are more comprehensive and usually administered at the end of the unit or specific timeframe. In the collaborative model for teaching and learning Mathematics, regular and planned assessment will be of paramount importance as feedback from the assessments will be used to plan remedial intervention in capacitating slow and struggling learners.

Equally related to assessments is the nature of assessment tasks used in classroom, best practices in Mathematics` assessment requires that students be exposed to exploratory and interactive mathematics where they explore functions, develop formulae, and actively engage in non-routine problem solving and interaction about Mathematics. Use of learners' portfolios, journal writing, student self-assessment and investigative tasks geared towards problem solving will be ideal for the collaborative model.

Accurate assessment of students' academic abilities has been identified as one of the most crucial variables related to effective instructional planning and positive student outcomes (Shin, 1998). This implies that without quality and informative assessments of students` academic and Mathematics skills, instructional decision making will not promote students' academic competence. Stiggins *et al.,* (2007) postulate that there are two kinds of assessment during instruction; assessment to aid assessment of learning. Assessment for learning involves the use of homework, assignments, quizzes, and self-assessment drafts and portfolios. Assessment for learning is learner-centered and affords the learner an opportunity to find information about areas of strengths and further learning. Educators in Mathematics should be guided by fundamental questions which address the purpose of assessment, the target of learning, methods of assessment, and ways of reporting the outcomes or results of assessments. In the collaborative model educators will plan assessment, design varied activities for assessment and give feedback to learners on their performance in assessments.

Assessment in Mathematics helps the teacher in various ways. The Ministry of Education, Science and Technology (2007) in Kenya identified that through assessment, a teacher is able to identify pupil's achievement, pupil's needs, weakness, and strengths. Through assessment the teacher is able to evaluate if intended objectives of the lesson were attained, and if not, remediation measures be instituted. According to Indimuli *et al.,* (2009), evaluation in Mathematics determines the extent to which the stated objectives were achieved. Evaluation is done to identify the knowledge, skills, and attitudes that pupils have acquired, find out weaknesses and strengths of teaching strategies and learning resources use, motivates pupils, and helps them to know their progress in specific concepts. Thus, evaluation of assessments forms an integral variable in improving the teaching and learning of Mathematics in secondary schools as it serves as an introspection of what goes on in the learning of Mathematics in classrooms.

#### 4.8.1.3 Initiating Remediation in Secondary Schools' Mathematics Education.

Students under achievement in Mathematics in secondary schools is evidently (Baseline data) due to pedagogical and content gaps in educators' knowledge, non-supportive teaching-learning processes, routine, and predictable nature of lesson deliveries. Students in most classrooms observed exhibited lack of basic concepts' grasp during lesson delivery. Paradoxically, in most classrooms educators do not mention or signal any intentions to scaffold or conduct remediation for slow learners and those left behind in concept development. However, because their learners are struggling, educators appear confused and without tangible solutions to the challenges they faced in their Mathematics classrooms.

The South African education system which is governed by the Schools Act of 1996 does not have specific legislation regarding interventions in capacitating learners performing below set standards. In contrast, education authorities in the United States of American enacted the No Child left behind Act (2001), which mandated that schools and teachers be accountable and use teaching methods that work, and use planned and legislated interventions to assist students with difficulties. Bahr (2008) asserts that schools must consider specific or tailor-made research-driven interventions which fit the specific needs of their students. Specific and professionally done diagnostic tasks should be planned, their duration, materials to be used and how new pedagogical approaches will be used to make learners understand concepts better where they have difficulties.

Kommer (2006) commented on the No Child left behind Act (2001) suggesting that teachers of remedial courses most use methods that are effective for both genders, that is, if females are left brain dominant, they learn best with concrete concepts while males are right brain dominant and learn easily with abstract concepts. Therefore, in the Collaborative model, baseline data showed that remediation interventions are not coordinated nor governed by any legislation in the South African educational landscape. Remedial classes in Mathematics are left to the teacher to carry out and even if he or she does not carry out the classes there is no accountability to the immediate supervisor or the school principal. Conducting extra and remedial classes is dependent upon the goodwill of educators hence thousands of learners have missed out on remedial opportunities which could have improved their Mathematics performances.

Despite the absence of introspective legislation in South Africa such as A National at Risk (1981), No Child left behind Act (2001) in the USA where government deliberately enacted legislation to force schools and educators to implement remediation programmes so as to enhance better performance rates, the researcher recommends that remediation be part of the cornerstones of a Collaborative Model. Remediation in Mathematics is mandatory in the Collaborative Model and educators will, through staff development workshops, be equipped with skills to select learners into remedial classes, with instrumentation used, and planned interventions and their evaluations. In supporting Mathematics remediation, Kurtz and Batarelo (2005) posit that students should be taught using anchored instruction which creates shared environments that permit examination by both students and teachers of the application of Mathematics skills in solving real-life problems. Through meaningful contextualised problems solving, students become confident in their ability to tackle difficult problems, eager to figure things out on their own, flexible in exploring mathematical ideas and trying alternative paths, and willing to persevere (National Council for Teachers of Mathematics, 2002).

As part of the remedial education in Mathematics, teachers in the Collaborative model will be capacitated in using peer tutoring as an intervention and modification to traditional teacher centered instruction. Menesses and Gresham (2009) recommend that reciprocal peer tutoring where students support each other in finding solutions to difficult or misunderstood mathematical concepts. Peer tutoring decreases teacher responsibility in implementing intervention and that enables improved students` performances that are learner centered and sustainable.

**4.8.2. Chapter Summary**

The chapter focused on the construction of a Collaborative Model for teaching and learning Mathematics in secondary schools. The model was informed by Loucks-Horsley *et al.*, (1998) and has four key elements namely, study guide for Mathematics, staff development workshops, projects, and investigations as well as tests and assignments. Processes and activities of participants in the model were discussed and suggestion on improving the model were discussed which as well centred upon capacitating educators to improve Pedagogical-Content Knowledge (PCK) modifying beliefs and attitudes towards Mathematics, improving quality of assessments, and finally initiating remedial classes. Lockes- Horsley *etal.*, Professional development Framework will underpin the research activities and processes in implementation of the baseline study which will provide data to input and modify the Collaborative model as presented in Chapter 5 Fig 5.7. Foreign language as a medium of teaching Mathematics is quite a challenge both for the teachers and learners interpreting and understanding concepts. If educators are able to explain some concepts in vernacular, learners are able to relate and conceptualize even if confronted by the mathematical problem alone. If it is difficult for the educator, it is not going to be easy for the learner. The next chapter focused on the Research Design and Methodology used in the study. Recommendations for further studies of the model were suggested.

## CHAPTER FIVE: RESEARCH DESIGN AND METHODOLOGY

### 5.1. Introduction

Research studies are a set of actions and procedures that begin with a research issue and study question that motivate the researcher to discover solutions to it. The researcher then examines the relevant literature and finds gaps that the present research aims to fill. Methods of research, which are the focus of this chapter, were a crucial aspect of the study, and their interrelationship with other chapters is shown in Fig. 5.1, which depicts the complete research process.

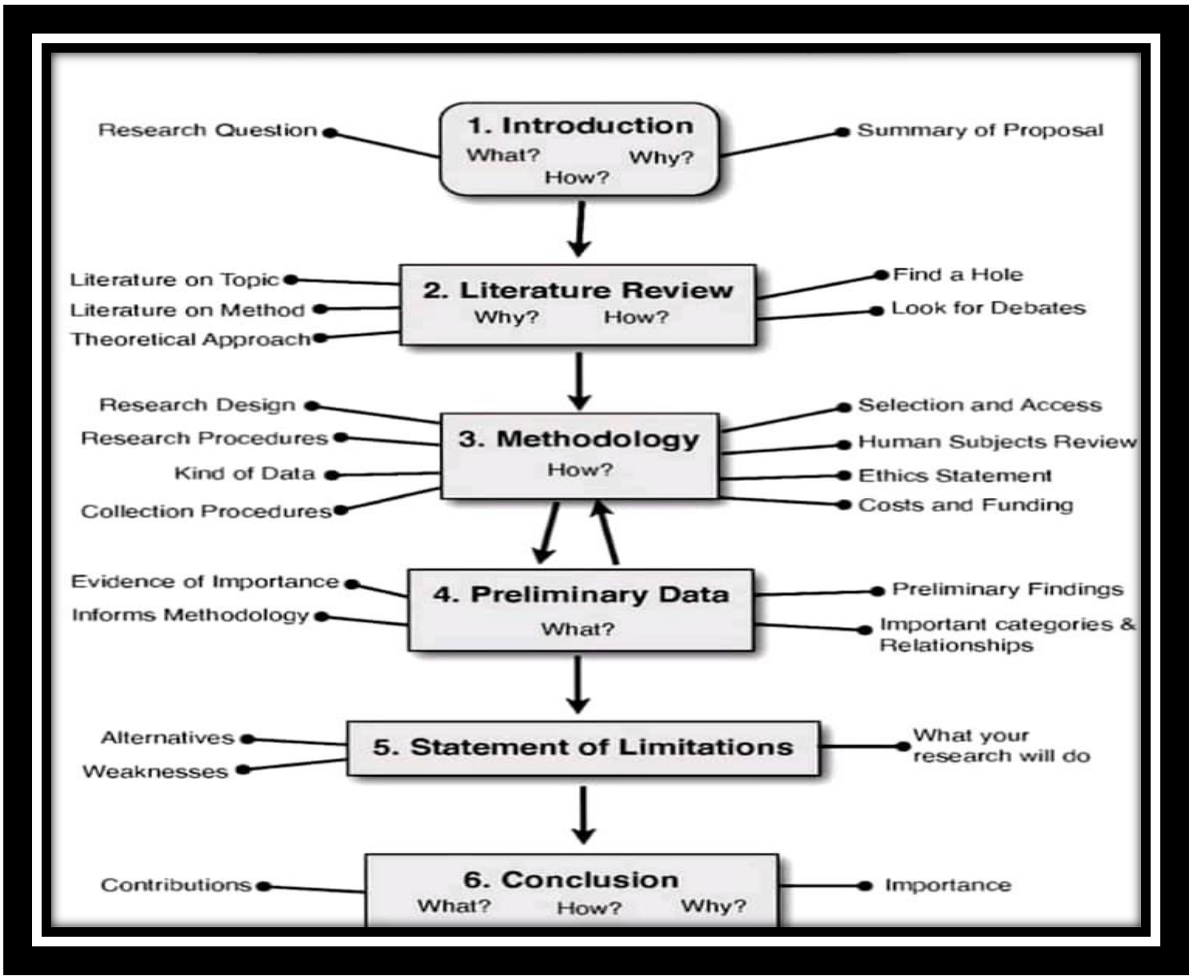


**Fig 5.1: A summary of the research process (Adapted from Creswell (2014)**

The previous chapters discussed the need for, as well as the literature on, a professional development model for secondary school mathematics teachers. In a review of worldwide performance in mathematics and science benchmark examinations, Reddy (2012) found a bleak picture, with most states, including South Africa, failing. As a result, the low performance status of most countries around the world poses a significant challenge, as there are no ready answers to the broader picture of international mathematics education reform, as well as the specific circumstances in South Africa (which performs the worst), which must be carefully crafted in the model development.

In the South African educational context, needs analysis, goals and plans were formulated as consideration for the development of a culturally sensitive professional development model. The baseline construct of the model was developed from the literature and extension of Loucks' professional development model. The modifying parameters were created by combining the quantitative and qualitative data acquired in the research and analyzing the results. The previous chapter began with a description of the model design framework by Loucks-Horsely et al., (1998), outlining its key features, followed by a reflection on the researcher's views on the framework's features for the South African context. A significant data gathering phase and model foundation, the diagnostic/baseline study's results were utilized to create and construct a Collaborative model for teaching and learning Mathematics in secondary schools. The research design and methods, research instruments, population and sample, measures to guarantee instrument validity and reliability, as well as a pilot study and ethical issues are all provided in this chapter.

This study sought to design and construct a Collaborative model for teaching and learning Mathematics in secondary schools in answer to the following research questions restated from Chapter two:

a. What are the possible factors that contribute to low performance in Mathematics education in secondary schools?
b. What intervention strategies and activities can education stakeholders (those involved in teaching and learning of Mathematics) who are educators, learners and subject advisors who collectively use a stakeholder's approach to curb poor performance in Mathematics?
c. How can the concept of collaboration be used in developing a model for teaching and learning Mathematics in secondary schools?
d. What conditions should be put in place to implement and measure the effectiveness of the intervention strategies of a Collaborative model effectively?

## 5.1 Research Methodology

Studies use a wide variety of research approaches. Figure 5.2 depicted the various research strategies used in investigations. Methods like ethnography, history, and content analysis fall within the category of qualitative research. However, quantitative research includes a wide variety of methodologies, such as experimental investigations, correlational analyses, and comparative studies of causes and effects.

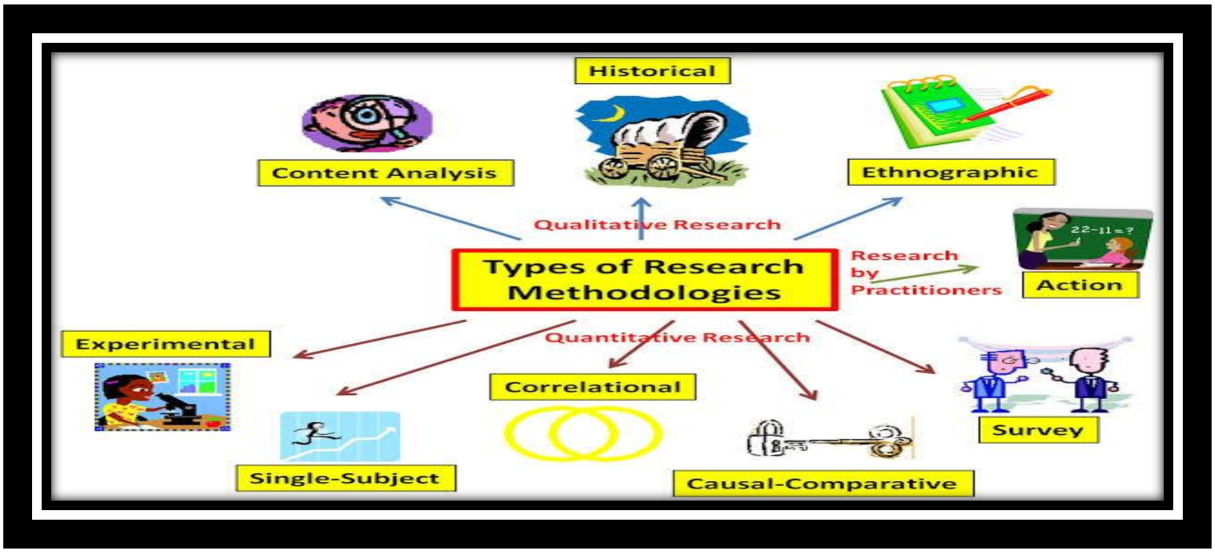


**Fig 5.2 Types of Research Methodologies (Source: Adapted from Creswell (2014)**

Pursuant to Goundar (2012), the phrases research methods and research methodology are often used interchangeably. Research techniques are the tools used to do research on a topic or problem, which is one of the main differences. On the other side, study technique shows how you may continue your investigation. The systematic way of doing research is known as research methodology. Thus, according to Creswell (2014), there are different methodologies employed in various types of research, and the term is often interpreted to include study design, data gathering, and data analysis. Research techniques include experiments, testing, and surveys, among other things. On the other hand, research methodology includes understanding the many techniques that may be used in the performance of research, such as tests, experiments, surveys, and critical studies.

Furthermore, research technique is the means through which researchers do their research. It depicts the process through which these researchers construct their issue and objectives, as well as deliver their findings based on the data collected during the study time (Sileyew, 2019). As a result, research methodology is a systematic approach to problem resolution. It's the science of figuring out how to do research. Research methodology refers to the methods used by academics to describe, explain, and foresee phenomena. It's also known as the study of methods for gaining information. Its purpose is to give a research work schedule. There are three types of research methodologies: quantitative, qualitative, and hybrid approaches.

Research methods or strategies are the ways and/or instruments that researchers use to conduct any kind of inquiry or study (Walliman, 2011). There are several tools that may be used to administer various inquiries (Walliman, 2011), and it is the obligation of the researcher to pick the most suitable instrument for their unique study. Each of the instruments used must complement the others so that the information collected is relevant to the topic of the research and follows a logical sequence (Jonker & Pennink, 2010). Furthermore, research procedures are the methods used to acquire and analyze data. These strategies were created in order to acquire information in a reliable and legitimate manner (McMillan & Schumacher, 2010). Thus, the procedures that researchers use to conduct research investigations are referred to as research methodologies. The term research methodology refers to the procedures employed by researchers to define, clarify, and predict phenomena. It is often referred to as the study of information-gathering techniques.

### 5.1.2 Research Methods

Descriptive, analytical, and case study research procedures are shown in Figure 5.3. However, other research methodologies are experimental, and feature controlled or uncontrolled research circumstances. A more thorough explanation is provided in the paragraphs that follow.

Rahi (2017) points out that experimental techniques are included in research methods because they include the process of variable testing, which allows the influence of one variable to be seen in relation to other factors. The survey technique, which is common in social sciences and is related with the deductive research method, is described here. In this research technique, information is gathered via interviews or a questionnaire that has been pre-designed. Archival analysis technique, on the other hand, provides the occurrence and prevalence of a certain phenomenon in relation to other phenomena. This research approach was utilized to investigate difficulties that have occurred in the past. This method is used in particular when no one who is relevant to the situation is present to provide a response or to report on a specific problem. A written description of a problem or a circumstance is referred to as a case study approach. It provides challenges to small groups of students or focuses on a certain subject. When the researcher has limited influence over the course of events, a case study is chosen, Saunders etal (2016).

## 5.2 Research Design

Hair Jr et al. (2011) describe a research design as the strategy for conducting the study and the method through which the researcher will recruit participants for the research. Exploratory, descriptive, and explanatory designs, as well as combined techniques, are the four kinds of study designs available. A method for discovering "what is occurring" and "seeking fresh insights" without first studying the causes for the events (Saunders et al., 2016) is characterized as exploratory research. When the researcher does not have adequate knowledge, this sort of design is employed. Additionally, exploratory research may begin with a wide emphasis and then reduce it as the study progresses (Saunders, Lewis &Thornhill, 2016). The current study was underpinned by a descriptive research design which employed a mixed methods approach in both the collection and interpretation of data and presentation of findings.

Cooper and Schindler (2013), define descriptive design, on the other hand, as a method for describing the present state of a phenomenon or variable. By directly investigating, analyzing, and describing individual events, the objective of a descriptive research strategy is to transmit facts in a manner that is as understandable as is reasonably feasible. This is accomplished by describing those specific occurrences. Descriptive studies are used in order to get a better understanding of the phenomena of interest in the real world, Creswell (2014). Researchers often do not start with a hypothesis but rather construct one after gathering evidence, and the data gained is generally observational in nature. In order to gather information that identifies the aspects of the topic of interest in the research, a design is required. The two most prevalent forms of descriptive research designs are cross-sectional and longitudinal descriptive research designs. Explorative design, on the other hand, is used to study a situation and describe the link between the factors involved, (Saunders et al., 2016). The mixed methods design that was employed in this study is described in more depth below, along with additional sections that discuss the research paradigm, sample strategies, data collecting methods, and data analysis methods that underpinned the investigation.

### 5.2.1 Mixed Methods Approach

A mixed methods approach is a process for combining quantitative and qualitative research in a single study so that researchers may better comprehend a research question, Creswell (2012). Schoonenboom and Johnson (2017) reaffirm that mixed methods research is a type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches, such as the use of qualitative and quantitative perspectives, data collection, analysis, and inference techniques, for the broad purposes of breadth and depth of understanding and corroboration. Creswell (2014) views study designs as distinct modes of inquiry within the many methodologies dubbed "strategies of inquiry" by Denzin and Lincoln (2011, referenced in Creswell, 2014). The blueprint or theoretical framework for research is referred to as a research design, and it is a subset of a research methodology, as per Saunders, Lewis, and Thornhill (2016). The research used a mixed-methods design. A mixed methods research methodology includes techniques for gathering, interpreting, and combining quantitative and qualitative data in a single study in order to get a better understanding of a research subject (Creswell & Plano Clark, 2011). The remaining paragraphs of this chapter detail the use of these approaches in this case study. The Fig 5.3 summarizes the rationale for using mixed methods design and its relevance to a study on designing a collaborative model for teaching and learnin Mathematics in secondary schools.

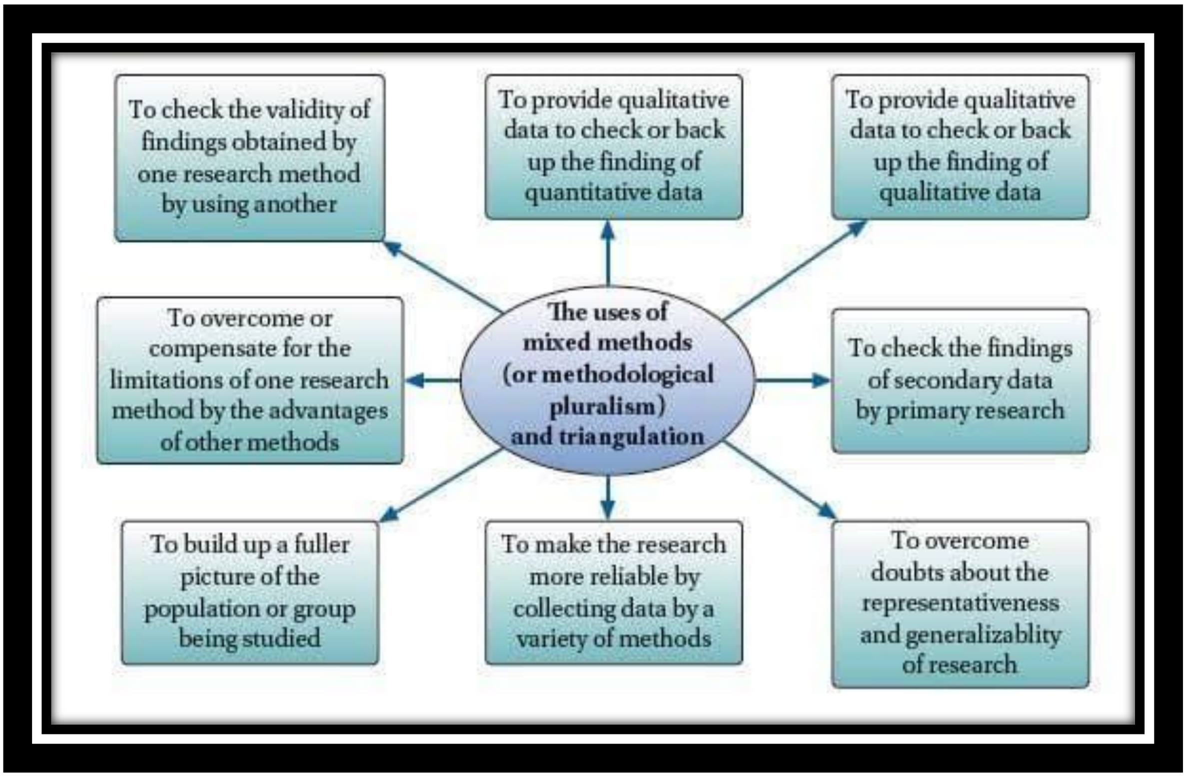


**Fig 5.3: Justification for use of mixed methods designs (Researcher creation)**

Fig 5.3 provided a justification for employing a mixed methods design which among other reasons was to ovedrcome the limitations of both qualitative and quantitative research, to make the current research more reliable and to build up a more comprehensive picture of the research sample which was made up of 27 participants. Johnson and Christensen (2017) justify the usage of triangulation by stating that it aims to achieve convergence, corroboration, and correspondence between data obtained via several approaches. Complementarity is the process of elaborating, enhancing, illustrating, and clarifying the outcomes of one approach by comparing them to the results of another method. Methodological developments strive to use one method's results in order to help in or guide the further development of the other technique, with development including sampling and implementation as well as measurement options. It is the goal of initiating to discover paradoxes and inconsistencies, to give new perspectives on frameworks, and to reframe questions or findings from one method in terms of questions or findings from another approach. Finally, expansion tries to widen and vary the field of inquiry by using a range of approaches for different inquiry components, Creswell (2014).

Mixed methods approach has three types of designs namely, convergent parallel mixed method, concurrent nested design or concurrent triangulation as well as explanatory/ exploratory sequential mixed method respectively, Creswell (2014:21). A diagrammatical illustration is presented in Fig 5.4.

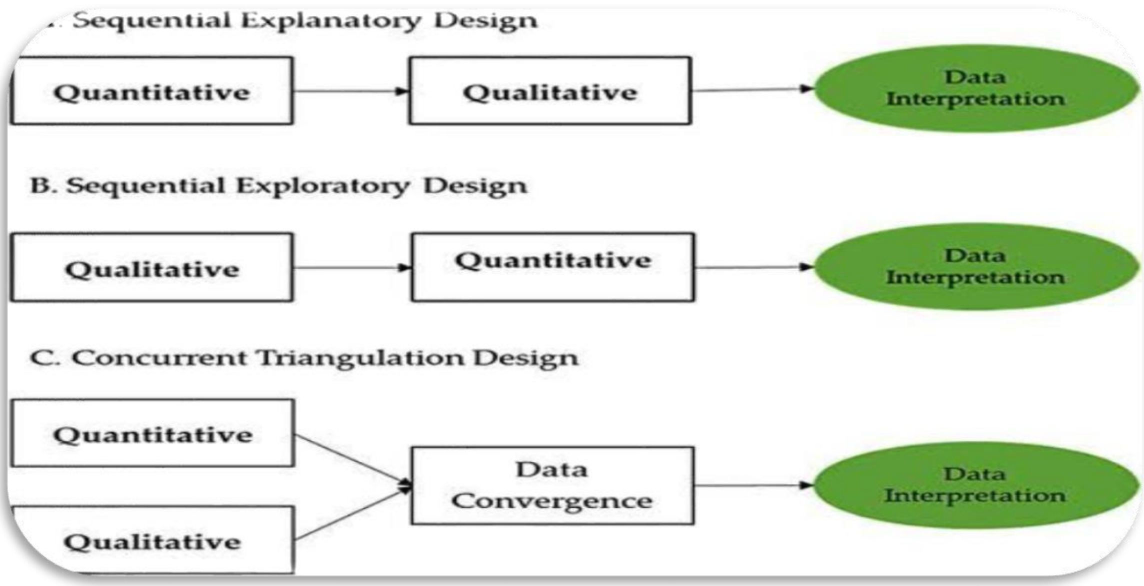


**Fig 5.4: Mixed methods strategies (Adapted from Creswell (2009).**

Fig 5.4 presented the various types of mixed methods strategies that could be employed in research and specified that the study employed a concurrent triangulation mixed method. The mixed methods approach design incorporates both quantitative and qualitative research methodologies and offers distinct ways for qualitative and quantitative data collection. The data analysis process involves a variety of ways for combining and interpreting qualitative and quantitative data. The researcher utilized a concurrent triangulation mixed method technique in this investigation, in which several data gathering devices were used concurrently.

#### 5.2.1.1 Concurrent triangulation mixed methods design

Fig 5.5 illustrates the use of concurrent triangulation approach and the phases that are employed in its application. Concurrent Triangulation is the most widely used and well-known method. Its objective is to collect disparate but complementary data on the same subject.

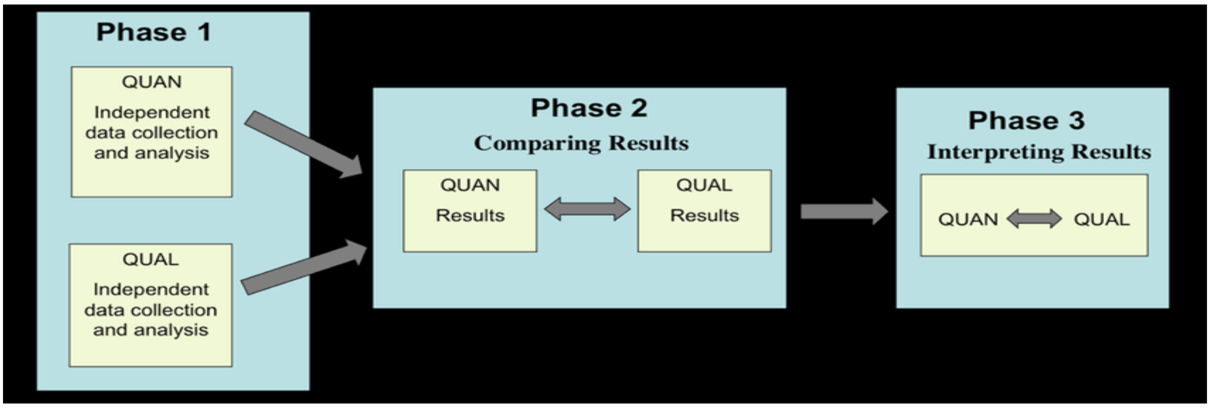


**Fig 5.5 Concurrent Triangulation design (Source: Creswell (2014).**

The findings of a concurrent triangulated study are interpreted quantitatively (QUAN) and qualitatively (QUAL). A diverse form of mixed method assessments may be employed, including different conceptual frameworks, data gathering methods, interview techniques, and times or places and circumstances (Bamberger, 2012). This strategy employs both qualitative and quantitative methods continuously and simultaneously. Koskey and Stewart (2013) argue that although this technique is advantageous for reducing implementation time, it lacks flexibility and learning potential in terms of the outcomes gained by individually executing each of them. Additionally, Bryman (2006) uses the word "parallel" to refer to a concurrent technique.

Almeid (2018) states that the concurrent triangulation design's use of simultaneity defines whether both studies may be undertaken simultaneously or only after the completion of the other, whilst dependency decides if one research's procedure is reliant on the outcomes of another investigation. According to Schoonenboom and Johnson (2017), simultaneity and reliance are distinct aspects. This means that sequential design may include independent data analysis, but concurrent design may incorporate dependent data analysis. In a similar vein, Molina-Azorin (2016) notes that a critical aspect of mixed methods research is the issue of integration. He claims that while mixing qualitative and quantitative methodologies, a researcher should think about the synergies that may be obtained. Burt (2015) notes that many researchers struggle with the integration problem since few have received formal training in hands-on strategies for integrating data.

Qualitative and quantitative data were gathered concurrently, with no priority or preference for gathering within the same phase (Terrell, 2012). The qualitative and quantitative data were then examined separately in stages, and then compared and contrasted in successive steps, as described in the data mixing approach below. However, this application included gathering survey and interview data simultaneously and then interpreting the findings thematically for qualitative data and numerically for quantitative data. The outcomes were then compared and contrasted using meaning and data transformation was necessary to blend methodologies below. Since a consequence, this approach is referred to as triangulation, as it is also used to confirm, cross-validate, or corroborate data. Additionally, the underlying limits of one technique (quantitative vs. qualitative) were accentuated by the strength of the other manner. A noteworthy component of this case study was the ease with which the restricted viewpoint supplied by quantitative data might be broadened by the acquisition of open-ended qualitative data.

Contrary to other kinds of mixed approaches such as sequential data collection, the concurrent triangulation strategy allowed data gathering stages to be finished rather quickly (Terrell, 2012). It was a risk reduction method aimed at reducing the risks associated with unskilled researchers and the complexity involved with comparing data kinds through transformations (Terrell, 2012). The rigor, quality, and validity of this research process were ensured by a strictly supervised research effort overseen by an experienced supervisor who verified the study's techniques and procedures.

However, Terrell (2012) warns that, despite the success of the concurrent triangulation methodology, it requires a great degree of prior information about the phenomenon under investigation in order to utilize two techniques simultaneously and effectively. Correlation and comparison between two distinct types of data, as well as the resolution of any disputes that may arise, may be difficult tasks. In order to address the drawbacks of the concurrent triangulation approach outlined above, the researcher applied quality control measures throughout the data collection and analysis stages. However, the validity and appropriateness of research and findings are not guaranteed by the use of proper techniques; rather, it is the suitability and completeness of research that determines the validity and efficacy of research activity, (Bailey, 2009). Mixed techniques are intrinsically neither more nor less legitimate than other specialized approaches to study. As with any study, the appropriateness, completeness, and efficacy with which those methodologies are employed, as well as the attention given to careful weighing of evidence, are more important in determining validity than following a specific set of rules or adhering to an established tradition, Bailey (2009).

Thus, the research challenges of this case study were continually reduced under the supervision of a research supervisor who gave insights and recommendations on best practices for conducting case studies throughout the process. A few of the best practices discussed were the careful selection of cases or objects of study to be investigated based on the study's goal, accessibility of participants, availability of resources, and timelines, as well as the use of case studies to test hypotheses, Creswell (2014). Almeid (2018) continues on to argue that the use of different data collecting methodologies helps to verify the data acquired and helps to eliminate bias and lack of impartiality, which are typical in case studies, from being introduced. One such risk-mitigation method was the collecting of extensive data in the Centocow Cluster utilizing a variety of instruments as a means of validating the authenticity and reliability of the information gathered. of this, extensive knowledge of various research methods, including the assumptions that underpin each method, working knowledge of analytic procedures and tools related to both quantitative and qualitative research, and the ability to understand and interpret the results of various methods are required as pre-requisites for this position, among other qualifications, Almeid (2018).

Specifically, the research was limited to the Centocow cluster of the KwaZulu-Natal Province, which consisted of five secondary schools and was conducted as a case study. A total of 20 grade 10 students were randomly chosen from each class, using a selection of random numbers issued to every student in each class in which at least four students were participating in the case study (including at least two girls). This strategy ensured that every student in a particular class had an equal chance of being chosen. A total of two subject advisors whose advisory topics include mathematics, as well as five Mathematics Educators who were grade 10 Mathematics educators, were employed in this project. Both the advisers and the educators were selected on purpose, with no consideration given to gender. The variables for the quantitative data, which are x, y was derived from the above constructs, and the procedural questions in the questionnaires for subject advisors and focus group interviews for learners and semi structured interviews for educator participants were designed to test both the existence and or understanding of such procedure from the participants' stories as well as what was measured by the quantitative data outcomes and corroborated by any convergence.

As defined by Kumar (2019), in order to analyze a social phenomenon, it is necessary to conduct a careful analysis of each unique occurrence. In this sense, a case may be defined as a person, a group, an episode, a process, a community, a society, or any other unit of a social group that fits the criteria. Approximately all necessary data for this case was acquired and arranged in line with the study's objectives, to the best of our knowledge. In-depth evaluation of numerous specific aspects was possible as a result of the study, which was beyond the scope of this particular study, but which might be significant resources for future educational research.Regarding the use of a case study, if one wants to understand more about a situation that is little known or poorly understood by the general public, a case study may be extremely instructive. It may be used to explore how particular situations or interventions have an influence on an individual or program, in addition to analyzing how a person or program changes over time. Pursuant to Leedy and Ormrod (2010), the data collecting techniques that may be employed in a case study include observations, interviews, documents, previous records, and audio-visual resources, such as pictures, videotapes, and audiotapes. Typical data analysis procedures in a case study include the following procedures:

- Organisation of details about the case - the specific facts about the case are arranged in logical order.
- Categorisation of data - data are clustered into meaningful groups.
- Interpretation of single instances - specific documents, occurrences, and other bits of data are examined for the specific meanings that they might have in relation to the case.
- Identification of patterns - A thorough examination of the data is carried out to identify underlying themes, as well as syntheses and generalizations - an overall picture is built, and conclusions are drawn. Even though Stakes (in Creswell, 2014) noted that case study research is not a methodology but rather a choice of what is to be investigated (that is, a case

inside a defined system), others have described it as a strategy of inquiry, a methodology, or a thorough research plan. It was chosen by this researcher to be considered a technique, a form of design in qualitative research, or an object of study in addition to a product of the investigation.

Additionally a case study is a setting in which the investigator explores a bounded system (a case) or multiple bounded systems (cases) over time through detailed, in-depth data collection involving multiple sources of information (for example the literature observations, interviews, audio-visual material, documents and reports) and report a case description and a case-based themes for an example, several programmes (a multi-site study) or a single programme (a within-site study) may be selected for study. Types of case studies are distinguished by size of the bounded case, such as whether the case involves one individual, several individuals, a group, an entire program or an activity, Yin (2014).

- They may also be differentiated based on the purpose of the case analysis performed. In terms of goal, there are three types of case studies: the single instrumental case study, the collective or numerous case studies, and the intrinsic case study (which is the most common). In an instrumental case study, the researcher concentrates on a specific topic or concern and then picks one specific bounded instance to highlight the issue in question. If an enquirer chooses a single topic or worry to be addressed in a collective case study (or numerous case studies), the issue or concern is addressed again, but the enquirer chooses a number of case studies to highlight the issue.

The researcher may choose to investigate various programs from different research locations, or he or she may choose to study several programs from a single research site. Frequently, the inquiry purposely picks a number of examples in order to demonstrate a variety of viewpoints on the problem. According to Yin (2014), the logic replication design is used in the multiple case study design, in which the inquiry duplicates the technique for each instance under investigation. Generally speaking, qualitative researchers are hesitant to generalize from one example to another since each instance is situated in a different social and cultural environment. However, in order to get the best generalization, the inquirer must choose representative's examples for inclusion in the qualitative research (Creswell, 2014).

A case study is, therefore, a setting, in which the study methodology of choice can be quantitative, qualitative, or mixed when a sample is large enough to represent a target population. Any quantitative findings can be used to generalize findings to the population. However, a qualitative inquiry regardless of sample size relies on generalization but expands on the understanding of phenomena methods. In this case study the purpose was to explore and understand the improvement of the mathematics education process (if any) through measuring and evaluating the current state of Mathematics teaching and learning methods, measured by a plausible model for professional development, modified and extended to a collaborative mathematics education model.

**5.3 Research Paradigm**

The theoretical or philosophical foundation for a research project is referred to as the research paradigm. The term "research paradigm" refers to the conceptual underpinning or framework that underpins a research project. Additionally, it may be described as an all-encompassing belief system and world view that helps researchers structure their investigation into a certain pattern of thought. Khatri (2020) asserts that in a research endeavor, philosophical viewpoints are those held by the researcher that claim and justify how the researcher sees reality, what his or her assumptions about knowledge, method, and value are (among other things) and how the researcher observes reality. As a consequence, the attitudes and beliefs of the researcher concerning any issues under investigation will ultimately dictate the course of their study. Through the entire investigation process, it assists the researcher in making decisions about research topics, formulating research questions, determining the nature and types of reality, knowledge, and technique as well as the significance of the research effort itself, it guides the researcher through the entire investigation process.

Using the term paradigm to describe a world view, a viewpoint about the manner in which evidence about a phenomenon should be gathered, analyzed, and generalized is proposed by Sharma (2017). In its original usage by Kuhn (1962), the term derives from the Greek word "paradeigma," which means pattern, and is intended to describe conceptual frameworks shared by a community of scientists that provides them with a commitment model for explaining problems and finding solutions to societal challenges. A research paradigm is defined as a well-established model that has been accepted by a large number of individuals in a research community, Morgan (2014:50). Continuing, Kumar (2011) explains that paradigms, also known as research philosophy, are made up of beliefs, values, and procedures that determine what should be examined and how the findings should be interpreted. As per Kivunja and Kuyini (2017), the term paradigm is derived from the Greek word meaning pattern and has been liberally defined by numerous scholars. For example, a paradigm is defined as "a way of perceiving the world that frames a research issue" and has an impact on the way researchers think about the subject matter they are studying. The research philosophy that one chooses is determined by the way one observes the world in conjunction with certain assumptions. The assumptions behind the research approach and methodologies are listed below. Saunders and colleagues (Saunders et al (2016) argue that knowledge and the method by which this knowledge is generated, as well as one's perspective on this, impact the philosophy that one adopts. As a result, research paradigms are conceptual frameworks that interact with one another and aid the researcher in the selection of research design, data collecting tools, data analysis procedures, and subsequent findings about a particular research project. As a paradigm, pragmatism was applied in the research.

### 5.3.1 Pragmatism

Despite that the term pragmatism has been defined differently in different literature studies, James (2014) asserts that it is founded on the researcher's goal to grasp human experience in a specific real-world environment. In ancient Greece, Sophist philosophers argued that man is the measure of all things, and it is believed that this is where the term originated (2013). When it comes to pragmatism, Kumar (2011) says the phrase originated from a Greek word that literally means to do, create, or achieve something. When it comes to gaining knowledge, the pragmatic paradigm, as perceived by McMillan and Schumacher (2014), places an emphasis on common sense and practice in addition to scientific methods, with individual phenomena having their own way of interpreting their surroundings as part of the learning process. As summarized by Durant (2011), pragmatism is the notion that truth is the practical efficacy of an idea and that pragmatism is more than a philosophy, it is a technique of doing things to get knowledge. Consequently, pragmatism as a research philosophy empowers the researcher to project the processes and eventual outcomes of the study in the context of providing a practical problem-solving output of research that has value in the community.

### 5.3.2 Principles of pragmatism

Based on Curry (2016), pragmatists are pluralists who think that there are as many words as human beings can make and as many realities as there are individuals, since everyone seeks truth and purpose in life and utilizes those experiences to improve their surroundings. Therefore, the purpose and values of life change throughout time and climatic zones, and human existence and the planet serve as a laboratory for the production of these purposes and values, Reck (2015). The demand for flexibility to changing conditions in life is crucial to pragmatic philosophy; as Nohl (2013:13 points out; pragmatists prioritize action above ideas since action is the means through which significant knowledge is acquired. Consequently, stakeholders must cooperate and develop realistic solutions to the fragmentation of pedagogical discourse that mystifies mathematics teaching and learning and professionally isolates teachers, resulting in impaired teaching and learning processes and poor learner outcomes.

### 5.3.3 Contributions of pragmatism to developing a collaborative model

Kelly, Marcella, Dowling, Maura, Millar, and Michelle (2018) recognise that the pragmatic paradigm provides a pluralistic approach to both comprehending the world and resolving research issues or problems from an ontological and epistemological standpoint. Patton (2015) purposely places a pragmatist emphasis on' methodological openness' in order to confront and offer solutions to the complexity of real-world research reflecting a multiplicity of real-life difficulties, Creswell (2014). Thus, a pragmatist's focus is on plurality, which implies that a variety of research methodologies, methods, and designs are used by teaching collaborators to address the research topic.

By applying a pragmatic philosophy to the challenge of mathematics teaching and learning, this study develops and implements a shared value solution-based technique for addressing the study goals. Yannou – LeBris and Chapdonnel (2014) argue that adopting a pragmatic paradigm enhances competitiveness by including stakeholders in the development of context-based and jointly agreed solutions for secondary school mathematics teaching and learning.

The current study exhibits design-based research by attempting to construct educational innovations in order to conduct research on teaching and learning in the context of educational innovations, such as educational technology and new pedagogical methodologies. Simultaneously, as Plomp (2013) points out, the iterative process of designing and testing the suggested innovation leads in the formation of novel educational phenomena for teaching and learning research. Additionally, Kelly (2004) notes that one of the components of design-based research is universally applicable educational innovation. From a pragmatic approach, educational innovation is meant to aid educators in teaching and students in learning more successfully. This necessitates that the teacher participates actively in the cognitive process. Teachers ultimately build the learning environment via their classroom activities, Meisalo, Juuti, and Lavonen (2016).

Thus, the multiple processes involved in developing and creating a teaching model as a pedagogical innovation contain intrinsic immaterial and indeterminate components that comprise classroom activity and can be understood only via the teacher's thinking. Juuti, Meisalo, and Lavonen (2016). This might be viewed of as perceived educational innovation's viability. The educator 'personalizes' each instructional innovation. To implement it successfully, a teacher must understand and agree on some level with the innovation. On the basis of our experience with the design and teacher adoption processes (Lavonen et al. 2006), it becomes clear that developing a smart or future breakthrough with affordances that teachers are unaware of is worthless. If educators do not understand the rationale for the innovation, they will simply reject it. Thus, it is vital to understand a teacher's environment in order to ensure that the intended innovation is adequately flexible, and that adoption does not need an excessive amount of adaptation on the instructor's side. Design-based research creates unique information about mathematics teaching and learning via reflection on classroom experiences, Plomp (2013), and so pragmatism philosophically supports all acts and activities conducted by collaborators in building the mathematics model.

## 5.4 Research Setting

Fig 5.6 presents a map of Centocow Cluster of KwaZulu Natal Province (Source: Google maps) the research setting, rural cluster of five schools which were sampled for the study.

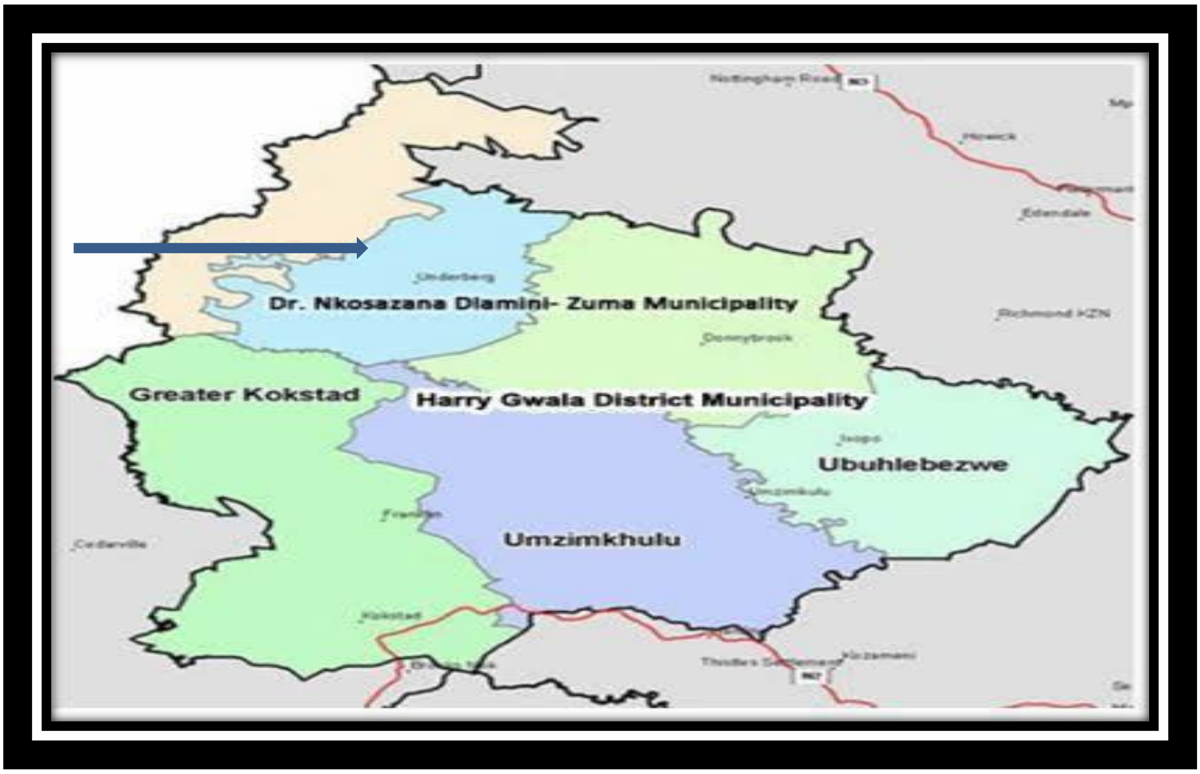


**Fig 5.6: Centocow Cluster of KwaZulu Natal Province (Source: Google maps)**

The research setting refers to the place where the data are collected. The Centocow cluster is located in Dr Nkosazana Dlamini-Zuma municipality a predominantly rural and underdeveloped with five secondary schools which are situated within a radius of 10 km apart. The schools are A, B, C, D and E secondary schools. The five schools combined had 520 Mathematics learners, 10 educators, five Heads of Departments and two subject advisors. Grade 10 was chosen for the study because it is the foundation upon which Mathematics in the Further Education and Training phase is introduced and influences performances in Grades 11 and 12 respectively.

### 5.4.1 Target Population

Based on Hassan (2018), the population in a research study refers to a big group of persons or items that constitute the primary focus of the research issue. Taherdoost (2016) defines a target population as the number of persons or research participants whose data will be used to answer the study's research questions. A research study is conducted for the benefit of the study's population. It is well established that all people within a group have some features (Hassan, 2018). However, a researcher cannot contact every member of the study population. As a result, the researcher must construct an easily accessible population in order to perform the study (Hassan, 2018). A target population is the total set of persons or objects required by the researcher to make conclusions about the study. Typically, the study's target group has similar features (Hassan, 2018).

Borg and Gall (1989) describe the target population by implying that they are all members of a genuine imaginary collection of people, events, and objects to which the research process's findings may be applied. As per McMillan and Schumacher (2010) and Johnson and Christensen (2008), the target population may be defined as the total group of persons who have the researcher's desired qualities. Thus, the population is a bigger group of persons or organizations from whom an in-depth research sample is drawn. The research population includes all Grade 10 Mathematics students, their teachers, and subject advisers in the Centocow cluster of KwaZulu-Sisonke Natal's district. The approximate statistics of the population is 15 educators, 150 mathematics learners and 2 subject adivisors.

**5.5 Sampling Techniques**

In the context of academic studies that are time-limited and mostly self-funded, the researcher will be required to choose a sample from which data to answer the study questions and findings to generalize to the full population will be acquired. Alkindy et al. (2016) define a sample as a group of respondents (individuals) chosen to be representative of a larger population. Sampling is defined as the act, process, or technique by which a sample is selected. In other terms, a sample is a group or subset of a population; more precisely, sampling is defined in research as the process of picking an element or elements of the population (individual participant, or item) that accurately reflect the complete population. Sampling enables the researcher to acquire a smaller amount of data representative of the whole population. Cooper and Schindler (2013) add that sampling is the act of selecting study respondents from a large range of objects and involves adopting a position on which items, places, events, behavior, and/or social processes to watch. Thus, sampling is a research procedure in which a researcher selects study respondents to be exposed to data collecting tools in order to answer the research questions. The graphic below depicts the link between population and sample size and sampling strategies.

Saunders et al. (2016) distinguish two types of sampling techniques: probability or representative sampling and non-probability sampling. Tuovila (2020) adds that sampling is the method by which the number of people or observations drawn from a bigger population is determined. Glen (2016) defines nonprobability sampling as a strategy in which the probability of picking a sample participant is not determined. As perceived by

Burns and Grove (2015), sampling is the process of choosing a group of individuals, events, or behaviors to examine. Sampling has a strong correlation with the generalizability of results. Probability samples have a predefined probability of each element being picked from the population, which is almost always equal for all items. Gentles et al. (2015) add that sampling is the act, process, or technique of selecting a representative sample of a population for the purpose of determining population parameters or characteristics, as well as the selection of specific data sources from which data are collected to address the research objectives. Burns and Grove (2013) expand on this definition by defining sampling as the process of choosing a group of individuals, events, or behaviors to investigate. Sampling has a strong correlation with the generalizability of results. Additionally, sampling entails choosing a limited number of significant examples that "provide the largest amount of information and have the biggest influence on the creation of knowledge,"Patton (2015:276). Thus, sampling is the act of selecting a random sample of respondents from a population with the goal of subjecting them to data mining using research tools. This sample strategy was chosen by the researcher due to its cost and time effectiveness. Due to the short duration of this investigation, non-probability sampling enabled the researcher to obtain data quickly.

**5.5.1 Purposive sampling**

The purposeful sampling strategy was adopted in this study since the researcher required only individuals who may be relevant to the investigation. McMillan and Schumacher (2010) claim that deliberate sampling refers to the process of picking information-rich examples for research in order to get a better understanding of them without having to generalize the knowledge to all similar situations. Purposive sampling was the primary non-probability sampling technique utilized by the researcher.

According to Saunders et al. (2016), non-probabilistic sampling is a type of sampling in which the probability of each element being chosen from the total population is not predetermined, making it impossible to respond to research questions or accomplish objectives that require the researcher to make statistical inferences about the population's characteristics. Showkat and Parveen (2017) demonstrate that, in contrast to probability sampling, non-probability sampling employs non-randomized approaches for sample selection. Non-probability sampling entails considerable discretion. Rather of randomness, individuals are chosen based on their ease of access. Daniel (2012) explains that non-probabilistic sampling, often known as convenience sampling, entails the selection of samples depending on the researcher's accessibility. The study's components are selected based on their ease of recruitment and the approach regarded to be the least time consuming and least expensive.

Showkat and Parveen (2017) argue that non-probabilistic sampling is more cost effective, more accessible, and easy since it selects just those individuals who are relevant to the study design. Additionally, there is no way to assure that the sample is actually representative of the population, and greater emphasis is put on the researcher's ability to analyze demographic components. On the contrary, Sharma (2017:4) demonstrates that owing to the subjective and non-probability-based nature of unit selection in sampling for instance picking individuals, and cases/organizations, it may be difficult to justify the sample's representativeness. In other words, convincing the reader that the judgment used to pick units to study was suitable might be challenging. To mitigate this, the research will adopt systematic triangulation, in which several data gathering tools will be used.

The sampling technique used in this research will be non-probability and purposive. Burns and Grove (2015 define purposeful (non-probability) sampling as sampling with a specific objective in mind, often an interest in certain populations Purposive or judgmental sampling enables the researcher to use his or her judgment in selecting study items. Sharma (2017) explains further that purposive sampling, also known as judgmental, selective, or subjective sampling, refers to a collection of sampling procedures that depend on the researcher's judgment when choosing the units to be investigated for example persons, cases/organizations, events, or bits of data. Purposive sampling's major focus is not sample proportionality, but rather that the sample picked should aid in addressing the study objectives. Burns and Grove (2015) agree that using purposive or judgmental sampling allows the researcher to use his or her judgment in selecting study materials. The researcher chose this strategy because she wishes to get information about the professionals' perspectives on the critical importance of cooperation in mathematics education, which the professionals may supply via their experience.

Purposive sampling is the intentional selection of an informant based on the informant's characteristics. It is a nonrandom strategy that does not need underlying theories or a predefined sample size. Simply said, the researcher determines what information is required and then seeks out individuals who are capable and ready to supply it based on their expertise or experience. Shepard and Lewis (2016). Purposive sampling is used to choose a sample depending on the characteristics of the population and the research purpose (Crossman, 2020). The homogeneous purposive sample strategy was utilized in this investigation. This indicates that the researcher chose participants based on the fact that they had one or more of the same features (Crossman, 2020). The researcher identifies and studies information-rich important informants, groups, locations, or events. In other words, these samples are selected based on their likelihood to be educated and useful about the phenomenon under investigation. Purposive sampling was utilized to pick five educators and one representative from each of the five schools. Additionally, two subject advisors were sampled for the research. A sample of twenty Grade 10 learners was randomly selected for the study, four learners per school. The research respondents will be subjected to research processes of interviews, questionnaires, classroom observations and writing diagnostic tests. The Fig (5.9) illustrates the sample of schools, educators and learners and subject advisors.

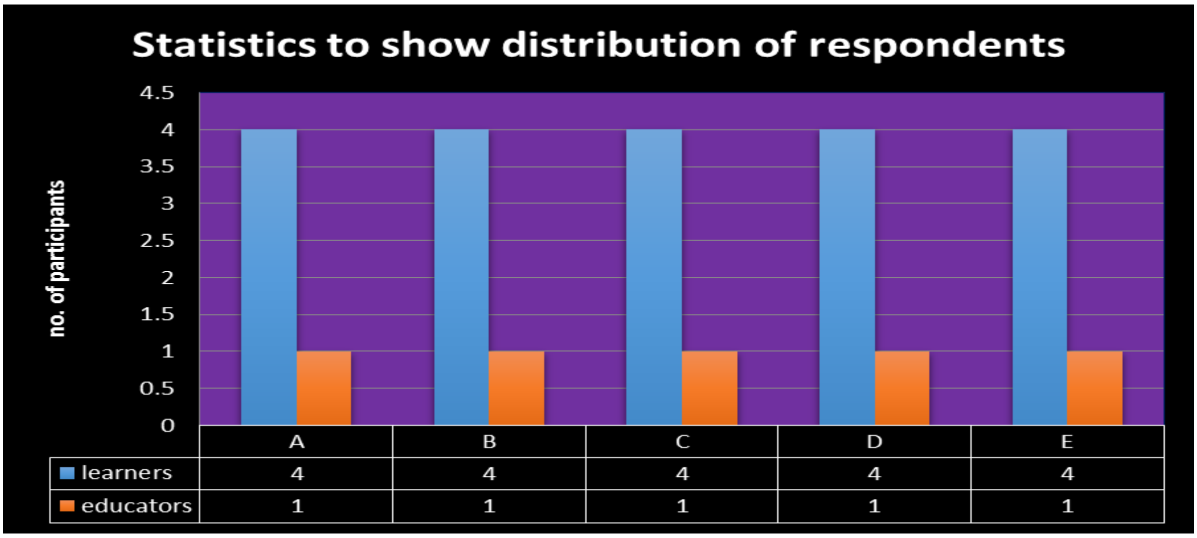


**Figure 5.8: Bar Chart-Number of Respondents in each Category**

The Fig (5.8) bar graph presented the distribution of learners and educators per each of the five sampled schools in the study total of twenty learners and five educators is graphically presented.

In the study, which was a case study, there is an evident sampling bias to enable the researcher to do an in-depth study of the respondents. McMillan and Schumacher (2010) define sampling bias as a systematic over or under representation of certain population characteristics that are relevant to the study. To minimize sampling bias in this study the researcher adopted a proportional, stratified random sampling method for selecting Mathematics learners in the five schools in terms of gender. Proportional stratified random sampling is a technique in which a population is divided into subgroups (strata) according to stratification variables such as gender, age, or level of education and then a sample is chosen from each stratum (Grey *et al.*, 2006, Johnson & Christensen, 2013).

In implementing the stratified random sampling, the researcher employed the following processes as suggested by McMillan and Schumacher (2001), Johnson and Christensen (2008):

- List of all Mathematics learners sampled before the commencement of the study.
- Learners were divided into strata on the bases of gender and separate lists of males and females in each school sampled.
- Names of learners per gender, were put in separate containers.
- Using a raffle format, the names of two girls and two boys per school were selected making a total of 20 learners from the five schools.

In justifying the sample size, McMillan, and Schumacher (2010) cite that several factors must be considered such as type of research question(s), financial constraints, the importance of the results and the number of variables studied, methods of data collection and degree of accuracy needed. In the study, which was a case study based on grounded theory, the selection of 27 respondents, 20 learners, 5 educators and 2 subject advisors was mainly based on the judgment of the researcher and as such the sample size was adequate enough to answer the research main question and sub-questions.

**5.6 Collection of research data**

A research study's climax was the collection of data from respondentsand participants which was then analysed to offer answers to the research questions. Since a result, the data collecting phase is critical, and it has the potential to make or break the final conclusions of a research, as flawed and unauthenticated data may not provide reliable results, or it may fail to yield credible results. As per Jovancic (2019), data collection is the process of acquiring certain information that is essential for a research project to be successful. The data collecting process was carried out using a Concurrent Triangulation design technique. They explain that these types of designs are well suited for studies in which the quantitative and qualitative components are equally weighted, and where data is collected concurrently while being subjected to both qualitative and quantitative analysis techniques. Wium and Louw (2018:5) provide an example of a study in which the quantitative and qualitative components are equally weighted and where the data is collected concurrently while being subjected to both qualitative and quantitative analysis techniques. The study, a triangulated concurrent design case of Centocow cluster collected data using four main instruments namely questionnaires, observation, document analysis, tests and semi structured interviews which are given detailed description in section 5.7 of the same cahapter.

**5.6.1 Data and Data sources**

Marshall and Rossman (2014:14) define data as "information obtained over the course of an inquiry or research". Quantitative data in the form of statistics and qualitative data in the form of descriptive text are two types of data. Fig 5.10depicts the types of data as either quantitative or qualitative, varioable or descrete and also descriptive and open and subjective. The process of data collecting starts once a research problem has been determined and a study design/plan has been drafted and implemented. Whenever a researcher is choosing on the technique of data collecting to be utilized for a study, he or she should bear in mind two sorts of information: primary information and secondary information.

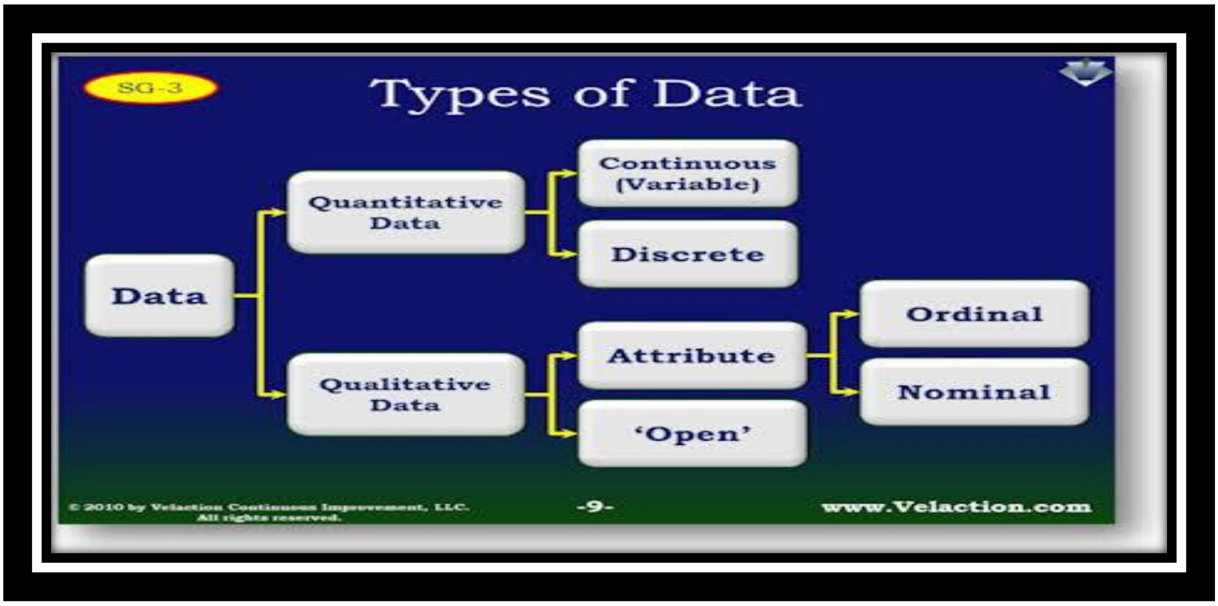


**Fig 5.9: Types of data (Source: Marshall and Rossman (2014)**

Primary data are those that are obtained from scratch and for the first time and are thus considered to be unique in nature. The secondary data, on the other hand, are those that have already been acquired by someone else and have already been subjected to the statistical analysis procedure, Mahto (2016).

As Abawi (2013) expounds that there are many ways to collect first-hand data, including observation, direct communication with respondents in various forms, or even personal interviews. This is true for both experimental and non-experimental research, as well as when conducting surveys of any kind (sample and/or census). There are several ways to collect primary data, including surveys and descriptive studies. It's crucial to keep in mind the following points: methods include observational, interviewing, questionnaire, and scheduling techniques.

Secondary data, on the other hand, refers to information that has already been gathered and processed by someone else. It is necessary for the researcher to investigate numerous sources from which he might collect secondary data while he is using secondary data. The issues that are often involved with the acquisition of original data, as described by Saunders et al., (2016) are not present in this situation. Secondary data sources may be either public or unpublished, depending on the nature of the information. Diaries, letters, unpublished biographies and autobiographies, among other sources of unpublished data, may be available to scholars and useful in providing answers to research questions. Books, magazines, and newspapers; reports and publications of various associations connected with business and industry, banks, stock exchange, as well as sources of unpublished data such as diaries, letters, unpublished biographies and autobiographies may also be available to scholars and useful in providing answers to research questions, may be available to scholars.

**5.7 Data collection instruments**

A research instrument is a tool used to collect, measure, and analyze data related to your research interests. These tools are most commonly used in health sciences, social sciences, and education to assess patients, clients, students, teachers, and staff. A research instrument can include interviews, tests, surveys, or checklists, Saunders etal (2016). Different instruments are illustrated in Fig 5.10.

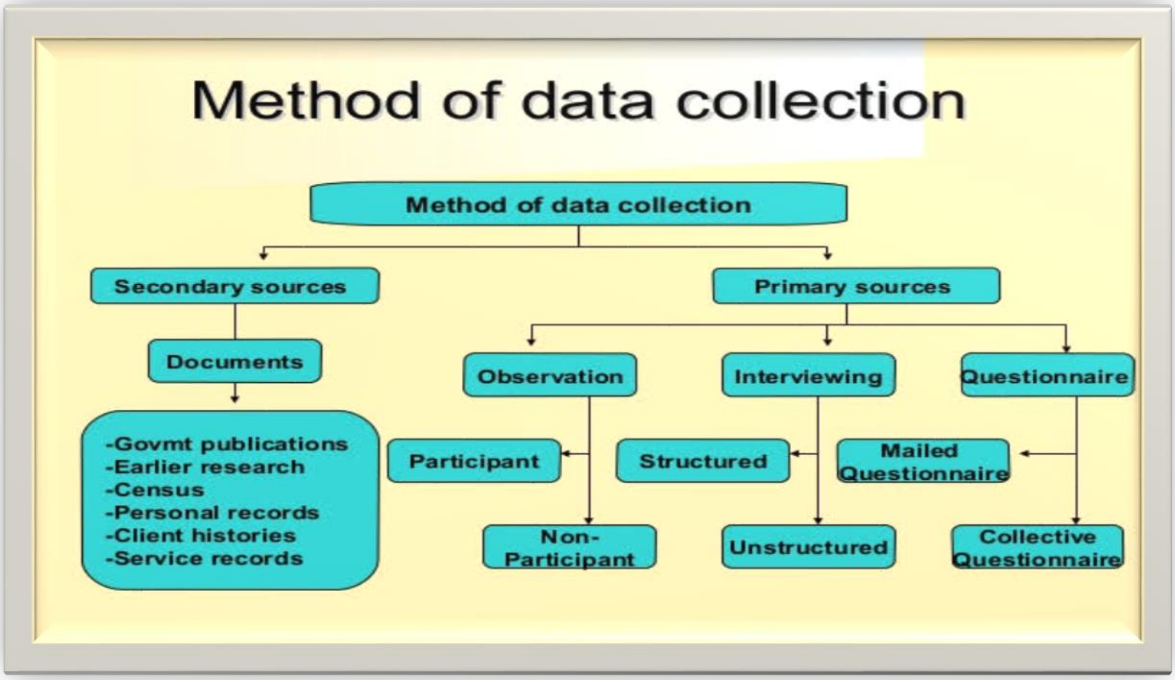


**Fig 5.10: Data collection instruments (Source: adapted from Saunders etal (2016)**

Fig 5. 10presented research methods or intruments that were used to collect both primary and secondary data from participants. Questionnaires and interviews were among the study tools employed by the researchers to gather information from respondents. Results of performance tests were compiled in conjunction with a questionnaire, but additional quantitative data was collected and utilized for a statistical analysis. People's thoughts and feelings were acquired via interviews and surveys as well as direct observations. The data collection process is frequently meticulous in case study research, with researchers depending on a range of sources of information, including observations in the literature, interviews, documents, and audio-visual recordings, among other sources of information. In agreement with Yin (2014), the following six types of information should be gathered: documents and archival records, interviews, direct observation, participant observation, and physical artifacts (Creswell, 2014).

### 5.7.1 Semi- Structured interviews

Creswell *et al.*, (2010) define an interview as a two-way conversation in which the interviewer asks the participant questions to collect data and to learn about the ideas, beliefs, views, opinions, and behaviours of the participants. As defined by Teijlingen (2014), a semi-structured interview is a collection of planned questions whose order may be varied depending on the interviewer's assessment of what seems to be the most suitable in each interview session. It is possible to modify the phrasing of the questions and to provide explanations for them. If the interviewer determines that some questions are unsuitable for a specific interviewee, the questions may be removed, and new questions can be added in their place as appropriate. Hofisi, Hofisi, and Mago (2014:43) agree that a semi-structured interview allows for the same basic questions to be asked to every respondent, but there is flexibility in how the questions are asked, as well as the ability to ask extra probing questions when necessary.

Based on Almeda etal (2017), this form of data collecting allows participants to express their own tales in their own terms, rather than being compelled to follow pre-established lines of thought generated by the researcher, which is similar to the approach described above. As a means of investigating and accumulating experienced narrative material that may serve as a resource for generating a richer and deeper knowledge of human phenomena, interviews are often considered to be the most effective method. The interviewer is there to clarify the question in order to minimize misunderstanding from respondents, based on Maxwell (2013). Semi-structured interviews have a high response rate, as per to Maxwell (2013). It is, nonetheless, necessary to allocate sufficient time to preparation for a structured interview. Consequently, interviews record respondents' perspectives, experiences, and opinions about a study topic, with interviewee coaching and explanations provided when appropriate, to help in the collection of data.

They further indicate that the main aim of qualitative interviews is to see the world through the eyes of the participants. They also mentioned the key factors that make interviews successful are namely:

a) Finding suitable person(s) in terms of the research questions,
b) clarifying to the person being interviewed about the aim of the interview,
c) questioning strategy,
d) the types of questions asked, and
e) The interviewer assuming the role of a listener and not dominating the interview.

**Advantages of using interviews.**

The advantage of interviewing is that as an interviewer, one can explain more explicitly the purpose of the investigation, and just what information the researcher wants. If the subject misinterprets the question, the interviewer may follow it up with a clarifying question. People are usually more willing to talk than to write. If the interviewer establishes a friendly and secure relationship with the subject, certain types of confidential information may be obtained that an individual might be reluctant to put in writing. The researcher used interviews because they are found to be user-friendly for the purpose of this study. A number of advantages of interviews which made the researcher consider using them as a data collecting instruments are as follows:

a) Interviews are flexible. Researchers can probe for more specific answers and can repeat a question when the response indicates that the respondent misunderstood.
b) The respondents give their original responses, which is not obtained through cheating by receiving answers from others.
c) The possibility of all the questions being answered is high.
d) The interviewer can record the exact time, date and place of the event that has occurred.
e) The interviewer can standardise the interview environment by ensuring that the interview is conducted in privacy, that there is no noise, and that all the research ethics are taken into consideration.
f) They provide insight on participants' perspectives, the meaning of events for people involved, information about the site and perhaps information on unanticipated issues.
g) Supplying of large volumes of in-depth data rather quickly.
h) Allows immediate follow-up and clarification of participants' responses.

**Disadvantages of using interviews**

- Interviewees may not be willing to share information or may offer false information.
- Interviews require a great deal of time to conduct and later to transcribe the audiotapes or other notes.
- Interviewers need skill and practice to carry out a successful interview.

In a bid to ameliorate the disadvantages that arose from using interviews the researcher probed respondents who had a specific position and expertise, such as the subjects' specialists employed by the department participating in the current study. Semi-structured interviews allowed the researcher to ask a set of structured questions before delving further into the subject matter with open-ended questions in order to get more data that is comprehensive and to allow the respondents to express themselves in more detail, Ingmar Henning (2014). As further explained in the article, the approach lets the researcher to gather open-ended data, investigate participant ideas, emotions, and opinions about a certain subject, as well as dig deeply into personal and often sensitive matters, owing to De

Jonckheere and Vaughn (2019). Because of its flexibility, adaptability, and capacity to provide the researcher with the freedom to probe the interviewee, follow up leads, expound on responses, gather more and more complete data, and explain replies, semi-structured interviews were utilized in this study.

### 5.7.3 Focus group interviews

Focus group interviews are used when it is decided that it is desirable to get information from a group of participants rather than from individual participants in research, which is often the case. When examining a phenomenon, group interviews are ideal because they allow researchers to get an understanding of the circumstances, behavior, or attitudes of people involved by engaging in a collective dialogue. In order to get deeper insight into the study, the researcher conducted focus group interviews in order to gather more information about the group dynamics or any cause-and-effect aspects that may have been identified throughout the research. Students in groups where they felt they belonged were expected to contribute their views and ideas concerning the teaching and learning of mathematics in their particular classrooms, and this was expected to happen.

In terms of group size, Maughan (2003) recommends that a sample group consist of 6-12 people because a smaller group may limit the amount of information that can be collected, and a larger group may make it difficult for all participants to participate and interact, as well as for the interviewer to make sense of the information that has been provided. It has been stated before by Davies et al. (2008) that certain groups may be limited to as few as four individuals to allow for more in-depth and participatory engagement in the matter being addressed. The study groups were made up of four learners in each of the five groups in a class, which was the case for the whole class. As per Genise (2002), numerous groups should be employed in order to achieve more goals and a more comprehensive picture of the inquiry. It broadens and deepens the scope and depth of knowledge. For best practice techniques, it is suggested that a minimum of three focus groups be conducted. In the research, five focus groups were created, one from each school, and each group consisted of four Grade 10 students who were questioned on a variety of topics related to mathematics teaching and learning, including views and attitudes, techniques, and performance on exams. Focus group interviews, despite the fact that they are a highly effective tool for gaining insight into participants' thoughts and opinions, need the development of soft skills such as facilitation, group skills, moderating, listening, observation, and analysis.

### 5.7.4 Observational Evaluations

In a research environment, observation is a supplemental data gathering tool that the researcher utilizes to acquire data. Observation is the most fundamental way of learning about the world around us. Not all observation, on the other hand, is scientific observation. When a researcher is trying to accomplish a certain objective with their study, observation transforms into a powerful tool that may help them do so. Utilizing it calls for methodical planning, a connection to more general theoretical concepts, methodical documentation, and submission to valid and dependable checks and controls, Kumar (2011). Further, according to Creswell (2014), observation is "a systematic and purposeful examination of spontaneous happenings through the eye of the observer at the time they occur" and is "a systematic and purposeful examination of spontaneous happenings via the eye of the observer at the time they occur." To summarize, observation is done with the eyes, and its purpose is to discover crucial reciprocal links between naturally occurring events. Observation is done with the eyes since it is the only way to see things. Adding to this, Biklen (2007) explains that field notes are written down as observations are being made and are focused on what is seen. As part of the research process, a researcher may also add notes to help in the interpretation of what the observed occurrences may mean, which will be useful in answering the research questions during future data analysis.

Observational evaluation by participants or by non-participants is a possibility. As a participant observer in the study, the researcher observed the interactions and activities that took place in a Mathematics classroom. As Yogi Berra, an American philosopher puts it: "By just watching, you may learn a great deal." By simply watching, he means that the researcher can gather data in its natural setting, resulting in authentic and reliable information that adds value to the study's findings. Despite this, Kumar (2011) maintains that it is a useful method because of the following advantages. Observation is, by far, the most basic of all the social science tools when seen in a comparative context. To become a trained observer, you must go through a simple procedure that involves just a little amount of training time. On the contrary, while doing an observation, it is not essential for the responder to consent, although this is not the case when conducting a questionnaire or interview. It is possible that they may encounter roadblocks, although this is not entirely reliant on the observer’s aid in the inquiry. Finally, since observation is based on authentic, first-hand experience, its findings are more realistic than those gained via other techniques, which rely on secondary and indirect sources of information for their knowledge.

Obtrusiveness, on the other hand, is a basic downside of observation. For the purpose of gathering primary and verifiable data from genuine processes and activities that occur in mathematics classrooms throughout the course of the subject's teaching and learning, the study relied primarily on observational assessment techniques. According to this, the presence of a researcher in a classroom may have an impact on the conduct of study participants. The researcher visited the study settings several times before doing the actual observations in order to get acquainted with the participants and decrease interference when data was collected afterwards.

### 5.7.5 Questionnaires

The data for the quantitative analysis was gathered via the use of structured questionnaires. Based on Sharma (2017), a questionnaire is a form that has a series of questions that are particularly addressed to a statistically significant number of persons and that is used to collect data for a survey in order to gather information. It is used to obtain statistical information or to solicit opinions from the public. As per Abawi (2013), a questionnaire is a data collection instrument that consists of a series of questions and other prompts that are used to gather information from respondents. The questionnaire was created by Sir Franci Galton, who is credited with inventing it. As a consequence, a questionnaire is a set of written questions concerning the study subject that the researcher uses to collect data from research participants. A questionnaire is a kind of survey.

As per Teijlingen (2014), questions in structured surveys are predetermined and asked in a specified sequence. Morris (2015) outlines the primary benefits of structured surveys and goes on to say that since structured questionnaire answers are collected in a standardised manner, questionnaires are more objective than interviews. A structured questionnaire, according to Roop and Roni (2017), is made up of organized questions that are precise, specific, and planned. All responders are asked the same questions with the same language and in the same sequence. All questions and responses are described in a carefully organized questionnaire, and comments in the respondents' own words are minimized. Structured questionnaires, according Roop and Rani (2017), consist of closed or prompted questions with preset responses. With pre-coded replies, the researcher must anticipate all potential responses. This means that the questions in a structured questionnaire are objective and scientific in nature, since the responses are pre-defined in order to ensure the objectivity of the data gathered, which will be measurable.

A 5-point Likert scale was used to measure the data. The survey questionnaire measured the following dimensions: Activities in supply chain collaboration, challenges encountered and how they can be corrected. Questions for the survey were built from the salient themes that will have emerged from the qualitative data analysis and used the conceptual framework theory as a conceptual underpinning to evaluate the impact of collaboration in teaching mathematics in secondary schools. Survey data was analysed using SPSS version 25.0 for descriptive and inferential statistics. A complete description of the quantitative data collection and analysis strategies utilized has been described elsewhere, Berman (2017:17).

Structured questionnaires are not free of their own limitations. Questionnaires, like many evaluation methods occur after the event, so participants may forget important issues, Morris (2015:38). Structured questionnaires tend to be standardised and do not allow for detail or clarity in some questions which may lead to misinterpretations by participants. A possible solution to this challenge could be piloting the questions on a small group of respondents. The shortcoming according to Abawi (2013:5-10), is that a questionnaire reveals just the participants' response as the participant sees the circumstance, subsequently a few inquiries for example, to do with time estimation or recurrence of occasion event, are not as a rule dependably replied in surveys.

**Questionnaire Design**

The structured questionnaire, which was used in conjunction with a structured interview, was divided into three parts (A, B, and C), each of which uses a Likert-type scale. Simon and Goes (2013:15) developed the Likert scale to gauge 'attitude,' quantify outcomes, and get shades of impressions. (Joshi, Kale, Chandel, and Pal (2015) describe attitude as a preferable method of responding or reacting in a certain context rooted in generally long-lasting structure of beliefs and ideas gained via social interactions.According to Joshi et al. (2015) a Likert scale is a set of statements (items) offered for a real or hypothetical situation under study on which participants are asked to show their level of agreement with each given statement on a metric scale.

The questionnaire began with Section A which carries seven (7) questions on the biographical information of the respondents. The questions solicited academic and qualification levels, experience and job status in the sector. The data was intended to capture if qualifications and experience of respondents' impact on the capacity and competency to effectively teach and produce good results in mathematics education. Section B was composed of mathematics structural evaluation questions on the status of teaching the subject, challenges if any and the interventions to find lasting solutions. Section C, the last section of the questionnaire had questions that probed the effectiveness of implementation collaborative strategies that are intended to solidify efforts by role players in mathematics education. The key questions in this section sought to evaluate the measures that educators took into consideration in order to collaborate in bringing improved performance in mathematics in rural Centocow Cluster of KwaZulu Ntal Province.

Performance indicators for the collaborative structures were also solicited, as well as an evaluation of the collaborative engagements in mathematics education. The questionnaire was anonymous in order to preserve the privacy of those who complete it. Semi-structured questionnaires were presented to both learners and educators as part of the research in order to gather their thoughts and opinions on their beliefs and attitudes regarding mathematics. The questionnaires were individually delivered by the researcher, who then collected the responses from the participants.

**5.7.6 Performance tests**

Performance-based assessment, according to Oberg (2010:5), is "one or more approaches for monitoring student development and abilities," with performance assessments acting as the "ultimate way for bridging the gap between teaching and evaluation." Performance assessments, as explained by Frey and Schmitt (2010), are used to check for skill or ability; they are usually referred to as alternative evaluations or genuine evaluations; and they typically include subjective judgment in the process of obtaining a score. Performance evaluations may also be used to track a student's development as they proceed through the educational system. As per VanTassel-Baska (2013), performance evaluations themselves serve as a foundation for children, especially talented children, to engage in ongoing and meaningful learning throughout their schooling. Adeyemi (2015) provides an example of how actual and portfolio assessments help to the teaching and learning process via the use of a study of middle school pupils. Each of these evaluation procedures involves the participation of the students, enabling them to have a more meaningful role in the growth of their academic performance. As shown in the study, the triumphs of learners, as well as their sense of responsibility for keeping track of their own growth, act as an internal motivator for task interest. It was not only that the students in this research made connections between various components of the information, but they also made connections between those components of the knowledge and their previous learning and personal experiences (Adeyemi, 2015). As a result, performance evaluations are utilized in research to measure learner performance, conceptual knowledge of topics, and application of taught ideas in problem solving and everyday scenarios.

In the study, theoretically, the underlying basis for structuring the tests was to measure the ability to add, subtract, multiply, and divide whole numbers, decimals, and fractions; calculate percentages; and calculate the area and volume of simple geometric forms.The test was a form of diagnostic assessment conducted using test items derived from the Trends in International Mathematics and Science Studies (2011) (TIMSS) question bank, which were given to both learners and educators in the research. T-tests, measures of central tendency, standard deviation, and variance were used to examine and compare the outcomes of the performance tests with one another.In the study as earlier outlined on the methodology section that the study was a case of five schools in Centocow cluster only five Grade 10 educators were sampled and 20 laerners, four per school as well as two mathematics advisors were participants in the study. With regard to performance tests, only five educatotrs and 20 learaners were respondents to the test.

The tests were designed with the goal of improving the clarity and explicitness of mathematics' relevance for students at the 15-year-old level, while still ensuring that the questions created were situated in relevant and realistic situations. A major aspect of the TIMSS framework is the mathematical modeling cycle, which was utilized in previous frameworks such as the OECD (2013) to explain the processes people go through while addressing issues with contextualized contexts. Students utilize it to identify the mathematical processes they use while solving issues, processes which, together with deductive and inductive mathematical reasoning, will serve as the fundamental aspects of their reports. It was planned all along to provide assessments to both teachers and students so that a comparison could be made of their respective levels of knowledge of the subject matter rather than the simplistic and frequently false belief that teachers are superior to their pupils.

**5.8 Data Collection schedule**

Data collection is a critical stage of the research process and as such needs careful planning and implementation. Gay *et al.*, (2006) recommend that the higher the percentages of returned questionnaires the better the data. In pursuit of achieving the highest possible response rate, the researcher designed a data collection schedule to enable smooth data collection within research timeframes. The data collection plan is outlined in Table 5.4 below outlines the research instrument, research questions, type of data, the sample, and period of data collection.

| No. | Research Instrument (S) | Research Questions to Be Answered | Type Of Data | Recording Data | Sample Size | Data collection Period |
|---|---|---|---|---|---|---|
| 1. | | Informing stakeholders and getting permission to collect data from research sites (Director, Principals, HODS, Educators, Learners in Grade 10) | | | | 15/04/2016 to 30/04/2016 |
| 2. | Baseline / Diagnostic Test | What are the possible factors that contribute to the low performance in Mathematics education in secondary school? Is the teacher content knowledge compared to that of the learners they teach? | Discret test scores | Test score sheet | 20 learners 5 educators | 01/05/2016 to 05/05/2016 |
| 3. | Focus Group Interview | What intervention strategies and activities can education stakeholders be engaged in to curb poor in Mathematics performance? How can a collaborative model be formulated and constructed to improve Mathematics performance? | descriptive | Interview scripts / tape recorder | 5 classes one from each school sampled | 06/05/2016 to 20/05/2016 |
| 4. | Interview | What are the possible factors that contribute to low performance in | Descriptive | Tape Record data | 5 educators | 2/05/2016 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Mathematics in secondary schools? What intervention strategies and activities can education stakeholders be engaged in to curb poor in Mathematics performance in secondary schools? How can a collaborative model be formulating and constructed to improve Mathematics performance in secondary schools? | | Interview Notes | | |
| 5. | Classroom Observation | What intervention strategies and activities education stakeholders (those involved in teaching and learning of Mathematics in secondary schools) that are Heads of departments, educators, learners, and subject advisors are collectively engaged into curb poor performance in Mathematics? How can a collaborative model be developed and constructed to show the significance of collaboration as a component of improvement of Mathematics education outcomes in secondary schools? What conditions should be put in place to effectively implement and measure the effectiveness of the | Observation notes descriptive | Observation notes | 5classrooms | 01/06/2016 to 06/06/2016 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | intervention strategies of collaborative model? | | | | |
| 6. | Questionnaires | What intervention strategies and activities can education stakeholders (those involved in teaching and learning of Mathematics in secondary schools) that are Heads of departments, educators, learners, and subject advisors are collectively engaged into curb poor performance in Mathematics?<br>How can a collaborative model be formulated developed and constructed to show the significance of collaboration as a component of improvement of Mathematics education outcomes in secondary schools?<br>What conditions should be put in place to effectively implement and measure the effectiveness of intervention strategies of the collaborative model?<br>What conditions should be put in place to effectively implement and measure effectiveness of intervention strategy? | Descriptive data notes | Questionnaires | 20 learners (4 per sampled schools)<br>5 educators<br>3 subject advisors | 06/06/2016 to 20/06/2016 |

**Table 5.2: Data Collection Schedule**

## 5.8 Data analysis

The presentation and discussion of the findings, as well as the analysis of the data and the subsequent conclusions, are all included in the data analysis phase of a research project, which is the last part of the study since it also includes data analysis. One of the most crucial aspects in doing research is interpreting the data, which must be done thoroughly and with great attention to detail in order for the researcher to be able to answer the study question. As per Shamoo and Resnik (2015), data analysis is the process of converting data into information and knowledge, as well as exploring the connection between variables. It is the process of methodically utilizing statistical and/or logical tools to explain and illustrate, compress, and summarize, and assess facts in order to make decisions. Data analysis, according to Harding and Whitehead (2013), is defined as the formal interpretation of acquired data in order to generate order, elicit meaning, and convey conclusions. It may be difficult since there is no 'one size fits all' strategy for conducting an investigation. Large volumes of data are involved, and it takes a significant amount of time to organize and understand this information. In addition, Sharma (2018) adds that data analysis is defined as the process of producing solutions to questions via the investigation and interpretation of information.

The basic steps in the analytic process consist of identifying issues, determining the availability of suitable data, deciding on which methods are appropriate for answering the questions of interest, applying the methods, and evaluating, summarizing and communicating the results. Thus, data analysis is a means to giving meaning to the collected data and affords the researcher tools to answer the research question(s). In this study, a mixed methods research specifically employing both qualitative and quantitative method design as earlier stated, analysis of data will be done using an integrative approach where data was be integrated during the interpretation and analysis phase.

### 5.8.1 Qualitative data analysis techniques

The processes involved in data analysis throughout the study process were shown in Fig. 5.12 and comprised gathering raw data from participants and the research environment, processing, interpreting, and presenting. The research's participants shared their thoughts, convictions, and ideas on their experiences in the field of mathematics education as well as their own life experiences in the concurrent triangulation mixed methods study. The respondents comprised students, teachers, and topic specialists. As noted, before, thematic data analysis was utilized to look more closely at the qualitative data.

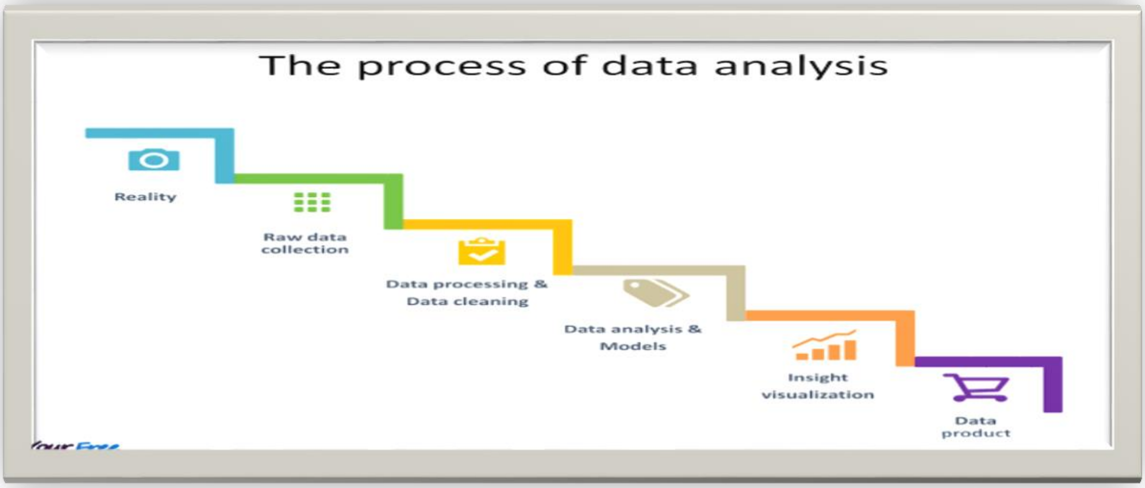


**Fig 5.11: Steps in conducting data analysis (Source: Researcher creation)**

Thematic analysis is explained in a variety of ways by scholars. A sort of qualitative analysis, according to Alhojailan (2012), is utilized to assess classifications and provide themes (patterns) that are related to the data. As per Maguire and Delahunt (2017), thematic analysis is the process of discovering patterns or themes in qualitative data. The purpose of a thematic analysis is to find themes, which are patterns in the data that are relevant or intriguing, and to utilize these themes to answer the research question or to say something about a problem. A strong thematic analysis does much more than merely summarizes the data; it analyzes and makes meaning of it. This is accomplished via sifting through descriptive material from interviews at different stages and organizing it into emergent themes or patterns that will be discussed and explained in connection to the research question.

Pursuant to Erlingsson and Brysiewicz (2013:3), a "theme" is defined as "Data" may be understood as having a subjective meaning as well as a culturally contextual message. An underlying theme may be constructed by grouping together codes that have similar points of reference, have a high degree of transferability, and allow concepts to be linked throughout the whole research area. As a result of the repeated meanings of the data, themes may be used to connect comparable bits of information and allow the researcher to get an answer to his or her study question ""Why?" you could wonder. It follows, therefore, that a theme is a recurring message that emerges from the data; it is the major important thrust of what the data gathered from interviews conveys to the researcher about the research question, as well as how research informants or respondents react to the questions requesting responses. As explained by Lorelli et al. (2017: thematic analysis is a method for identifying, analyzing, organizing, and reporting themes found within a data set), thematic analysis is a translator for those who speak the languages of qualitative and quantitative analysis, allowing researchers who use different research methods to communicate with one another. So thematic analysis may be defined as a researcher's presentation of the common voices that emerge from his or her data collection in an effort to answer his or her research questions.

Salleh, Syudhada, Ali, Mohd – Yusof, and Jamaluddin (2017) define the phases of thematic analysis as data familiarization, which is the process of immersing and familiarizing oneself with data obtained interactively during field observation and interview sessions, during which the initial ideas about possible flaws are identifiable. Data familiarization encourages the researcher to study the full data set frequently in order to discover significance and patterns related to the research topic. The second step is data coding, which is performed manually from a list of data patterns based on similarities in features such as location, unit operation, and function, which enables the researcher to easily identify coded data from uncoded data. The third and last step of thematic analysis is theme searching, which entails listing coded data and classifying it into broad categories based on the relationships between the themes and subthemes that comprise the data substructures. The fourth important step involves theme definition and analysis, the meaning presentation in relation to the research problem understudy. Maguire and Delahunt (2017:5) elucidate that the aim of defining themes is to identify the 'essence' of what each theme is about, what is the theme saying? If there are subthemes, how do they interact and relate to the main theme? How do the themes relate to each other?

Clarke and Rance (2015:188) present a recursive six-phase process for thematic analysis:

- Familiarising oneself with the data (text; maybe transcriptions) and identifying.
  items of potential interest
- Generating initial codes that identify important features of the data relevant
  to answering the research question(s); applying codes to the dataset (segmenting
  and "tagging") consistently; collating codes across segments of the dataset.

- Searching for themes; examining the codes and collated data to identify broader patterns of meaning
- Reviewing themes; applying the potential themes to the dataset to determine if they tell a convincing story that answers the research question(s). themes may be refined, split, combined, or discarded.
- Defining and naming themes; developing a detailed analysis of each theme
- Producing a report; weaving together the analytic narrative and data segments, relating the analysis to extant literature.

The use of thematic analysis as a data analysis technique offered a number of advantages and disadvantages. Neuendorf, (2019). Thematic analysis enabled a more nuanced comprehension of the meaning of a collection of texts. The investigator was the instrument, and often, investigator dependability was not tested. Alhojailan (2012) reaffirms that theme analysis is the most suitable method for any research seeking to find via interpretations. It added a methodical dimension to data analysis. It enabled the researcher to correlate an examination of a theme's frequency with an analysis of the whole material. This added precision and complexity to the study, as well as enhancing its overall significance. This implies that the researcher captured respondents' life experiences and perspectives about the study subject via theme analysis and enriched the genuine meaning of the research by generating responses from data that the researcher controlled from data collection to analysis.

On the contrary, using thematic analysis possess disadvantages, Wang, Wang, and Khalil, (2018) reveal that the worst disadvantage of thematic analysis as a data analysis method is that it relies on the researcher's subjective interpretations of volumes of data which places huge demands on the experience and expertise of the researcher without which the findings may not be trustworthy. Thus, in the study the researcher employed quantitative data analysis techniques on quantitative data collected for the study with intentions to triangulate the findings and mitigate the weaknesses of thematic analysis.

## 5.8 Quantitative data analysis techniques

In line with concurrent triangulation mixed methods research, quantitative data collected through questionnaires will be subjected to quantitative data analysis techniques namely correlational analysis, Standard deviation, and T -Tests as well as inferential statistical analysis of collected data.

### 5.8.1 Correlation analysis

Correlation, often known as correlation analysis, is a word used to refer to the connection or link between two (or more) quantitative variables, as defined by Gogtay and Thatte (2017). This study is predicated on the premise that the quantitative variables are related in a straight-line [linear] fashion. Schober (2018) explains further in a related exposition that correlation is a measure of a monotonic connection between two variables. A monotonic connection between two variables exists when either the value of one variable rises in lockstep with the value of the other variable, or the value of one variable falls in lockstep with the value of the other variable. Thus, when the values of one variable are somehow related to the values of the other variable, there is a correlation between them. When a pattern is seen in data, it is said that there is a correlation. Similar to binary variable association measures, it quantifies the strength or extent of a connection between variables as well as its direction. The Figs 5.12 illustrate the relationship status of variables in terms of positive, negative, and no connection.

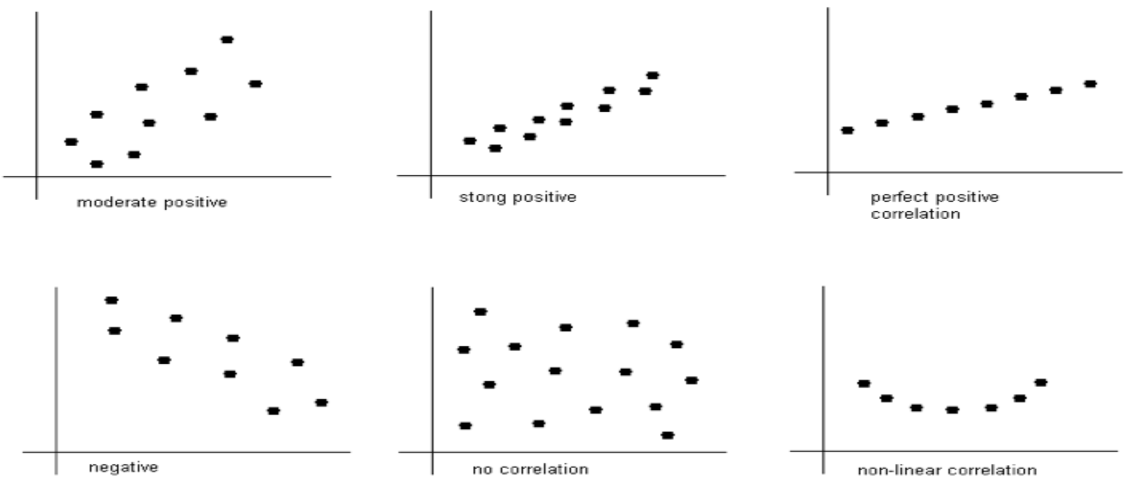


**Figure 5.13 Correlational patterns, Gotay and Thatte (2017)**

In this study, correlations were intended to measure the degree and direction of association occurring between constructs. The Pearson's correlation coefficient, which assesses the degree to which quantitative constructs are linearly related in a sample, Lewis' (2017) was used to determine the association pedagogical approaches used in teaching and learning Mathematics and the performance of learners in tasks and given activities. Chee (2015) and Schober (2018) concur on handling correlations that the larger the covariance is, the stronger the relationship. The covariance can never be bigger than the product of the standard deviation of the two variables" The denominator in the equations is always positive, however the numerator may be positive, zero, or negative thereby enabling *r* to be positive, negative, or zero respectively.

In the study which employs a mixed methods design as earlier stated, analysis of data was done using an integrative approach where data was integrated during the interpretation and analysis phase. The study used a mixed method concurrent triangulation case study design where both qualitative and quantitative data was collected from five research sites. The study was informed by Loucks-Horsley *al.*, (1998)'s framework for designing a professional development model whose central pivot is a planning sequence with four elements of goal setting, planning, doing and reflection. The four elements constituted pillars of the Collaborative model and data inputs from the diagnostic study fed into the structure of the model.

In studies analyzing qualitative and quantitative data within a mixed methods framework, data is subjected to several stages, at least seven, Onwuegbuzie and Teddlie, (2003). The researcher prescriptively used these guidelines. The three sources used for the data were interviews from the participants, participants' responses to questionnaires, and constructs from the existent literature. It is, however, critical in ensuring validity of the underlying assumptions of theories pertaining to the data and model constructs.

## 5.9 Analytical parsing in Mixed Methods

Data reduction is the process of finding emerging themes from qualitative data and descriptive patterns from qualitative data, analysed through exploratory thematic analysis for the qualitative themes, and descriptive statistics, factors, and cluster analysis for the quantitative data.

- ***Data Display:*** this is a pictorial display which could use illustrative artifacts, charts, graphs, networks, lists, rubrics, as well as Venn diagrams.
- ***Data Transformation:*** Quantitative data are converted into narrative data that can be analyzed qualitatively and qualitative data converted into numeric code that can be represented statistically.
- ***Data Correlation***: The Transformation then enables correlation between the two data forms, quantitative to qualitative and qualitative to quantitative,

- ***Data Consolidation:*** (First Mixing Stage) Both qualitative and quantitative data are combined into new or combined variables.
- ***Comparison:*** (Second Mixing Stage) Quantitative and qualitative data is then compared after this operationalisation, (differences noted, similarities noted *etc.).*

This is a final stage, wherein both qualitative and quantitative data are integrated into either a coherent whole or two separate sets of coherent wholes. (Mixed Methods: Creswell Plano Clark, 2011, Onwuegbuzie and Teddlie, 2003)

Validity and dependability are far larger ideas in the contexts of quantitative and qualitative research data, as well as quantitative data mixed in a single study, than the absolute meaning scientifically linked with quantitative research data. In mixed words, these ideas also imply validity and dependability, as well as trustworthiness, dependability, transferability, and credibility. In these broad words, validity refers to the degree to which participants' and researcher's perceptions and notions have reciprocal significance (MacMillan & Schumacher, 2010). On the other side, reliability refers to the extent to which the study results are independent of chance events, (Silverman, 2004). It is inextricably linked to ensuring the quality of field notes and ensuring the availability of research responses for the study. As per PuJoppe (2001:1), dependability refers to the degree to which findings are consistent across time and accurately reflect the overall population under investigation. The reproducibility of findings across investigations using the same approach demonstrates and supports the instrument's reliability.

In order to ensure the validity and reliability of the content of the two questionnaires, the questionnaires were reviewed by statistics, Mathematics, and thematic specialists at the UNISA School of Mathematics and Technology Education. The review process tested the adequacy of the research questions, wording and order of the questions, range of questions and average completion time of responding to the research instruments. Through the outcome of the review, the researcher improved clarity of each of the questions and the wording order of questions to reflect the intended outcomes of the study.

### 5.10 Reliability and validity of Research instruments

To verify validity, the researcher performed triangulation, which is the process of cross-checking data and findings using various procedures or sources. Additionally, data triangulation was performed to aid in the understanding of the phenomena by using many sources of information. We employed participant feedback (member checking) to verify the researcher's interpretations and findings with the participants. Triangulation of theories, in which numerous hypotheses are employed to aid in the interpretation and explanation of facts (Burke & Larry, 2012).

McMillan and Schumacher (2010) define validity as the degree of congruence between the phenomenon's explanations and the world's facts. As per Leedy and Ormrod (2010), the validity of a measurement is the degree to which an instrument accurately measures what it is designed to measure. They highlighted that an instrument's validity is situation dependent. Additionally, Creswell et al. (2014) define instrument validity as the amount to which an instrument measures what it is designed to measure. Additionally, they addressed the many sorts of validity indicated below, and the researcher discusses how he verified that his study complied with validity standards.

**Content validity** - the extent to which the instrument covers the complete content of the construct that it is set out to measure. The word content validity refers to the extent to which individual items in an assessment are reflective of the content universe to which the assessment will generalize (Straub, Boudreau et al. 2004). The researcher conducted a pilot study using the questionnaires and item-analyzed the responses to verify that the survey instrument contains all of the important items and excludes undesired items to a specific construct domain. As a consequence, the researcher made some changes to the questions to make them more straightforward and simpler for the study's participants to answer. When doing research, it is important to check that all of the necessary components are included in the survey instrument.

***Construct validity***- has to do with how well the construct covered by the instrument is measured by different groups of related items. In light of the aforementioned information and in relation to the current investigation, the primary objective of the construct for the performance test assessment was to identify the appropriate level of academic knowledge and abilities acquired by learners in Grade 10. Concerning this research, the construct of the test was validated by conducting a pilot study using the identical test items in a neighboring cluster of Umzimkhulu. A total of ten students who were enrolled in grade 10 were subjected to the examination. The issues on the exam were designed to be easy to understand for all of the students who were going to take it. This means that the majority of the problems on the test were ones that the students had already solved as part of the mathematics themes covering financial functions in grades 9 and 10.

***Criterion validity***- whether an instrument measures what it is supposed to measure. According to Leedy and Ormrod (2010), reliability is the consistency with which a measuring instrument yields a certain, consistent result when the entity being measured has not changed. Creswell *et al.,* (2010) define reliability as “the extent to which a measuring instrument is repeatable and consistent”. Johnson and Christensen (2014) define reliability as the consistency or stability of the test scores, and validity as the accuracy of the inferences or interpretations you make from the test scores. Pilot testing the test items and conducting item analysis assisted the researcher to ascertain the criterion validity of the test items used in the study.

According to Gay *et al., (*2006), validity is the degree to which the qualitative data collected accurately gauges what we are trying to measure. They maintain that two common terms used to describe validity in qualitative research are trustworthiness and understanding. They further noted that qualitative researchers can establish the trustworthiness of their research by addressing the credibility, transferability, dependability, and conformability of their studies and findings. They note that researchers can contribute to the trustworthiness of their research and to the understanding of it, by addressing descriptive validity, interpretive validity, theoretical validity, and evaluative validity.

Gay etal (2006) also pointed out that, while doing qualitative research, a variety of tactics may be used to increase the credibility and comprehension of one's results, according to Gay et al. There are a variety of tactics that may be employed, including extended stays at the research site, persistent monitoring, peer debriefing, member checks, and triangulation, to name just a few. Reliability, according to the writers above, is defined as the extent to which our research data consistently assesses whatever they measure. The dependability of the data collection procedures used in qualitative research is taken into consideration by the investigators. Owing to Creswell et al. (2014), when they refer to the reliability of an instrument, they are referring to the fact that if the same instrument is used at various periods or given to different participants from the same population, the results should be consistent. In order to assure validity and reliability in this research, member-checking will be employed, as well as a significant period of time spent on the field.

#### 5.10.1. Member-checking

Member-checking is a process that is used to ensure that the data obtained is accurate before releasing it to the public. Based on Gay et al. (2006), it is used to test the overall report with the study's participants before releasing it in its final form with the rest of the research community. In the current study, the researcher rephrased questions and simplified their intentions during interview sessions and that ensured to get fuller and delicate interpretations of data collected within the context of an interview (McMillan & Schumacher, 2010). In member-checking, the researcher also sent the interview transcript back to the interviewees to ensure that the information they provided was accurate, and the researcher called them via phone to seek clarification or confirmation of collected data.

#### 5.10.2. Prolonged stay at the site

Thus, according Gay et al. (2006), staying for an extended period of time at a location aid in overcoming distortions that may be caused by the presence of researchers as well as providing the researcher with the chance to examine biases and perceptions of the participants and place. The researcher remained at the location for a period of two months post dat collection in order to acquire as much information as feasible for the study.

### 5.10.3 Confidentiality and Anonymity

A permission form completed by the researcher and the participants allowed for informed consent from the participants. The researcher created a permission form that ensured the participants' privacy and anonymity. This form would safeguard them from any potential victimization that could occur as a result of the research. It also gave the participants trust in the study and allowed them to engage freely. The participants were guaranteed anonymity and secrecy, since their identities would not be used in the research. In the research report, pseudonyms were utilized instead. The researchers made it apparent to the participants that they were free to leave the study at any moment if they so desired, Creswell (2014).

#### 5.10.3.1 Ensuring trustworthiness

Robson and McCartan (2016) note that even with good intentions, researchers may nevertheless produce unreliable results. Credible and honest research is essential if it is to be taken seriously. This column has concentrated on qualitative research methodologies and the criteria for trustworthiness as it informs theory development and the application of results, despite the fact that quantitative research needs adherence to the criteria of internal and external validity. In their study of trustworthiness, Lincoln and Guba (1985) used four broad indicators. Credibility, transferability, reliability, and verifiability are these. We take all of these into account, and we also include the views of other authors who have discussed credibility in qualitative research.

When assessing credibility, one must consider how well the results line up with reality. Triangulation, in its many forms, is one way to bolster trustworthiness. By combining data from many sources, or triangulating, researchers are able to identify trends more reliably. Distinct from replicability in a priori empirical investigation is the phenomena of recognizing identical findings repeatedly via different data sources. There are several different kinds of triangulation which include methodological and data triangulation among others (which are given detail in a later section) Creswell (2014).

Lincoln and Guba (1985) provide a different angle on trustworthiness by discussing dependability. There are a handful of tangible research procedures that not only create trust but also feel trustworthy as they are implemented, and this is especially true in qualitative research because researchers (both producers and consumers) actively develop their confidence in the events as they happen. Trust is built via effective communication practices including debriefing and peer assessment. Having a co-researcher read and respond to your field notes, complete with your imbedded interpretations, is a validation that helps you establish a tacit reality.

**5.10.4 Caring and Fairness**

The researcher made certain that the participants did not suffer any physical harm, since they were interviewed at their working environment (schools), which meant that they did not travel to attend interviews. The researcher also made sure that there were no instances used where gestures or language that may be seen to be offensive by the interviewees occurred.

***5.10.5 Triangulation:*** The reliability of the data was verified through the use of many data gathering techniques and sources. When academics discuss the validity of research, they are referring to qualitative research that is reasonable, believable, and trustworthy, and is thus defendable (Pillay, 2012). Triangulation was accomplished in the study by administering questionnaires and interviews to the same educators and learners, as well as diagnostic tests and observation checklists, with the goal of gathering as much accurate and in-depth data from the respondents as possible.

Triangulation achieved the following additives:

- Substantially increased the trustworthiness and credibility of the research findings as multiple sources were used (Johnson & Christensen, 2013) in the construction of a Collaborative model.
- Different divergent perspectives were obtained from comparison and integration of questionnaires, interviews, and observation checklists.
- Weaknesses of each one of the data collection instruments were compensated by the strengths of the other.
- Data collection methods included interviews with participants (educators, learners, and administrators). The questionnaires were used to collect quantitative descriptive relative to the quantitative phase of the study. Qualitative data for the qualitative phase of this mixed study were collected through interviews to obtain exploratory data from a qualitative perspective, De Vos, (2005).

Noble and Heale (2019), in their pursuit of the triangulation notion, describe triangulation as the employment of two or more techniques of data collecting to explore a specific phenomenon. Pursuant to Murdock (2019), researchers may overcome the flaws and challenges associated with single-method, single-observer, and single-theory investigations by mixing many observers, theories, techniques, and empirical materials. In many cases, the goal of triangulation in a given setting is to acquire validation of results by bringing together multiple points of view. The point where the viewpoints converge is thought to be the representation of reality.

Triangulation is viewed as a verification procedure whereby researchers search for convergence among multiple and different sources of information to form themes or categories in a study. It is a system of sorting through the data to find common themes or categories by eliminating overlapping areas. Triangulation was employed in this study, the educators (5) and 20 learners and subject advisors (2) responded to questionnaires while educators (5) and learners in focus groups were also subjected to the structured interviews from the case study. Educators and learners were further made to write a competency test whose comparative results were discussed and findings incorporated into the model ideas. All the data collection instruments are attached in the appendix at the end of the thesis.

Data triangulation concerns itself with the use of various data sources, and in this study, interviews, questionnaires, and an in-depth literature review were conducted. Methodological triangulation concerns itself with the use of both qualitative and quantitative methods in the same study. A detailed exploration of the two research methods has already been provided in the preceding sections of this study**.**

Triangulation offered the following benefits for this study:
Firstly, it provided additional sources of valuable insight that could not be obtained from the literature review alone; it minimized the inadequacies of single-source research by engaging three data sources which complemented and verified each other, and it also provided richer and more comprehensive information in the sense that the researcher was able to draw information from various sources including the face-to-face interviews which provided first hand, lived experiences of the learners and educators. Gleamed from focus group interviews as well as face-to-face structured interviews and semi-structured interviews, the qualitative data was then triangulated with the quantitative data.

In an attempt to ensure validity and reliability, the researcher employed thick description, a procedure that is used in qualitative research to ensure validity and reliability. This procedure is concerned with describing the setting, the participants, and the themes of a qualitative study in rich detail. Thick description has been used in this study in the presentation of the qualitative research findings where the actual words of the participants have been used constantly. The purpose of thick description is that it creates ―verisimilitude that is, statements that produce for the readers the feeling that they have experienced or could experience the events being described in the study.

The purpose of reporting the findings using thick description is to provide as much detail as possible for the readers. It also enables the readers to make decisions about the applicability of the findings to other settings or similar contexts. In this study, the concepts of professional model development and its extension to an abstraction of a Mathematics collaborative teaching model and the background of the case study setting and samples of the participants have been thoroughly discussed.

## 5.11 Pilot Study

*'Do not take the risk. Pilot test first' – (De Vaus, 1993)*

The researcher conducted a pilot study to evaluate and confirm the rigor, research validity, and reliability of the research instruments in order to assure the authenticity of the data obtained. When an issue, process, phenomena, or mechanism peculiar to a certain community, place, item, or civilization is hardly explored, pilot studies, also known as preliminary studies, are conducted prior to the fundamental (core) investigations. Dźwigol (2020). The pilot research permits preliminary information regarding the phenomena to be gathered (Mutz and Müller, 2016). The main goal of such a study is to gather data (implicitly incomplete, because only core studies allow for the collection of all necessary data to verify the theses adopted in the work) to confirm the chosen direction, formulate assumptions for the work, or check the correctness of the developed questionnaire – in the case of surveys (Kaur et al., 2017). Pilot studies are frequently used to assess the suitability of the research methodologies and instruments used to explore a particular issue (Thomas, 2017).

The researcher receives confirmation or refutation of previously established relationships between the researched phenomena by doing preliminary investigation. In addition, a pilot study enables for the selection of the data gathered (Morris and Rosenbloom, 2017). As a consequence, information that is unrelated to the subject under inquiry or does not exist in the environment or population is rejected. It is also feasible to receive information on the length of fundamental research or a valid random sample size (Mutz and Müller, 2016) in addition to evaluating the accuracy of the generated questionnaire. As per (Hair et al., 2019), data collection instruments must be pilot tested for the following reasons: to ensure that any errors or anomalies discovered in the pilot study are corrected prior to beginning the full study data collection phases, and to ensure that the data collected is accurate:

- Ensure validity and reliability.
- Ascertain if questions mean the same to all respondents and that there is no ambiguity.
- Estimation of the duration it takes for respondents to answer questions.
- Check if all questions and instruments are concise and clear.
- Check if there are biased actions. Identify and correct problems experienced in using the instruments to ensure a user-friendly process that ensures that there are no difficulties in data collection.

In conducting the pilot study, the researcher used a nearby secondary school called F which is in a nearby district of uMzimkhulu. The school is within 5km from the nearest research site A and as such the variables are the same as the sampled schools which are rural, of poor socio-economic status and an underperformer in Mathematics and Science subjects.

The pilot study was conducted using demographics at a nearby school, not part of the main study, 10 Grade mathematics learners and 4 Grade 10 mathematics educators were participants in the pilot study whose demographics were more or less similar to the participants in the target case study, representing the learner, teacher and administrative groups of the schools within the case study, a small-scale replication of the actual study, targeting a small number of persons with characteristics similar to those of the target groups The measuring instruments (questionnaires and surveys) (all attached in the appendix at the end of the thesis) were developed with the assistance of UNISA specialists in Mathematics, Statistics and Technology, who validated the appropriate use of qualitative terms as well as validity of the established correlation between independent and dependent variables of the quantitative construct.

The pilot sample consisted of 10 Grade 10 learners and four grade 10 teachers. The educators were purposively sampled to ensure they were appropriate for the purpose of the study. The students were randomly selected to constitute two groups of five female students and five male students, to minimize the effects of gender bias. All the participants in the pilot study were from a nearby secondary school in the district of uMzimkhulu.

The results of the pilot study presented above were a go or no-go milestone for the study as it determined the feasibility of the collaborative model, as well as test the reliability and validity of the instruments and trustworthiness of respondents as a measure of their understanding of the questionnaire for data collection in the main study. Commenting on usefulness of a pilot research, Morris and Rosenbloom (2017) posit that you may think that you know well enough what you are doing, but the value of pilot research cannot be overestimated. Using feedback from the pilot study, the following processes were implemented:

- Focus group interview questions initially focused on individual learners and were modified to reflect possible group perceptions and dynamism which collaboration creates.
- Some questions in the educators’ questionnaire on Mathematics attitudes were deliberately modified to capture same or related perceptions for example Question 19 and Question 40

are related and extended questions on teachers' negative perceptions of Mathematics they teach.

- Classroom observation instrument was also modified to present in a Likert scale format specific aspects of Classroom lessons implementation which may not have been captured in general checklist.
- Most questions in the interviews' protocol for educators were modified to solicit both evaluatory and explanatory responses as educators' self-reflections on their work were of importance in the study.
- The performance test instrument items were also modified to include both theoretical and applicatory Mathematical concepts as evidence of creation, examples included in the test included use of mathematics concepts in real life contexts such as calculating interest, change and percentage increases, transfer and use of knowledge as espoused in constructivist classrooms.

Therefore, the pilot study successfully validated both the instrument and the scientific merit of the study. The verification and validation was further corroborated by the Promoter and research supervisor Professor Nkopodi Nkopodi, a seasoned researcher and Mathematician at UNISA Department of Mathematics Education and Technology.

## 5.12Ethical Considerations

The study takes into account many important ethical principles, including confidentiality, informed permission, anonymity, and protection of individuals from harems, as shown in Fig. 5.15. In order to conduct research studies involving people, it is necessary to follow the ethical standards that guide scientific inquiry. According to McMillan and Schumacher (2010), ethics is a set of rules that people use to decide what is good and wicked. Saunders, Lewis, and Thornhill (2016) define ethics as the standards of conduct that govern the researcher's activity with regard to the rights of the targeted respondents or study subjects, as well as those who are likely to be influenced by the study.


**Fig 5:14: Ethical issues in research (Source Adapted from McMillan and Schumacher (2010)**

Ethics, as per Wilson (2014), are the guiding norms, values, and standards of behaviour for people and communities. The following is a list of important factors to consider: According to Johnson and Christensen (2013), researchers should follow the following ethical guidelines:

- Informed consent
- Avoidance of harm
- Violation of privacy
- Anonymity and confidentiality
- Deceiving respondents
- Respect of human dignity which encompasses right for full disclosure and debriefing respondents.

In the study the researcher was granted permission by the following stakeholders:

University of South Africa Research Ethics Committee gave permission to the researcher to proceed with the data collection of the study. Department of Education (Provincial and District Office) gave permission to the researcher to collect data from the five research sites within the period from 17 March 2016 to June 2017. (Appendix attached at the end of the thesis) permission granted by the Department of Basic Education was self-delivered to principals of five schools and district office notifying them of the data collection process.

The researcher took many ethical steps, including obtaining informed permission from the whole sample of participants in the study. Respondents who engage in an inquiry only after being told of all relevant information that would be likely to impact their choice to participate or not participate, according to Johnson and Christensen (2013), are referred to as giving informed consent. All participants in this research, including learners, educators, and subject advisers, were told of the study's purpose, and ensured of their anonymity and confidentiality. Respondents were given a thorough explanation of the study's aim and methods before being given the opportunity to complete data collecting equipment. Since names were not written on surveys or test responses, respondents' anonymity was maintained.

The respondents were further made aware that participation was voluntary and that their participation can be withdrawn if they so wish at any stage of the research process. Thus, all steps were taken in this study to adhere to the covenant's requirements in research, documents with the appropriate approvals and acknowledgement by all participants and authorizing stake holders for the granting of permission, acknowledgement of confidentiality and privacy, as well as the voluntary participation and informed consent clauses. See exhibits Appendices attached at the end of the thesis) prior to data collection.

**5.13 Chapter Summary**

This subsection of the chapter has focused on the research design and methodology that underpin the formulation of the collaborative method. Detailed information regarding the mixed methods design, its relevance to this study and its general characteristics, were explored in this chapter. The application of the mixed methods philosophy to the case study was demonstrated in the mixing staged (parsing). The following chapter builds on from the methodological propositions made in this chapter by employing the proposed data presentation and analysis approaches to analyze the quantitative and qualitative data consistent with the mixed methods philosophy.

The Professional development design framework (Loucks-Horsely *et al*., 1998) and extensions modification made to facilitate this study were described in Chapter 4. This included the constructs of the variables and elements necessary to develop a model that might be used in any study, but more importantly for this study provide a preliminary yardstick of what might need to be done immediately to improve the learning and teaching of Mathematics. The validity and reliability of the instruments was validated by a pilot study supplemented by an appropriate ethics process. The following chapter presents an analysis of collected data and conclusions relating to the research problem.

## CHAPTER SIX: DATA PRESENTATION, ANALYSIS AND DISCUSSION

### 6.1 Introduction

The chapter served as the culmination of the research since it presented data gathered from the case study's 27 respondents, who served as primary sources of information for answering the research question and sub questions of the study in the first place. The preceding chapters defined the research problem, as well as its contextual and theoretical backdrop, as well as previous studies in the field and the research gaps that the study attempts to address. In this chapter, the research problem is defined as follows: The study data was gathered via the use of questionnaires, interviews, observations, and performance tests, all in the context of a contemporaneous triangulation mixed methodologies and methodology. The overall goal of the project was to develop a collaborative, interventionist approach for teaching and learning mathematics in secondary schools, with particular emphasis on the Centocow cluster in the Sisonke District in the KwaZulu Natal Province as the case study.

In essence this chapter pragmatically outlined the research activities and processes in the construction of the model using baseline data from Mathematics classrooms that were sampled for the study. As earlier alluded to, Lockes–Horsely *etal.,* (1998) Professional Development Framework (detailed in Chapter 4) was used as the underpinning framework to construct, implement and refine the model. Data presentation was done through frequency tables, pie charts, bar graphs and scatterplots. The chapter is structured through the framework of Lockes- Horsely etal., (1998) Professional Development Framework for Mathematics and Science educators (Represented in Fig 4.5 and replicated below in Fig 6.1) and used the concepts and elements of the framework to implement the study at Centocow Cluster of Sisonke district of KwaZulu Natal Province. A presentation of the pilot study results opened the chapter and highlighted how the pilot study results were instrumental in refining the research instruments and sampling processes for the study.

### 6.2 Results of The Pilot study

The pilot study involved 4 Mathematics educators and 10 learners were sampled from a nearby uMzimkhulu cluster. A random sampling of 5 girls and 5 boys in Grade 10A (Mathematics class), and purposive sampling of Mathematics educators in the school was carried out. The instruments which were pilot tested were questionnaire B for learners, diagnostic test for learners and teachers as well as interview A for educators and interview

B for focus group (learners*)*. The table 6.1 presented the response rate regarding the questionnaire administration.

**Table 6.1: Pilot Study Response Rates**

| Questionnaire (A+B) | Sent | Recorded | % |
|---|---|---|---|
| Grade 10 learners | 10 | 10 | 100% |
| Grade 10 Mathematics educators | 04 | 04 | 100% |
| Total | 14 | 14 | 100% |

Table 6.1 showed that the questionnaire distribution and collection to both learners and educators was excellently done with a 100% response rate which was largely as a result of personally administering the instrument. The higher response rate positively impacts on the quality of the attainment of the intended goal of the activity that of ascertaining if the instruments are able to collect authentic data within the set framework.

In administration of interviews, the researcher in both interviews had a 100% response rates as well which could be attributed to the fact that the interviews were semi-structured allowing the researcher and respondents to seek further clarifications where not clear. However, regarding the administration of the test most learners did not finish within the stipulated time and the results of their performance in the test are shown in Table 6.2:

**Table 6.2: Results of Learners and Teachers Diagnostics Test.**

| Names of learners | Marks obtained | % |
|---|---|---|
| A | 20/64 | 31% |
| B | 25/64 | 39% |
| C | 10/64 | 16% |
| E | 18/64 | 28% |
| F | 23/64 | 36% |
| G | 25/64 | 39% |
| H | 16/64 | 25% |
| I | 20/64 | 31% |
| J | 23/64 | 36% |
| H | 38/64 | 59% |

| Name of teachers | Mark obtained | % |
|---|---|---|
| A | 30/64 | 47% |
| B | 29/64 | 45% |
| C | 35/64 | 55% |
| D | 43/64 | 67% |

The above results in Table 6.2 from the researcher's point of view reflects a normal achievement by learners and educators given that the test was the same for both educators and learners. The highest score for teachers was 67% while it was 59% for learners so was the lowest for learners as 16% and 45% respectively for teachers. In view of the performance trend, the test items remained unchanged, but the duration was increased to 2 hours as opposed to 1 hour 30 minutes.

**6.3 Professional development framework for mathematics and science educators (Lockes–Horsely *etal.*, (1998)**

In the study data collection and generation within Centocow cluster geographical setting was referred to as the baseline study since data from the site was used to refine the theoretically conceived collaborative model. International Federation of Red Cross and Red

Crescent (IFRC) (2011) reiterates that baseline studies provide information to assess a programme and identify needs that need to be addressed to result in effectiveness. The elements and concepts of the professional development framework that were used to structure, analyse, and discuss the collected data were:

- Setting goals for professional development
- Description of the context for Professional development
- Critical issues in Professional development
- Knowledge and beliefs of educators to be developed.
- Strategies for Professional development
- Planning for Professional development
- Implementation and Reflection on Professional development. The Fig 6.1 presented tenets and concepts of Professional Development Framework (PDF) which were the analysis and discussion pillars used in data analysis intended to be used to refine the designed Collaborative model, the thrust of the study.

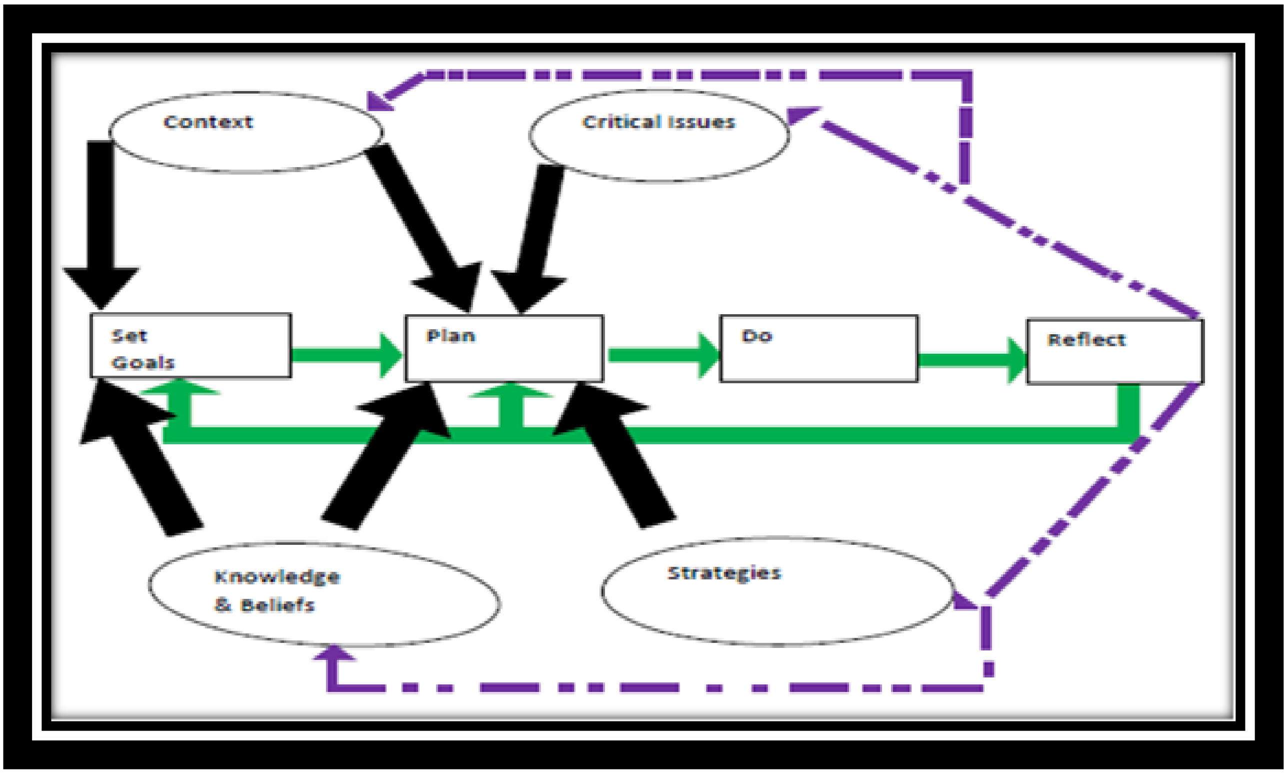


**Fig 6.1: Professional Development Framework for Mathematics and Science educators (Lockes- Horsely etal, (1998)**

The baseline study was intended to collect data on the pedagogical, content and knowledge of Mathematics in sampled schools so as to galvanise action that is to use the findings of the baseline to improve the Collaborative model theoretically designed in Chapter 4 and conceived as in Fig 4.4. The chapter unfolds by presentation of the implementation of the Professional development design framework outlined in Chapter 4. Data from questionnaires, interviews, observations, and performance tests are presented integratively in line with the concurrent triangulation design followed by an integrative analysis. Descriptive and inferential statistics were used to describe and elucidate the findings and relationships among the research variables. Findings were used to modify and input the collaborative model as presented in Fig 6.9.

### 6.4 Rationale/ goals of baseline study

Baseline studies by their nature are aimed at collecting foundation data that is needed to construct and develop a model or intervention. Thus, in the study the following goals were intended:

#### 6.**4.1. Baseline data collection on educator-content knowledge, pedagogical knowledge, and professional attitudes**.

- To identify areas of deficiency in which professional development is needed.
- To suggest intervention strategies and appropriate place-based pedagogy that could be used to improve the teaching and learning of Mathematics in rural contexts. The following content was covered: the work scheme year plan and lesson planning in Mathematiics, the educator as facilitator of learning in the classroom,the role of the learner in a Mathematics classroom ,assessment in mathematics,mathematics content coverage-algebra, trigonometry, data handling, calculus, financial mathematics.
-

### 6.5 IMPLEMENTATION OF THE DESIGN FRAMEWORK IN THE BASELINE STUDY

As earlier stated in the preamble of this section, the key pillars of the baseline study were knowledge and beliefs, context, strategies, and critical issues. The above components of the design framework are discussed in greater detail below:

#### 6.5.1. Context

Curriculum implementation is greatly influenced by the context in which the curriculum is implemented. Professional development in the same way is shaped by the contextual variables such as educators, learners, curriculum, teaching and learning resources as well as the school community.

- ***Educators-:*** Educators are the chief curriculum implementers, the foot soldiers of the curriculum enterprise and as such their competency is of paramount importance in the effective curriculum implementation. For this study a population of 160 Mathematics educators in Sisonke district was chosen as the research population. However, for purposes of in-depth case study, a baseline study only purposively sampled five educators for the study due to financial and geographic reasons. The teachers sampled for the baseline study come from the Centocow cluster of the Sisonke district of KwaZulu-Natal Province. The teachers were teaching Mathematics in Grade 10, in mostly impoverished rural secondary schools. The educators have produced varying pass rates in the subject across the grades they teach. The educators' qualifications, teaching experience and pedagogical approaches they used are expounded in later sections of the chapter.

- ***Learners:*** **-**Learners are the main consumers of curriculum products and thus constitute a major variable of the baseline study. The number of learners in each of five schools varied from four hundred to one thousand. The learners enrolled for Mathematics in Grade 10 ranged from fifty to ninety in each of the sampled schools. The pass rates in Mathematics in the five schools are shown in the Table 6.3 below:

| SCHOOL | 2014 | 2015 | 2016 |
|---|---|---|---|
| GINYANE | 48% | 46% | 17% |
| CENTOCOW | 58% | 60% | 56% |
| LESHMAN | 13% | 10% | 0% |
| SONYONGWANA | 19% | 3% | 39% |
| EMSHIBENI | 20% | 14% | 52% |

**Table 6.3: Centocow Cluster Pass Rate in National Mathematics Examination 2014-2016**

Evidence from the Table 6.3 suggests that even though there are fewer learners studying Mathematics, the pass rate has remained low, and few learners pass the subject beyond 30%. Average pass rate for the cluster in 2014 was 31.6% compared to 32.8 % in 2016 a mere 1.2 % increase within three years. Poor pass rates may be a mirror of poor and ineffective pedagogical issues and non-supportive school community contexts hence the current study focused on designing an interventionist model to effectively teach mathematics in Centocow cluster.

- ***Curriculum:*** **-**The Mathematics curriculum is the syllabus that is nationally approved by the education minister and is implemented in schools throughout South Africa. A baseline study was undertaken by doing an in-depth case study of Mathematics educators who were purposively sampled to take part in the study to identify challenges in content knowledge, teaching approaches and professional attitudes in general. In tandem with the implementation of the design process for planning and implementation of the baseline study the context, knowledge and beliefs of educators, critical issues and strategies were identified as pillars in the South African education context.

Another influential stage of the design stage of the model was reflection. Loucks – Horsley etal (1998) clarifies that reflection is a relook, a collection of feedback, on ongoing evaluation of the implementation process of the ongoing professional development and subsequent response to emerging issues that give a deeper understanding and insight on curriculum isssues.In the study additional content and approaches gaps identified in the results collected were inputted in the construction and refining of the collaborative model as reflected in Fig 6.9 later in the chapter.

**6.6 Implementation of the professional development framework baseline Study**

Fundamental to the implementation of the baseline study were the following features that shape any professional development model. These are knowledge and beliefs of educators, context of curriculum implementation, strategies, and critical issues. The above is discussed in detail as they relate to the baseline study and the entire research study.

**6.6.1. Knowledge and beliefs of educators**

Knowledge and beliefs of educators are the cornerstones of decisions that teachers take in their day-to-day execution of their duties. They are the knowledge base that informs decisions on professional development. (Knowledge and beliefs see Chapter 4).

**6.6.2. Context in which professional development take place.**

Professional development takes place within an educational context that varies from place to place but is a determinant of the success of the intervention programmes to improve educators' performance. Implementation process is shaped by the context changes where the professional programme is implemented, teachers, learners, curriculum, available resources, and community forms the context of developing a collaborative model for teaching and learning mathematics in secondary schools.

**6.6.3. Educators**

Educators are foot soldiers in curriculum implementation and such deficiencies in their Teacher Content knowledge (TCK) and Pedagogical Content knowledge (PCK) affect the outcomes of implementing Mathematics subject curriculum. For the research, educators from the Centocow Cluster were purposively sampled for in-depth study due to the financial and time constraints regarding the academic theses. The educators teach Mathematics in Grade 10 in five rural schools in Sisonke district of the KwaZulu-Natal province. The qualifications and experiences of educators in the study were further discussed in sections that follow in the chapter.

**6.6.4. Learners**

The five sampled schools the Centocow cluster have learners that range from 400 to 1080. The mathematics classes also vary from twenty to forty learners per class. The number of initially enrolled learners in Mathematics in the selected schools has, however, continuously decreased with some learners shifting to do Mathematical Literacy which they consider to be epistemologically easier than Mathematics. This is an attempt to increase pass rates in the cluster schools as more learners are encouraged to take Mathematics Literacy and made to believe that they are not capable enough to study Mathematics. Constructing a collaborative method was, therefore, aimed at demystifying the myth that Mathematics is difficult and meant for geniuses.Table 6.4 presents comparative learner enrolments for Mathematics and Mathematical Literacy in the Centocow cluster in 2014.

| School | Number of Learners in 2014 | |
|---|---|---|
| | Mathematics | Mathematical Literacy |
| Ginyane | 27 | 42 |
| Sonyongwana | 32 | 25 |
| Mtshibeni | 21 | 28 |
| Centocow | 38 | 100 |
| Leshman | 29 | 40 |
| Total | 137 | 225 |

**Table 6.4 Learners Statistics in Mathematics Compared to Mathematics Literacy in Centocow Cluster in 2014**

The table 6.4 presented learner enrolments in Mathematics and Mathematical Literacy the two compulsories but different disciplines. Two hundred and twenty-five learners were enrolled in ML compared to Mathematics which had a total of 137 resulting in a difference of 88 learners. A surge in Mathematical Literacy enrolments may imply that learners fear failing Mathematics hence they opt for a simpler version that is Mathematical Literacy. A further implication may be that due to poor teaching methods and contexts in mathematics classrooms learners opt to take a simpler and less complex subject.

### 6.6.5. Curriculum in use

The National Curriculum in use is CAPS which is newly reconstructed following the National Curriculum Statement (NCS) the successor of Outcomes Based Education (OBE) whose emphasis is content mastery, examination driven, and teacher centered. In the CAPS curriculum the educator is at the centre of the curriculum implementation and as such should be knowledgeable in the subject content and pedagogical approaches.

### 6.6 .6. Available learning and teaching support materials (LTSM)

The five schools that were part of the study were well resourced with adequate learner textbooks of various authors and different study guides written by Mathematics experts. However, learners do not carry textbooks or study guides to class as they fear they could be stolen by their peers. Thus, classroom use of a textbook as learning and teaching aid in Mathematics may constitute a key variable in improving performance in the subject.

### 6.6.7. School Community

Schools as social institutions are located within communities. Schools in the study are located in a very rural environment where most people survive on government grants. The socio-economic status of the community is low hence home environments might negatively impact on the quality of teaching and learning of Mathematics effectively.

### 6.6.8. Critical Issue

The fundamental issue which is critical to the success of a professional development intervention regardless of geographical or social context is the need for equitable and quality Mathematics education. This provision of equal and quality Mathematics education to all people that were denied them by apartheid policies and government that neglected education for black people. The need for equity in education is espoused in national documents namely, The National Strategy for Mathematics, Science and Technology (see Chapter 3). Recently crafted National Development Plan (NDP), published by the National Planning Commission (NPC) highlights the need for education to link to opportunities and employment, with particular emphasis on building capabilities (NCP, 2012:12). The National Development Plan (NDP) is underpinned by the thinking that is explained by Levin (2007:2) that, “fairly universally poverty reduction is seen as unlikely unless knowledge, skill and capabilities are extended to those marginalized from value added economic activity by illiteracy, lack of numeracy and higher-level reasoning that links causes and affect nationally”. The above framework recognizes that without equitable and quality education poverty will remain a context of development for most people and thus creating a circle of poverty from generation to generation.

Therefore, in evaluating the South African education system, the NPC (2012:38) boldly states that the quality of education for most children, who are back, is poor. This demise lessens many pupils' accesses to future employment. It also reduces the earning potential and career mobility of those who do get jobs and limits the potential dynamism of South African business. The above citation truthfully represents the South African educational landscape and how it frustrates social and economic development. Mathematics is rated among the highest underperforming subjects that have great potential to improve the economy. Spaull (2013) elucidates that as part of intervention measures NPC targets improvement in teacher performance and accountability as a key variable in improving education. Teacher training, remuneration, time on task, performance measurement, content, and professionalism rank among various intervention proposals.

### 6.6.9. Strategies for professional development

Effective professional development programmes are hinged on specific strategies that enrich and capacitate educators in their content and pedagogical knowledge. The following were identified for the baseline study:

### 6.6.10. Study material

Forms of the study were to collect baseline data as opposed to developing learning teaching material and as such a prescribed Grade 10 Mathematics textbook published by Platinum was used, in particular its theoretical content, examples and practice exercises for each topic.

### 6.6.11. Educator content and pedagogical workshop

Workshops are a contemporary strategy of disseminating curriculum content and methodologies to large groups of people at the same time. In the study, Mathematics educators' workshops were held at most twice a term with the intention of improving and capacitating teachers' content knowledge and different teaching methods that could be used in teaching Mathematics. The duration of the workshops that are held during the week and on Saturdays were three hours per day covering both content and pedagogical knowledge.

## 6.7 Data on educators' mathematics Pedagogical Content Knowledge (PCK)

In an effort to determine the teachers' content knowledge authentically before commencement of the programme, the educators wrote tests intended to identify the competency of educators in Mathematics global test.

The test was adapted from TIMSS (2012) advanced Mathematics test designed to test the content knowledge and insight of Grade 10 learners globally. The test has 25 items from number sense and numeration, measurement, pattering and algebra as well as data management and probability. The other content of the Grade 9 2011 TIMSS test was out of 45 countries that participated. South Africa came 44 out of 45 in achievements and was in the last 6 in Grade 8 achievement in the Mathematics and Science international tests, (Reddy 2011). The test was an appropriate measure as Grade 9 is a transition phase towards Further Education and Training and as such, Mathematics educators need to be competent in the basic concepts that are the foundation for Mathematics. The test was marked, and their results statistically analyzed.

### 6.8 Data on Mathematics Pedagogical Approaches

Kleickmann *et al.,* (2013) postulate that Teachers Content Knowledge (TCK) is directly correlated to Pedagogical Content Knowledge (PCK) and affects their instructional practice and students' achievement levels. This is based on the heart of professional competence (Woolfolk Hoy *et al.*, 2006). This implies that teachers first possess the subject matter of Mathematics which in turn affects their confidence and teaching approaches they use to deliver the content and teach it to the learners.

Mathematics is a kind of deductive reasoning. Calculating quantitatively entails thinking in a logical way, generating, and testing hypotheses, making sense of the world, and formulating and justifying judgements, inferences, and conclusions (Batista, 1999). Due to the fairly evident aforementioned processes, effective teaching techniques that may result in improved student accomplishment are required. Batista (1999) and Teaching Today (2005) proposed a fundamental mathematics teaching strategy that might be used to improve the effectiveness of mathematics instruction. The strategy is referred to as Standard Based Instruction, and it necessitates the use of best practices in order to be successful. Specifically, Standard-Based Instruction, as per Teaching Today (2005), is designed to identify what students should learn at each level and its essential characteristics include lessons designed to address specific standards-based concepts and skills, student-centred activities, inquiry and problem-solving focused lessons, critical thinking and knowledge application skills, adequate time, space and materials to complete tasks, and varied continuous assessment designed to evaluate both student and teacher effectiveness.

In implementing Standards Based Mathematics, Sabean and Bavaria (2005) have synthesized the following best practices for implementing effective Standards Based Mathematics lessons:Students' engagement is at a high level, tasks are built on student's prior knowledge, scaffolding takes place, making connections to concepts, procedures and understanding, high level performance is modelled, students self-monitor this progress and appropriate amount of time is devoted to tasks,Sabean and Bavaria (2005).

Thus, in the context of the study, Mathematics pedagogical approaches were fundamental in improving the performance of learners in the subject. In collecting information on teachers' pedagogical approaches, the educators completed a self-evaluated test designed by Danielson (2013) entitled, The Framework for Teaching Evaluation instrument. The self-analysis scale test on personal evaluation was designed following the Likert scale and ratings went from well (4) to poor (1). The subtitles in the test were preparation, management, and communication teaching strategies, evaluation, attitudes, and relationships. Teachers also had to submit a work scheme, a year plan and a one-hour activity / lesson plan for Grade 10 for observation. The researcher subjected the above documents to intensive scrutiny using an observation checklist.

### 6.9 Data on professional beliefs and attitudes

Personal conceptions that give an understanding of a teacher's work are referred to as beliefs. As per Perry and Howard (1999), the teacher's views about mathematics influence the methodology utilized in the classroom. Cobb (1996) also agrees that educators' attitudes about mathematics and studying mathematics encroach on students' attitudes and ambitions in the discipline. As a result, instructors' ideas and attitudes about mathematics influenced the educational techniques they used, as well as the answers they received from their pupils. Teachers' ideas about Mathematics have a substantial influence on teaching methods, as shown by Charalambos et al., (2002) and Ernest (2002). A teacher who has bad feelings about mathematics has a detrimental impact on his or her students, while students who have favorable feelings about mathematics enjoy and do well in mathematics. Ajzen (1989) defined attitudes as a person's positive or negative assessment of an item. Attitudes are a function of beliefs, which means that one's views about an object's attitude influence how one feels about it. When a student feels that mathematics is difficult, they are more likely to have a negative attitude as a consequence of that perception. As a result, instructors' attitudes about mathematics may have a direct impact on their classroom instruction. Teachers' mathematical pedagogies may be influenced in various ways by a negative attitude than by a good one. Attitudes may have an impact on how individuals, especially instructors, perceive and interact with mathematics.

In collecting data on professional attitudes, five teachers selected for the study completed an attitude survey towards Mathematics inventory designed by Shackow (2005) and adapted for the study. The inventory had 40 items that were designed in the Likert Scale ratings of SD, D, A, and SA. The questionnaire had Section A with biographical and School information and the statements in Section B ranged from seeking views on the importance of Mathematics, teaching approaches, and challenges faced in learning and teaching Mathematics in secondary schools.

## 6.10 Professional development framework implementation stage (Referred to as Do in Fig 4.5)

In the Professional Development Framework (PDF) Fig 4.5the implementation stage (Do) represents the activities that were done in sampled schools as part of data collection of the baseline study. The baseline study was done on five educators sampled for the study in the Centocow Cluster of the Sisonke District of KwaZulu-Natal Province. Data was collected from their teaching records, questionnaires, and observations in a triangulated format to create a clear and authentic picture of the sampled teachers' content knowledge pedagogical approaches and professional attitudes.

The objective for utilizing different data sources was to guarantee that the data obtained was genuine and reliable, making it authentic and valuable in establishing the foundations for a mollaborative model of teaching and learning mathematics. The inclusion of a case study research design added to the reliability. The key advantages of doing a case study, as per to Yin (2014), are the precise information and comprehensive insight researchers acquire from a given situation. This means that the researcher obtained significantly more genuine in-depth data on the research variables under examination by doing a case study. Self-evaluation exams, work schemes, lesson plans, and questionnaires on topic knowledge, teaching methodologies, and professional attitudes were supplied by the mathematics educators in the sample. The diagnostic tests also served as credible research data sources. Additionally, in the framework of the research, classroom observations were analyzed and evaluated. The researcher created case studies of the analyzed samples in order to ensure dependability and validity.

## 6.11 Case studies in the Centocow cluster baseline study

In keeping with collection of in-depth data on the study, a purposive sample of educators was selected based on the proximity of their schools within the Centocow cluster. The teachers taught Mathematics in Grades 10 in their schools. The learners in their schools varied from 300 to 1000 while Mathematics learners in their classes ranged from 16 to 40 from school to school as illustrated in table. The researcher carried out five observations of classrooms during the course of the research with the aim of obtaining different sets of data regarding teachers' content knowledge and classroom competency and practice. The results of the data collected are presented in sections that follow.

### 6.11.1 Baseline study results

In line with the goals of conducting a baseline study, the researcher organised the research findings in the following themes: Results on content knowledge of Mathematics, Results on professional attitudes, Results on pedagogical approaches, Reflection goals I and II of baseline study and Recommendations for developing a Collaborative Model. Tables 6.5 and 6.6 presents the frequency of educators and learners respondents' genders.

#### 6.11.1.1 Data from questionnaires

##### 6.11.1.1.1 Biographical data of respondents

Table 6.5 presents the educator respondents and participants in the study which included five schoolteachers and two subject or curriculum advisors.

| Gender | Count | Percentages |
|---|---|---|
| Male | 6 | 85,71% |
| Female | 1 | 14,29% |
| Total | 7 | 100% |

**Table 6.5 Demographic analysis-gender distributions of educator respondents.**

The composition was skewed in favour of males as 85.71% respondents were males compared to only 14.29% of females.

| Gender | Count | Percentages |
|---|---|---|
| Male | 12 | 60% |
| Female | 08 | 40% |
| Total | 20 | 100% |

**Table 6.6: Gender distribution of learners' respondents.**

The Table 6.6 reflected on the gender of learners who participated in the study which was 60% male and 40% females. The above statistics for both educator and learners participating in the study could imply that mathematics in Centocow secondary schools is taught by mostly male educators which could be a gender variable with consequences. Morrell and Parker (2013) explain that the gender gap could be due to teachers' perceptions, those words, tones, and actions towards girls in sciences. Wilkens (2013) reiterates that there is need to transform interest in STEM (Science, Technology, Engineering and Mathematics) into action in STEM. This implies that few female Science and Mathematics educators and learners compared to males could be a perceptual challenge and gender stereotyping which mystify Mathematics and sciences making girls to scared to take them nor pursuing careers in STEM, (Wilkens, 2013). Gender imbalances in Mathematics classrooms are a reality with more boys studying Mathematics and Sciences compared to girls.

In an attempt to find out educators' competency, Table 6.7 illustrates the frequency distribution per qualification categories found in the education sector.

| Qualifications | Count | Percentages |
|---|---|---|
| Diploma in Secondary Education (Mathematics) | 1 | 14,29% |
| Diploma in Secondary Education (General Science) | 2 | 28,57% |
| Bachelor of Science Degree (Mathematics) | 2 | 28,57% |
| Master of Education Degree (Mathematics) | 0 | 0% |
| Bachelor of Education (Under Study) | 2 | 28,57% |
| Total | 7 | 100% |

**Table 6.7 Demographic analysis for academic and professional qualification of educator's respondents**

Table 6.7 shows that educators and their subject advisory held varying qualifications in Mathematics with 28, 57% constitutes the advisory have Bachelors' Degrees in Education majoring in Mathematics. Twenty-eight comma fifty-seven percent of respondents held a Diploma in Education but not majoring in mathematics while 14, 29% held a Diploma in Education majoring in mathematics. Lastly 28, 57% of educators are still studying towards a qualification. Gaps in knowledge of mathematics could be due to non-majoring in the subject by the percentages of those still undergoing professional training in mathematics education. Subjects' advisory was holding a bachelor's degree, which may not be competent enough for supervisory role as most educators supervised may be holding the same qualifications as their supervisors.

### 6.11.2 Data on mathematics specializations

Mathematics as a discipline requires in-depth specialization by would be educators during teachers training courses as extensive knowledge and skills are imparted to educators resulting in them becoming experts in the subject. Table 6.8 presents educator specialisations in their subjects they teach.

| Educator Specializations | Count | Percentages |
|---|---|---|
| Physical Sciences and Mathematics | 04 | 60% |
| Mathematics | 01 | 10% |
| General science (other than Mathematics) | 2 | 30% |
| Total | 7 | 100% |

**Fig 6.8: Educator specializations**

In the study the majority of (60%, n = 4) majored in Science and Mathematics implying that they are double majors in critical subjects (Physical Sciences and Mathematics). Only 10%, n = 1 of respondents majored in Mathematics and were foreign educated, indicating that the South African Teacher Training System differs from other countries. Interestingly, 30%, n = 2 of the respondents majored in sciences and another subject other than Mathematics despite that they teach Mathematics. From the above, educators' subject knowledge is varied and not comparable to each other as their specialization differs. Thus, different subject knowledge may suggest huge gaps in interpretation and implementation of Mathematics education curriculum in schools. On subjects' specializations of educator respondents, Fig 6.2 presented the percentages.

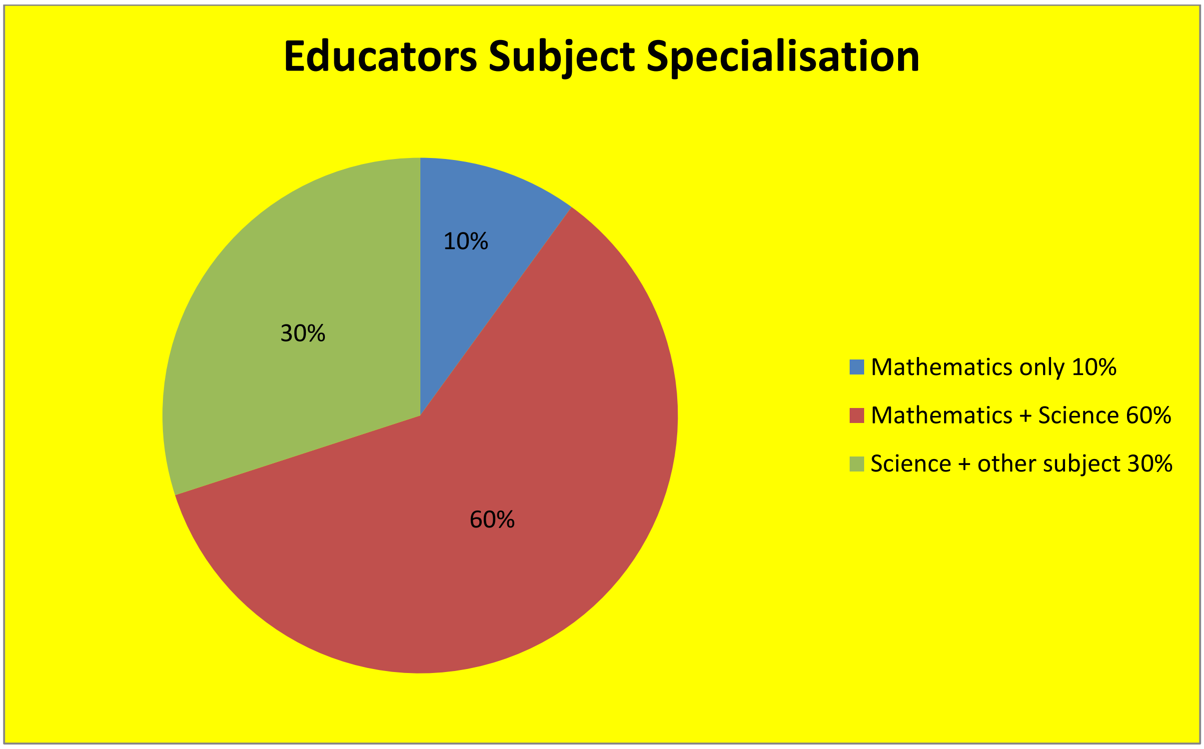


**Figure 6.2: Educator subjects Specialisation**

Fig 6.2 presented educator subjects specialization which depicted that in the study only 10% of educators were mathematics subject specialists while 60% were both mathematics and science whereas 30% were not Mathematics majors. Subject majoring is critical regarding pedagogical content knowledge in the subject and competency to handle the learners and subject changes in a changing curriculum hence it is a key variable which determines effective teaching of Mathematics.

### 6.11.3 Experience in teaching mathematics at FET level

Educators' experience in teaching Mathematics at Further Education and Training phase was a key variable in determining the performance of learners in the subject. Experienced educators are competent in content, pedagogical approaches, and quality of assessment. Fig 6.3 and Table 6.9 illustrate teaching experience of educators at FET level which is a variable in the study as impact of experience in teaching mathematics may positively result in improved outcomes.

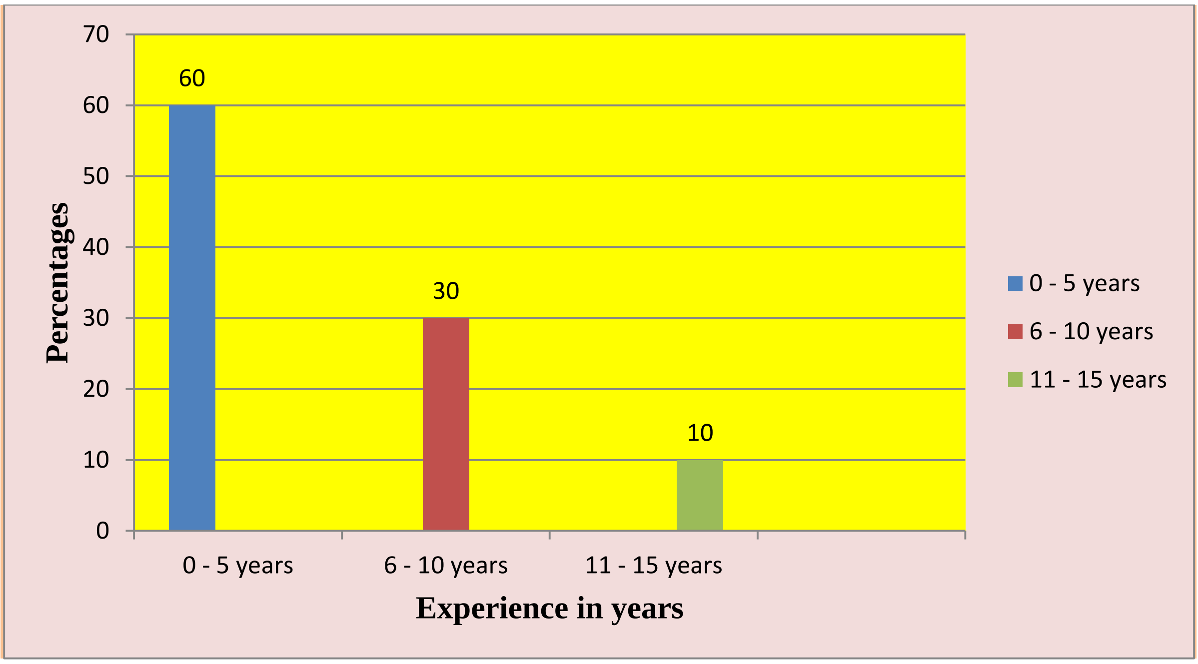


**Figure 6.3: Educators experience in teaching mathematics at FET Level**

Evidence from the graph Fig 6.3 shows that (60%, n = 4) of educators have the least experience in teaching Mathematics with ranges between 0 to 5 years. This is followed by (30%, n = 2) who have experience of 6 to 10 years. The last bar represents (10%, n = 1) whose experience ranges from 11 to 15 years as Mathematics educators.

| Years experience | Count | Percentages |
|---|---|---|
| 0 – 5years | 2 | 28,57% |
| 5 – 10years | 2 | 28,57% |
| 10 – 15years | 1 | 14,29% |
| 15years plus | 2 | 28,57% |
| Total | 7 | 100% |

**Table 6.9 Demographic analysis for teachers experience in secondary schools' mathematics.**

Evidence from Table 6.9 shows that 71, 43% of respondents have above 5years of experience in teaching mathematics in secondary schools. The experience looks positive and should all things be equal, correlate with good mathematics performances. Findings from the study showed that of the few mathematics educators, three (66%) obtained marks below 40% (f) in mathematics while (40%) obtained a C. The quality of the above mathematics educators was further exposed by their performance in the test given benchmarks by TIMSS for Grade 9 and Grade 8 respectively (results outlined in the next section) In the test only 40% obtained marks above 40% which was, however, lower than the top marks obtained by learner respondents who got 64% (41/64). The performance of the educators compared to learners where a learner out classed educators confirms Spaull`s (2013) findings where a Grade 9 top learner outclassed in a test where even their teachers wrote.

**6.11.4. Data from performance tests and observational evaluations**

Learner performance in mathematics was a key variable and as part of data collection a performance test was administered to both learners and educators. Tables 6.6 and 6.7 present performance of learners in the test as raw scores and percentages.

| Learner | Count | Percentages |
|---|---|---|
| A | 10/64 | 16% |
| B | 15/64 | 23% |
| C | 19/64 | 30% |
| Ď | 20/64 | 31% |
| E | 21/64 | 33% |
| F | 16/64 | 25% |
| G | 11/64 | 17% |
| H | 13/64 | 20% |
| I | 15/64 | 23% |
| J | 10/64 | 16% |
| K | 13/64 | 20% |
| L | 15/64 | 23% |
| M | 19/64 | 30% |
| N | 09/64 | 14% |
| O | 05/64 | 8% |
| P | 41/64 | 64% |
| Q | 08/64 | 13% |
| R | 14/64 | 22% |
| S | 07/64 | 11% |
| T | 02/64 | 3% |

**Table 6.10: Demographic analysis of the results of the baseline test on the learners Score**

| Count | | Percentages |
|---|---|---|
| A | 25/64 | 39% |
| B | 20/64 | 31% |
| C | 18/64 | 28% |
| D | 38/64 | 59% |
| E | 29/64 | 45% |

**Table 6.11 Analysis of results for test educators scores**

Table 6.10 shows that only 5 out of 20 learners (25%) got marks above 30% which is the pass mark in Further Education and Training phase (FET). Only one learner obtained a respectable 64% in the test and 15 (75%) failed the test. Educators' performance (Table 6.11 despite at 80% pass was not good enough in terms of quality marks as the highest mark of 59% was less than that of learners at 64%. One educator (20%) failed the test set for learners he or she taught. The above results revealed that teachers do not have adequate content knowledge of mathematics despite being majors in the subject and having experience in teaching the subject. The above performance replicates what Spaull (2013) found in a comparative study of Grade 9 learners' performance and that of their educators where some learners outclassed their educators in a test. The low performance of educators in this task points to a need to capacitate them in content and pedagogical approaches which the model seeks to address.

In comparing the above frequencies of learners and educator performances in the test, a scatter plot was used to find a correlation between educators and learners scores. Fig 6.4 presents the correlation of the scores.

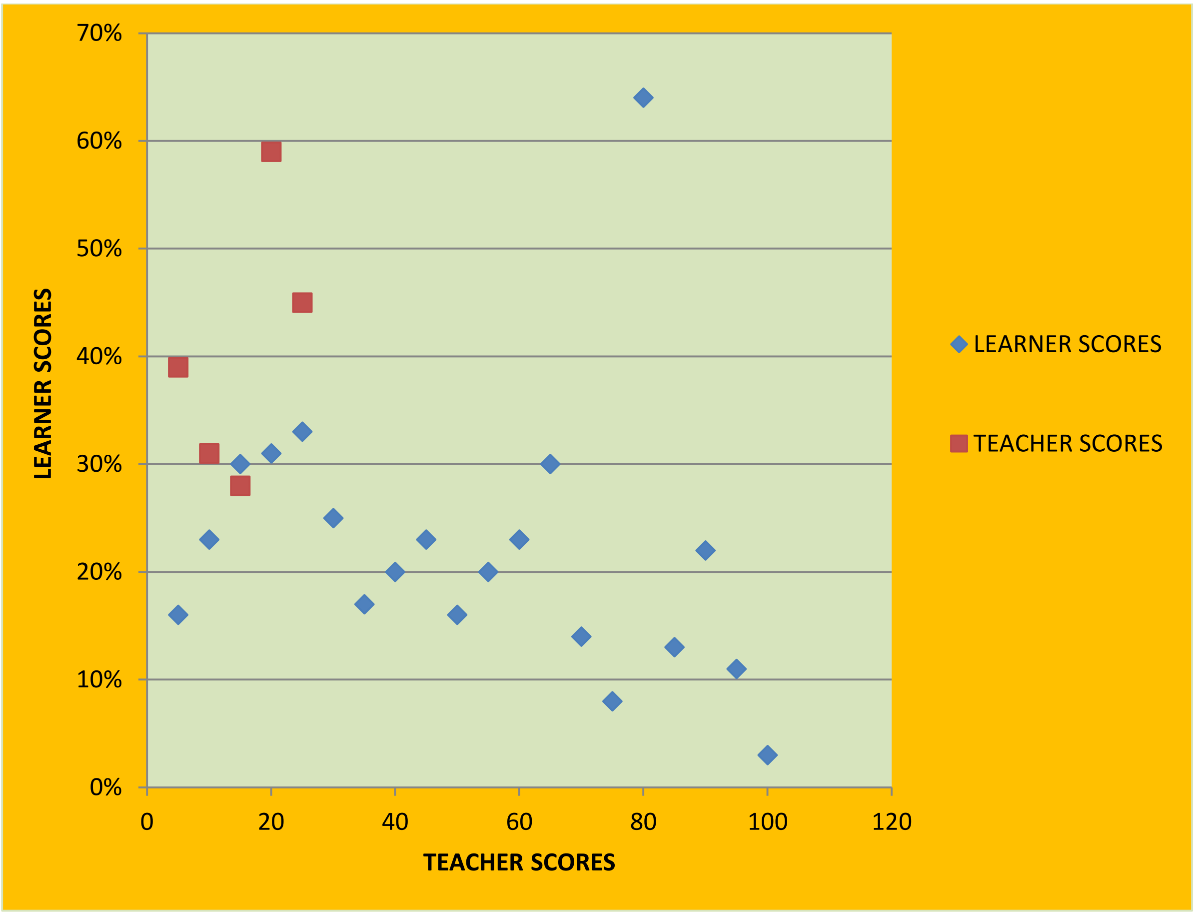


**Figure 6.4: Scatter plot of learners and educators scores in the performance test**

Fig 6.4 presented a correlational relationship between learners and educator scores in a similar performance test. The distribution of scores on the scatter plot depicts a positive correlation between marks obtained by educators and those from the learners. Thus, the lower marks obtained by 80% of educators directly relates to 90% failure scores obtained by learners. This implies that among a host of reasons such as educators' content – pedagogic incompetencies, learner backgrounds in mathematics, shortage of teaching and learning resources, learners may not understand mathematics concepts they are taught, hence they perform poorly in tests. Table 6.8 presents a standard deviation of each of the learners score from the mean of the distribution of the scores.

| Case # | Scores $x_1$ | $x_1 - \bar{x}$ | $x_1 - \overline{x^2}$ |
|---|---|---|---|
| A | 10 | 0 – 4,15 | 17,22 |
| B | 15 | 0,85 | 0,72 |
| C | 19 | 4,85 | 23,52 |
| Ď | 20 | 5,85 | 34,22 |
| E | 21 | 6,85 | 46,92 |
| F | 16 | 1,85 | 3,42 |
| G | 11 | – 3,85 | 14,82 |
| H | 13 | – 1,85 | 3,42 |
| I | 15 | 0,15 | 0,02 |
| J | 10 | – 4,15 | 17,22 |
| K | 13 | – 1,85 | 3,42 |
| L | 15 | 0,85 | 0,72 |
| M | 19 | 4,85 | 23,52 |
| N | 09 | – 8,85 | 34,22 |
| O | 05 | – 9,85 | 97,02 |
| P | 41 | 26,15 | 684,61 |
| Q | 08 | – 6,85 | 46,92 |
| R | 14 | – 0,85 | 0,72 |
| S | 07 | – 7,85 | 61,62 |
| T | 02 | – 12,85 | 165,12 |

**Table 6.12 Demographic analysis calculation of standard deviation of scores of learners in the baseline test.**

ƀ$= \frac{\sqrt{\sum(x_1 - \bar{x})^2}}{N}$

$= \frac{1278,46}{20}$

$= 63,92$

Table 6.12 presented the standard deviation of learners' scores. The standard deviation of 63, 92 means that the marks obtained by the learners are so varied or dispersed from the mean score of 14, 15. The above five schools selected in the study varied so much from each other as reflected by the various scores they each obtained from the baseline test. The bigger the standard deviation from the means, the more variability within the data set it represents. The variability could be different in mathematics performances of learners per school that was sampled and further could mirror teacher performance variations in mathematics. The higher standard deviation may also imply that the participants' marks are affected by outliers as the range between lowest and highest learner was 62 % (64-2). Lack of consistency in mathematics performance in the sampled classes may also be a valid explanation. Variability in marks mean that teachers in sampled schools teach learners that are variable in mathematical performance hence need to use individual dispositions and differences while attempting to use collaborative, group learning pedagogical approaches. The table below Table 5.9 also presents a composite comparison of the standard deviation for schools, educators, and learners in the performance test.

**Table 6.13 Comparison of baseline test results-schools and educators**

| Schools /case | Scores (64) | Teachers score | $\overline{X}$ Mean | $\overline{X}$ Schools |
|---|---|---|---|---|
| 1 | | 25 | $\frac{64}{4}=$ 16 | $\frac{283}{20}=$ 14,15 |
| A | 10 | | | |
| B | 15 | | | |
| C | 19 | | | |
| D | 20 | | | |
| 2 | 21 | 20 | $\frac{61}{4}=$ 15 | $\frac{283}{20}=$ 14,15 |
| F | 16 | | | |
| G | 11 | | | |
| H | 13 | | | |
| 3 | | 18 | $\frac{53}{4}=$ 13 | $\frac{283}{20}=$ 14,15 |
| I | 15 | | | |
| J | 10 | | | |
| K | 13 | | | |
| L | 15 | | | |
| 4 | | 38 | $\frac{74}{4}=$ 19 | $\frac{283}{20}=$ 14,15 |
| M | 19 | | | |
| N | 09 | | | |
| O | 05 | | | |
| P | 41 | | | |
| 5 | | 29 | $\frac{31}{4}=$ 08 | $\frac{283}{20}=$ 14,15 |
| Q | 08 | | | |
| R | 14 | | | |
| S | 07 | | | |
| T | 02 | | | |

A comparison of results in Table 6.13 shows that the fourth school has the highest mean of 19 compared to schools 1(16), 2 (15), 3 (13) and 5 (08) respectively. The school with a mean of 19, the highest has a teacher score of $\frac{38}{64}$, the highest as well as implying that there is a correlation between school performance and teacher performance. The overall mean of the schools was, however, lower at 14, 15 as it is affected by the outliers in the data set. Additional analysis of the results of the lowest underperforming schools 3 (13) and 5 (08) correlates with the poor performance of the educators from the two schools who got $\frac{18}{64}$ and $\frac{29}{64}$ respectively.

Evidence from observations in classrooms further revealed that the educators who performed better teach better as the following were observed in their classrooms:

- Teacher explained concepts using concrete teaching and learning aids.
- Learners were given opportunities to ask questions and demonstrate their understanding of concepts.
- Group activities were taken seriously, and learners enjoy them.
- A variety of activities were used in teaching and learning practices.
- Teachers used various methods of teaching.

On the contrary, classes with underperforming schools had the following characteristics:

- Educators were not clear on concepts they were teaching, often confusing learners.
- Learners seemed uninterested in what was taking place in the lesson, and they asked no questions nor answered any.
- No teaching and learning aids were made use of in the classroom.
- Teachers dominated the lesson using the question-and-answer method.
- Textbook examples dominated the teaching and learning demonstrations of concepts. In attempting to get more insight into the quantitative dimension of the data, educators' scores standard deviation was also calculated and is presented in Table 6.10

| Case # | Scores $X_1$ | Mean $\overline{X}$ | $X_1 - \overline{X}$ | $X^1 - \overline{X^2}$ |
|---|---|---|---|---|
| A | 25 | 26 | –1 | 1 |
| B | 20 | | –6 | 36 |
| C | 18 | | 8 | 64 |
| Ď | 38 | | –12 | 144 |
| E | 29 | | –3 | 9 |
| ∑ | | | | 254 |

**Table 6.14 Standard deviation of teachers scores in the test.**

$$Ƀ= \sqrt{\sum\left(\frac{(x_1-x)^2}{\mathbf{n}}\right)} \quad = \frac{254}{5} \quad = 50{,}8$$

Table 6.14 showcased the teachers' standard deviation of scores in the test. The standard deviation for educators' test scores is 50, 8. The standard deviation score signifies the variability among educators' competences in answering the diagnostic test. For further analysis of the results of the baseline test, paired t – test was used to compare the learners and educators' performances in the diagnostic test. Table 6.11 presents the T- test of educators and learners' performance.

| Category of Respondent | N | Mean | Standard Deviation | Standard Error Mean |
|---|---|---|---|---|
| Mathematics Learners | 20 | 14,15 | 63,92 | $\left(\frac{sd}{\sqrt{n}}\right)$ 14,29 |
| Mathematics educators | 5 | 26 | 50,8 | 22,72 |

**Table 6.15 Independent sample test for equality of variance**

The Table 6.15 described the means and standard deviations of each group. The mathematics learners' average mark is 14, 15 compared to the educators who are at 26. The two means show a significant difference in the performance in the test with educators performing better than their learners. The huge standard deviations from the means serve to show the variability of the levels of content knowledge within the two groups of respondents. Table 6.12 presented the educators standard deviation separately from that of the learners and their schools.

Contrary to their performance in the tests, all the educators had awarded themselves high rating on the Likert Scale questions (see appendix for questions) seeking if they have thorough knowledge of mathematics and teach it competently. A percentage (66.66%) of the educators could not truthfully evaluate themselves as the results prove otherwise. Flavell (1979) counsels that professional educators must develop meta-cognitive awareness of themselves so that they open room for improving their professional competency.

On marrying theory and practice of teaching, the teachers were observed teaching lessons in Grade 10 on topics of their choice and the following results were obtained: five (100%) of the educators were not clear on the elements of a lesson and key steps that a lesson follows, no introductions and recapitulation of previous knowledge was used. The concept taught in the observed lesson fell under financial mathematics where the educators were expected to teach compound interest, compounded half yearly and quarterly using a given formula. Teacher C could not make the difference between two compounding intervals and how they are converted to a statistic which becomes an exponent **(n)** in the formulae ($\boldsymbol{A = P(1+i)^n}$), hence confusing learners in concept development. In interactions between the learners and teachers there were very limited questions, except teacher centered explanations with the teacher stuck on the chalkboard. In the few instances where questions were asked, low level questions were the focus. Harlen (1999) posits that teachers with limited content knowledge and below confidence in their ability to teach stressed progress outcomes rather than conceptual understanding. Thus conceptually, the educators were not well grounded on the concepts they taught, hence less quality of teaching and learning observed in their classrooms. There is thus a strong relationship between teachers' content knowledge and focus on quality teaching. A low level of content knowledge of mathematics may lead to low level questions and out of depth discussions on the concepts taught in their classrooms.

#### 6.11.5 Results on teachers' professional attitudes of mathematics educators

Professional attitudes are the cornerstones of a teacher's actions and beliefs about the subject and learners taught. From the baseline study (see Appendix at end of thesis) it emerged that three (60%) of the educators were neutral when asked the question: **1**. Mathematics is a very worthwhile and necessary subject. On the role mathematics plays in developing the mind and helping people to think, 40% of respondents disagreed, whilst 40% were affirmative. Question **25** asked if mathematics makes teachers feel uncomfortable and in response all (100%) agreed strongly. The above responses to the few questions reveal shocking, negative responses to the belief in Mathematics, hence the impact on how teachers teach and attain status in the subject.

On further seeking relationships between professional attitudes and actual teaching, the researcher observed that four (80%) of educators do not mark learners' books nor follow up on corrections and re-teaching of concepts that learners have failed. On the question of allowing children to discuss their solutions to Mathematics tasks in groups (Question **11**), three (60%) of the respondents were affirmative while others (40%) ranged from strongly disagree, to undecided. This may imply that teachers still used teacher-centered approaches in their teaching of Mathematics, thus denying learners opportunities to try their methodologies in finding solutions to challenging questions.

In response to question **14** which read: As a result of my experience in mathematics classes, I have developed an attitude of inquiry. Only two (40%) were affirmative while (60%) were negative. The high percentage of negative responses could imply that the majority of educators are disillusioned by the frustrating experience of teaching mathematics, possibly due to continued underperformance by the learners in rural contexts in particular.

### 6.11.5 Results on teaching approaches used in mathematics classrooms.

Teaching approaches are a direct product of teachers' beliefs and attitudes coupled with the depth of a teacher's content knowledge. Thus, the researcher triangulated the collection of data through self-evaluation tests, and classroom observations. Findings from the self-evaluation test show that all educators (100%) use the Socratic method and demonstration and relied so much on the talk and chalk approach to teaching mathematics. Only one (20%) used problem solving and group work more often. On being probed about methods preferences, 60% of respondents concurred that nature of content determines pedagogical approaches.

In the follow up on the above responses, the researcher went into classrooms and observed the sampled mathematics educators practically teaching. The Table 6.17 below illustrates the findings from the observation check list.

| Classroom Pedagogical and Teacher- Learners Interactions | Frequency | Percentages |
|---|---|---|
| Use of traditional chalk and talk methods | 04 | 80% |
| Concept development stage not adequate | 03 | 60% |
| Learner involvement limited | 02 | 20% |
| Common use of textbook examples and illustrations | 04 | 80% |
| Shallow development and explanations of concepts | 03 | 60% |
| Uses learner centered approaches, adequately develops concepts and uses own examples | 01 | 20% |

**Table 6.16: Findings from the observation check list**.

The findings from Table 6.16 showed that 80% of educators relied on traditional question and answer methods, and use of chalkboard illustrations. In all the classrooms, it was observed that teachers do not devote much time in concept development. Instead, they use textbooks examples in their Mathematics lessons. The educators' inabilities to explain and develop concepts in-depth could be directly linked to their inadequate mathematical knowledge hence the need to capacitate them in all teaching ethos and processes.

**6.11.6 Data from educator's survey questionnaires**

**6.11.6.1 Results on learners' attitudes towards mathematics**

Learners' attitude towards mathematics constitutes a key variable in determining the performance of learners in the subject. Educators 10% (n = 1) rated their learners as having positive attitudes towards mathematics whilst 20% (n = 2) indicated that their learners were very negative. Despite that 40% (n = 3) rated themselves as average. It was depressing to note that 30% (n = 2) of learners have negative attitudes which translates to 50% (n = 4) of learners who are very negative and negative towards mathematics. Thus, in classes, 50% of learners are likely to underperform in mathematics, a trend evident in diagnostic tests analysis. Fig 6.5 presented a visual presentation of learners' attitudes towards mathematics.

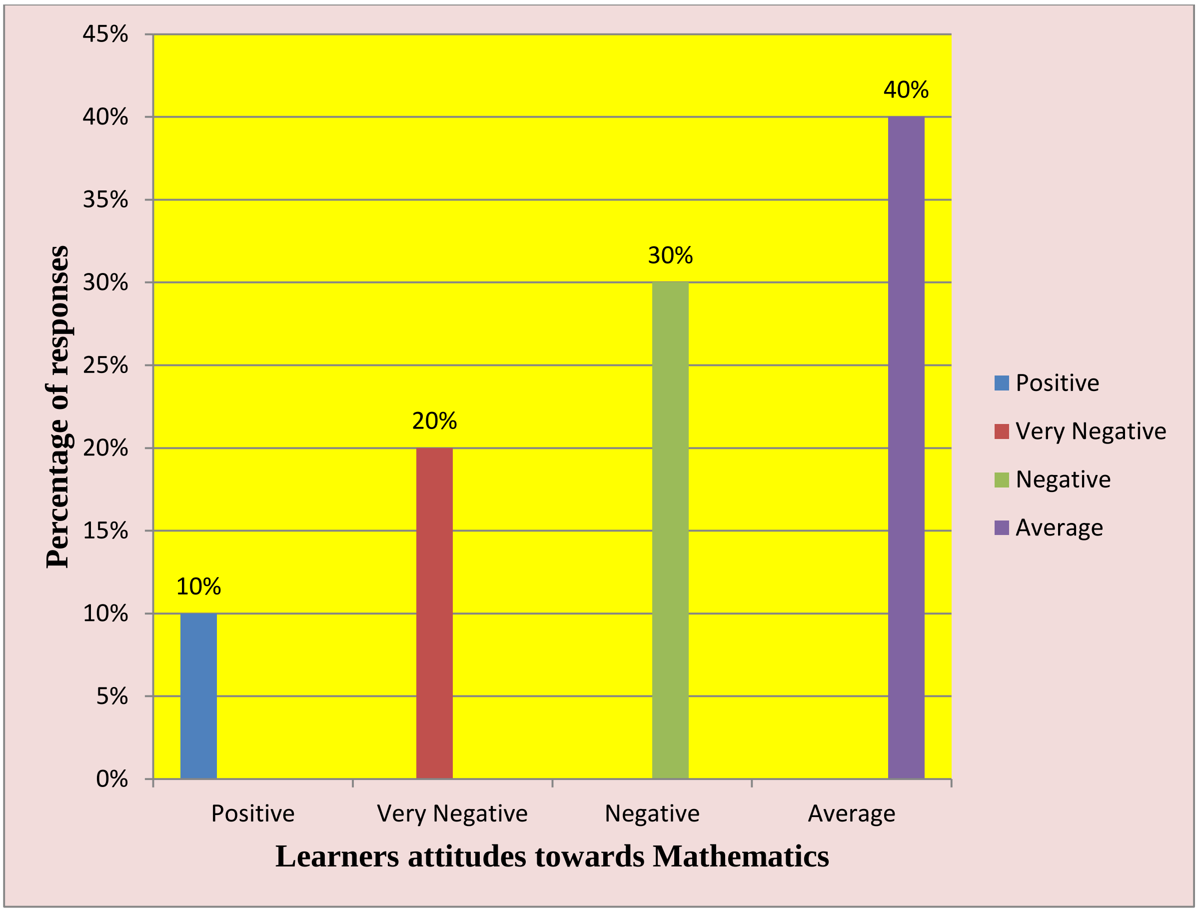


**Figure 6.5: Educators rating of learning attitudes towards mathematics**

Fig 6.5 depicted the learning attitudes of learners regarding mathematics, 10% were positive and 50% were negative with 40% on the average. Statistically, 50% of sampled learners do not like mathematics which negatively impact on their capacity to perform in the subject and correlational, poor performance as depicted in the table 6.10 where 75% of learners failed the performance test. Thus, changing learner attitudes towards the subject is critical in shaping a paradigm shift in intervening in mathematics education in secondary schools. With regard to educators' pedagogical approaches to teaching and learning mathematics, Table 6.14 shows responses to questions seeking how educators teach in their classrooms and impacts thereof.

**Tables 6.17 Responses related to educators' teaching methods in mathematics.**

| TEACHING METHODS | n | RATING TEACHING METHODS ON SCALE OF 1 TO 4 | | | | TOTAL |
|---|---|---|---|---|---|---|
| | % | NEVER | SELDOM | USUALLY, | ALWAYS | |
| **Use a variety of teaching methods** | **n** | **04** | **01** | **00** | **00** | **005** |
| | **%** | **80** | **20** | **00** | **00** | **100** |
| **Allows learners to discover the lesson content by using interesting teaching strategies** | **n** | **00** | **04** | **01** | **00** | **005** |
| | **%** | **00** | **80** | **20** | **00** | **100** |
| **Succeed in capturing learners in the learning material** | **n** | **04** | **00** | **01** | **00** | **005** |
| | **%** | **80** | **00** | **20** | **00** | **100** |
| **Make use of different learning activities** | **n** | **01** | **04** | **00** | **00** | **005** |
| | **%** | **20** | **80** | **00** | **00** | **100** |
| **Remedial teaching** | **n** | **04** | **00** | **01** | **01** | **005** |
| | **%** | **80** | **00** | **00** | **20** | **100** |
| **Expanded opportunities** | **n** | **01** | **04** | **00** | **00** | **005** |
| | **%** | **20** | **80** | **00** | **00** | **100** |

Table 6.17 illustrated the responses from participants regarding pedagogical approaches and practices in Mathematics classes of sampled teachers. Concerning classroom practices, 80% of respondents cited that teacher never used various teaching methods and only 20% said that its seldom. On allowing learners to discover content 80% was seldom and 20% was usual. Quizzed on delivering capturing and motivation lessons only 20% were positive while

80% said that it never happened. On using different learning activities 80% were seldom, and teachers were reported that they never conduct remedial teaching (80%) and they seldomly offer expanded opportunities (80%). The above state of affairs reflected an inadequacy mathematics teaching practices in schools which may be attributed to poor pedagogical competency and resultant underperformance in Mathematics.

## 6.12 Reflection on baseline study results: Goal one

The key goal of the baseline study was to establish the competency level of educators on mathematics content knowledge, professional attitudes, and beliefs, as well as pedagogical approaches. Thus, the researcher designed the study framework and selected adapted instruments from instructionally acclaimed mathematics researchers and curriculum evaluation organisations like the Human Research Council of South Africa, among others.

### 6.12.1 Reflection on Content Knowledge

Results from the baseline study on mathematics Content Knowledge showed that four out of five educators failed to obtain 50% in the test intended to test their knowledge. The one (20%) who got marks above 50% was not quality marks considering that the tests were for Grade 10 learners. Observations in classrooms also corroborated that content knowledge of concepts taught was inadequate as most educators fumbled on their teaching approaches which are correlated to content knowledge.

Educators' weaknesses were also revealed in the poor handling of questions and mathematical errors from learners. Poor response to questions and failure to resolve some emerging mathematics problems in the classrooms by teachers was very disappointing and symptomatic of a vacuum in Teacher Content Knowledge (TCK) and Pedagogical Knowledge (PK). Quizzed on interventions and approaches that could be used to improve mathematics in the cluster, the respondents gave the following responses presented in Fig 6.6 which follows in the next section.

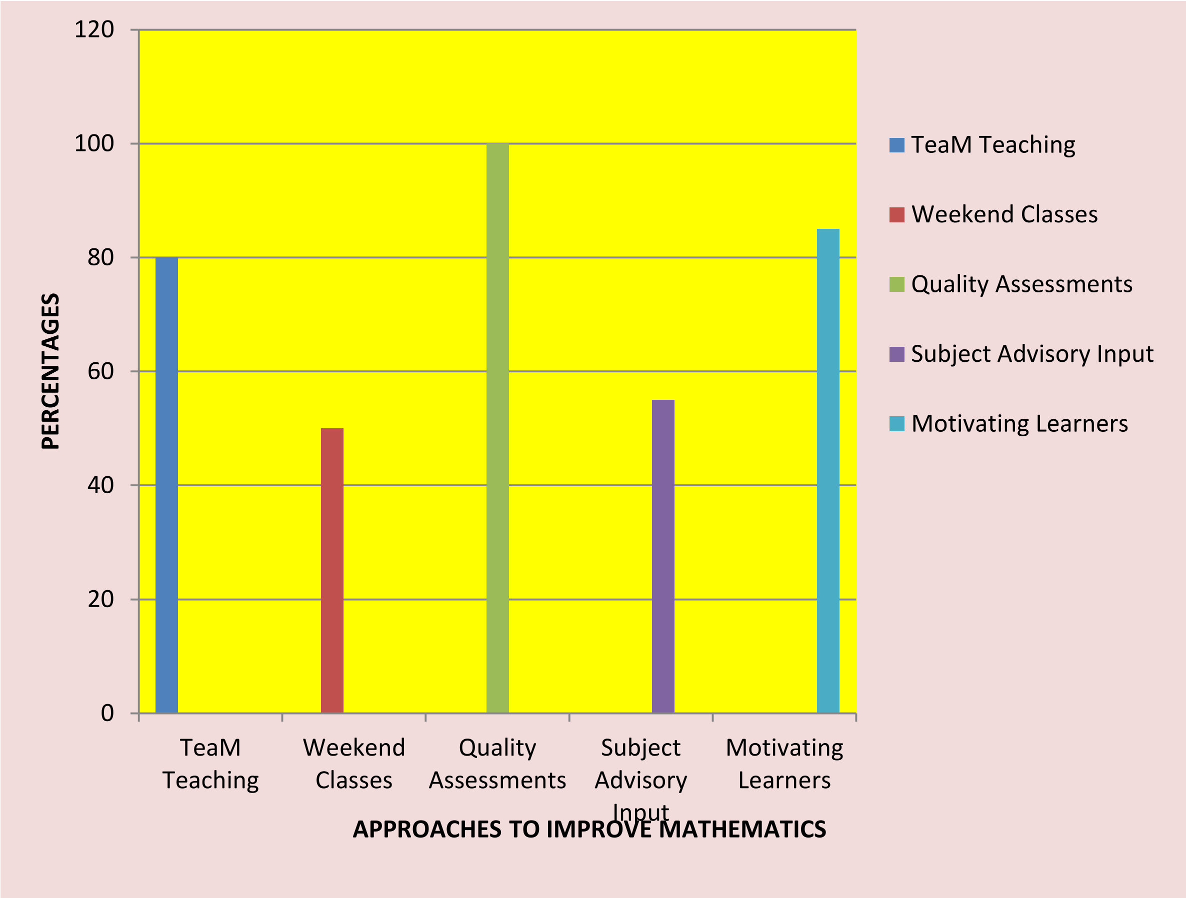


**Figure 6.6: Different approaches that can improve the teaching and learning of mathematics.**

The respondents were further probed on approaches that they think could improve the teaching and learning of mathematics and 80% suggested that team teaching could improve mathematics, 50% suggested weekend and extra classes to enable more practice of concepts, 100% cited that assessment that is quality could improve delivering of good results. Sixty percent (60%) of responses cited that subject advisory should be supportive and more hands-on deck to capacitate mathematics educators in improving teaching and learning of the subject. Changing the beliefs and attitudes of mathematics learners was also central as 80% of participants cited that learner suffer from methophobia and need a paradigm shift which could only be done through motivations and demystifying of mathematics to an interesting and doable subject that has practical benefits in everyday life contexts. Table 6.18 illustrated the responses of educators with regard to their organizational skills in the teaching and learning of mathematics in their classrooms.

**Table 6.18 Educators responses on mathematics teaching and learning**

Table 6.18 presented responses regarding how teaching and learning of mathematics is done by the five sampled educators.

| ORGANISATIONAL SKILLS | N | RATING OF ORGANISATIONAL SKILLS ON SCALE OF 1 TO 5 | | | | | TOTAL |
|---|---|---|---|---|---|---|---|
| | % | VERY POOR | POOR | AVERAGE | GOOD | VERY GOOD | |
| Planning of Mathematics lesson | N | 02 | 01 | 02 | 00 | 00 | 005 |
| | % | 40 | 20 | 40 | 00 | 00 | 100 |
| Supervision of learners during tasks | N | 04 | 01 | 00 | 00 | 00 | 005 |
| | % | 80 | 20 | 00 | 00 | 00 | 100 |
| Classroom management during Mathematics lesson | N | 02 | 01 | 02 | 00 | 00 | 005 |
| | % | 40 | 20 | 40 | 00 | 00 | 100 |
| Use of resources or equipment | N | 03 | 00 | 02 | 00 | 00 | 005 |
| | % | 60 | 00 | 04 | 00 | 00 | 100 |
| Assessment of learner's weaknesses and strength in Mathematical concepts | N | 01 | 00 | 03 | 01 | 00 | 005 |
| | % | 20 | 00 | 60 | 20 | 00 | 100 |
| Motivation of learners during the mathematics lesson | N | 04 | 00 | 01 | 00 | 00 | 005 |
| | % | 80 | 00 | 20 | 00 | 00 | 100 |
| | N | 04 | 02 | 00 | 00 | 00 | 005 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Improvising of Mathematical equipment | % | 80 | 20 | 00 | 00 | 00 | 100 |
| Recording and filing | N | 03 | 01 | 00 | 01 | 00 | 005 |
| | % | 60 | 20 | 00 | 20 | 00 | 100 |
| Assessment of your own weaknesses and strength | N | 02 | 02 | 01 | 00 | 00 | 005 |
| | % | 40 | 40 | 20 | 00 | 00 | 100 |

Variables included lesson planning, presentation and supervision of learners' work and outcomes of the processes. It emerged that regarding lessons planning 60% was poor while 40% was average, supervision of learners' work was 100% poor and rarely attended, classroom management and use of teaching aids was at 60% respectively. Learners' motivation and assessment of own weaknesses were pegged at 80% poor and only 20% average. Implicatively, effective teaching and learning of mathematics in secondary schools that were sampled is lost at the root of the process as lessons are poorly planned and implemented in classrooms resulting in poor outcomes. Interestingly, teachers despite underperforming rarely introspect hence the designing of a collaborative model seeks to inject a collective as compared to an individual accountability for a performance in a critical subject like mathematics.

**6.12.2 Reflection on professional beliefs and attitudes**

The learning culture in schools is directly linked to the beliefs and attitudes of teachers, learners, and the community and school management. Thus, findings from the baseline study indicated that most educators (66.66%) have negative, lukewarm attitudes toward the subject which they teach and are professionally trained in. Their negative attitudes could be exacerbated by the high failure rate in mathematics in their schools and lack of depth in Teacher Content Knowledge (TCK) in mathematics. Inadequate and haphazard teacher preparation programmes in mathematics could also be responsible for the observed attitudes towards the teaching and learning of mathematics. Quizzed on developing their Teacher Content Knowledge through further studies in mathematics, only (16.66%) of respondents indicated that he/she is studying towards a qualification in mathematics. Lack of drive to professionally improve their subject Content knowledge implies that the educators have accepted the status and performance of mathematics in their schools and do not see the need for efforts to improve the results. The Table 6.19 which follows presents responses from learners on their beliefs and attitudes with regards to the teaching and learning of mathematics, prospects of careers and the future of the subject.

**Table 6.19: View of educators on their beliefs and attitudes about teaching and learning mathematics obtained through questionnaires.**

| QUESTION | No | SA | | A | | D | | SD | | TOTAL | SA + A | | SD + D | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Pts | F | Pts | F | Pts | F | Pts | | Pts | % | Pts | % |
| Mathematics is a worthwhile subject | 27 | 10 | 50 | 5 | 20 | 10 | 20 | 2 | 2 | 92 | 70 | 76 | 22 | 76 |
| I want to develop my Mathematics skills | 27 | 5 | 25 | 5 | 20 | 8 | 16 | 9 | 9 | 70 | 45 | 64 | 25 | 36 |
| I enjoy Mathematics and like it | 27 | 10 | 50 | 4 | 16 | 10 | 20 | 3 | 3 | 89 | 66 | 74 | 23 | 26 |
| I believe studying Mathematics helps me with problem solving skills | 27 | 5 | 25 | 5 | 20 | 12 | 24 | 5 | 5 | 74 | 45 | 61 | 29 | 39 |
| I dread Mathematics of all subjects | 27 | 16 | 80 | 2 | 8 | 2 | 4 | 7 | 7 | 99 | 88 | 89 | 11 | 11 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Studying Mathematics make me nervous | 27 | 10 | 50 | 10 | 40 | 4 | 8 | 3 | 3 | 101 | 90 | 89 | 11 | 11 |
| I am self-confident in Mathematics | 27 | 5 | 25 | 5 | 20 | 10 | 20 | 7 | 7 | 72 | 45 | 63 | 27 | 37 |
| I enjoy Mathematics challenges | 27 | 7 | 35 | 15 | 60 | 5 | 10 | – | – | 105 | 95 | 90 | 10 | 10 |

KEY:

N --- Number of respondents per Question

F --- Number of respondents per alternative

SA --- Strongly Agree

A --- Agree

D --- Disagree

SD --- Strongly Disagree

WEIGHT POINTS:

SA --- 5 points

A --- 4 points

D --- 2 points

SD --- 1 point

Table 6.19 presented the respondents (both educators and learners) were asked questions intended to solicit their views, beliefs and attitudes towards mathematics and their responses were as follows: On how worthwhile mathematics in everyday life and job prospects is, 76% of respondents were affirmative while 24% were negative. On the desire to develop their mathematics skills, 64% were positive while 36% disagree. The negative attitudes about mathematics could imply that the respondents do not enjoy mathematics due to poor teaching approaches, among other factors. Asked whether they like and enjoy mathematics, 74% were affirmative and that is a firming foundation for improvement as it is liked by a high percentage.

On further probing on whether mathematics provides problem solving skills, 61% were positive and 39% were negative. The relatively high percentage of negative respondents could also be due to pedagogical approaches that are textbook based and do not afford learners problem solving avenues. Thus, teaching of mathematics must be contextualized to land itself in problem solving application where mathematics skills are put into use to help communities solve emerging issues using contextualized mathematics pedagogies that is applicatory of mathematics skills.

Respondents also answered questions on methophobia and nervousness in tackling mathematics problems. Of these 89% cited that they feared mathematics problem solving activities. The above scenario was shocking as such a high magnitude of methophobia and nervousness towards mathematics affects the teaching and learning of mathematics. Therefore, the construction of a collaborative model where teaching and learning of mathematics was unlocked, simplified, socialized, made interesting and worthwhile, is a panacea to the above negative beliefs and attitudes.

Quizzed on self-confidence and enjoying mathematics challenges, 63% were affirmative while 90% of respondents said they enjoy mathematics challenges. The study in constructing a model was to instill confidence in both educators and learners as positive beliefs and attitudes instilled abilities to strive in finding solutions to mathematics problems in class or out of class contexts.

### 6.12.3 Reflections on pedagogical approaches used in teaching mathematics.

Findings from the Baseline Study showed that despite all teachers indicating that they used a variety of teaching approaches in teaching mathematics, the reality observed in their classrooms pointed to the over-use of the Socratic Method and demonstrations on the chalkboard. Very scarcely were learners engaged in meaningful co-operative learning, problem solving and answering questions demanding reasoning and higher order skills. Use of the textbook in teaching and learning was very minimal as most learners leave their textbooks home fearing theft by others. Extended and remedial work was also neglected as most learners in classes hardly finished given work. In response to interview questions on

Pedagogical Content approaches used in teaching mathematics and challenges they faced, the following responses were given by both learners and educators:

### 6.12.3. Data from teachers' semi structured interviews and learners focus groups Interviews.

#### 6.12.3.1 Teachers' responses to interview questions

Interview questions for mathematics educators in each of the sampled schools were conducted as a follow-up and triangulation strategy to confirm and add the findings from observation protocol implemented in the same teachers' classrooms. The interviews were intended to collect data on lesson planning, presentation and pedagogical approaches used in teaching and learning mathematics in secondary schools. The interviews were tape recorded and transcribed by the researcher who familiarized himself with the data they contain then coded information into emerging themes and categories. The identified themes were accompanied by detailed interpretations followed by verbatim extractions from the interview transcripts (attached as annexures at the end of thesis). The recurring themes that emerged from conducting the interviews were:

- Inadequate planning and presentations to teach mathematics.
- Inappropriate pedagogical approaches used in teaching mathematics.
- Negative beliefs and perceptions about mathematics
- Recommendations to improve mathematics teaching and learning.
- Collaboration among educators as an emerging intervention strategy.

#### 6.12.3.2. Inadequate planning and presentation to teach mathematics.

**Question 2.1** Can you briefly describe what you planned for the lesson I observed? (Can you tell me more about what you mean by that?)

**Question 2.3** What do you think students had difficult learning –or were there things they didn't learn? How can you tell?

The interviews indicated the specific concepts planned for the lesson and what they intended to teach by the end of the lesson. They pointed out that most children did not understand the concept as evidenced by how they worked out their individual tasks where most of them failed. Lawson (2007) and Suurtamm (2015) concur that mathematics teachers ought to put emphasis on conceptual understanding before procedural fluency and engage students to work on interesting problems that promote interaction and collaborative work which enhances better understanding. Asked on what difficult students encountered, respondents

100% cited those students faced challenges in exponents and substituting into a formula Teacher 1, Understanding elements of a subset and presentation in diagrammatical format Teacher 2 and calculations of measures of central tendency (Teacher 3). Some responses from interviewees were:

**Teacher 1**: mhhh. The lesson you saw was on financial mathematics where my objective was for learners to calculate interest on investments using a given formula. I began the lesson by explaining concepts that relate to the task such as, interest, investments, investment period and percentage interest. After defining concepts, I went on to present an example on the chalkboard and engaged the class before giving group task and concluded by individual learner work.

**Teacher 1**: Eerr...Not really. Most learners hardly understand the concept of substituting into a given formula and as a result they do not get all the tasks questions given. At face value learners understand the concept of interest on an investment but working out sums seem a challenge.

**Teacher 2:** The lesson I taught intended to use probability variables to create subsets and result in drawing a Venn Diagram.I outline the sets and how they relate to each other and demonstrated creation of a Venn diagram from the subsets after which l gave class work on a similar concept.

**Teacher 2**: Sadly, few children comprehend the concept of subsets and how the sets intersect among themselves as they make a Venn diagram. They leave out some of the sets in the creation of the diagram.

**6.12.3.3 Inappropriate pedagogical approaches used in teaching mathematics.**

**Question 2.3:** What did you notice about student engagements during the lessons?

The respondents were unanimous that most students do not actively engage in mathematics concepts, teaching and learning citing that few attempts to respond to questions posed and to stand in class to demonstrate their understanding. This could be attributed to inappropriate pedagogical approaches that teachers are using in the classrooms. Teachers must motivate and instill confidence in children to enable them to participate fully in lessons**.**

**Teacher 1:** Oh Yes, quite a lot the financial concepts of mathematics help the learners to understand investments and how businesses earn interest on their investments. I can tell what they learnt by the way they respond to written tasks. My class has challenges in substituting into a given formula especially exponential aspect of the formula where they change the number of years to months depending on the compounding periods of investments. Students very few engage in lessons, they keep quiet throughout the lessons and as a teacher l find it upsetting because l don’t know if they get what l teach. They are indeed passive... eish bad. I do.

**Teacher 2**: Sad on that, only one or two learners participate in lessons. Most of the learners show little interest in mathematics, Learners struggle to understand mathematics concepts, Majority learners are not mathematically gifted, I don’t anticipate high passes in this class.

**Teacher 5:** Participation in lessons depends on the topic that is presented. In the lesson you observed on data handling more learners were participating but few do so in difficult concepts like trigonometry and functions. Much practice and motivation will help in that area.

**6.12.3.4 Negative beliefs and perceptions about mathematics**

**Question 2.3:** How do you think the way students learn influence your teaching of mathematics?

**Question 2.4:** What are your beliefs about the nature of mathematics and how it is taught in schools?

Respondents held the view that mathematics is enjoyable and interesting although they fail to transfer the perceptions and beliefs to the learners they teach. In their responses they decried how the poor responses from learners affect their (teachers) confidence to effectively teach mathematics and instill confidence among learners. The negative perceptions moulded by classroom contexts and how learners, respond result in negative beliefs about success in teaching and learning mathematics. Some examples of the responses were as follows:

**Teacher 4**: Poor responses in teaching and learning makes it difficult to evaluate my efforts, I have lost confidence in my teaching strategies and my love of mathematics, I find mathematics teaching boring and frustrating, I scare to get in a class and teach mathematics.

**Teacher 1:** (clears his throat). mathematics teaching and learning is quite a contested area as results in all grades are very low. But as an experienced teacher I think teaching of mathematics has remained static, traditional, and routine which makes mathematics boring and difficult to learners. mathematics teachers still use textbook examples that are worked out and rarely take questions from learners who in most classes do not ask nor answer any questions. Taking part in mathematics improvement research makes me proud and encourages me to change my methods and help improve teaching and learning of mathematics.

**Teacher 2:** I believe mathematics is interesting, mathematics needs concentration when concepts are introduced in class, I strongly see mathematics as a practical subject needing everyday practice, mathematics need learners that think positive and keep trying, Groups practice and sharing ideas could help.

**Teacher 1**: Ja...to be honest with you as a mathematics teacher I love the subject and used to think that it is easy and my learners will pass it but over the years I have experienced ups and downs in teaching the subject where results are not improving instead, they always get bad. However, despite that I believe mathematics is interesting and enjoyable.

#### 6.12.3.5 Recommendations to improve mathematics teaching and learning.

**Question 2.11** How do you think learners can be actively involved in the teaching and learning of mathematics?

**Question 2.12** Suggest different methods/ strategies that could be used to teach mathematics effectively in secondary schools?

Besides teaching and learning challenges, respondents, when asked what strategies could improve the teaching and learning of mathematics, 100% of them cited that proper planning to teach and use of teaching and learning aids, proper lesson pacing and involvement of learners in all the stages of the lesson are important improvement strategies. Involving learners in groups as they work out group tasks was also cited as crucial while giving learners chances to teach each other and explain concepts was also suggested.

**Teacher 2**: Oh yes, Individualised learning and daily practices of concepts, Practice and more practice at home and school, Motivation to love and enjoy mathematics, Use of groups in teaching could be a solution, Follow ups on homework.

**Teacher 5:** A number of strategies could be used such as group learning, pair work, monitored homework, peer coaching, peer reviews, oral presentations by learners, use of standardized assessments, inviting resource persons, practice work.

**Teacher** 1: Ok, mathematics learning and teaching must not be a teacher's task only. It should be a joint venture between the teacher and the students in a mathematics classroom. Teachers must plan a variety of activities that involve learners in actually practicing and doing mathematics. Again, use of tasks such as projects, investigations which will involve learners in groups in actual doing and helping each other to find solutions can effectively improve mathematics teaching and learning. Students should also be given chances to teach each other and demonstrate their understanding of concepts that are taught and tested.

**Teacher 1**: Eeh…secondary school mathematics is quite tricky to guarantee that any one method could be used to teach it effectively. I would suggest that not one method should be used in teaching and learning mathematics. Among strategies or methods that could be used are use of clear demonstrations and illustrations, group tasks and pair work where learners are engaged in the actual doing and practice of concepts that they are taught. Allowing learners to teach each other, demonstrate their understanding of concepts to their peers can also instill confidence and improve mathematics. Assessment is crucial as well; different assessment tasks must be given to learners in the form of projects, assignments, investigations and tests among others.

#### 6.12.3.6 Collaboration among educators as an emerging intervention strategy

**Question 2.13: How do you think teachers can effectively collaborate in teaching mathematics?**

Another emerging strategy which respondents were interviewed on was the use of collaboration among educators as a solution to poor performance in mathematics.100% of the respondents acknowledged the need to open the classroom and embrace collaboration through engaging in team teaching, co-teaching, and peer teaching among educators. MacMath, Wallace and Xiaohong (2009) stress that collaboration is important as it fosters mathematical understanding and increased confidence in mathematics. Thus through collaboration among themselves, educators will increase feelings of unity, share common goals and develop strong personal relationships that foster working together with a common goal. Respondents further said that collaboration enables sharing of resources and experiences which could be transferred from a different school to the other through assisted and joint implementation. Cited responses are as follows:

**Teacher 3:** Help from other teachers help, there are topics l cannot teach and assistance in them is necessary, I appreciate help from cluster network of teachers, Content workshops help me a lot, and I grow a lot through help from my colleagues in mathematics from other schools.

**Teacher 1**: Mhhuu…mathematics teachers need each other to effectively improve the results in their schools. The starting point is making the Orientation workshops more robust and engaging where content is clearly explained, and strategies shared coupled with written subjects' improvement plans. Other strategies could include networking of educators through sharing resources such as tasks, past papers, guidelines, and revision tasks. Teachers should also learn to team teach and peer teach where they alternate and work together to teach each other topics they do not understand well. They can also visit each other on planned exchange programmes and teach each other classes on topics that one is not effective in.

**Teacher 3:** Oh, quite a question, collaboration as in working together for common goal is the 'buzz' word in improvement literature as through its teachers can share resources, they can share experiences, tasks and strategies that could be useful in teaching and learning mathematics in secondary schools

**6.13 Learners' responses from focus group interviews**

Equally used to complement data from other research instruments were Interview questions for mathematics learners in each of the sampled schools which were conducted as a follow-up and triangulation strategy to confirm and add the findings from observation protocol and performance test. The interviews were intended to collect data on how mathematics is taught in different schools and views of students on how the subject could be an improved lesson in secondary schools. The interviews were tape recorded and transcribed by the researcher who familiarized himself with the data they contain then coded information into emerging themes and categories. The identified themes were accompanied by detailed interpretations followed by verbatim extractions from the interview transcripts (attached as annexures at the end of thesis) the recurring themes that emerged from conducting the interviews were:

- Poor teaching and learning of mathematics.
- Challenges faced in teaching and learning mathematics.
- Recommendations to improve mathematics teaching and learning.
- Assessment in mathematics as an improvement strategy

**6.13.1 Poor teaching and learning of mathematics.**

**Question 2.1**: How do you learn mathematics in your class? Describe how mathematics learning takes place in your class.

**Question 2.2:** How do learners participate in the teaching and learning process?

**Question 2.3**: How do methods used in teaching mathematics affect your understanding of concepts? Explain your answer?

The five focus groups code named A, B, C, D, and E responded interestingly that teaching and learning of mathematics in their classrooms is routine and predictable as their educators demonstrate on the chalkboard by giving a few examples mostly from the textbooks and then end with class work, which from the earlier interview data from teachers, few learners perform well in the tasks. Revelations from both educators and learners show that poor, traditional teaching methods could be a hindering factor in the quest to improve the teaching and learning of mathematics in schools. The poor participation of learners was also cited as constant occurrences where non responsive teaching methods which yields bad results.Colgan (2014) counsels that due to a reality that a large majority of students in classrooms find mathematics boring, mostly irrelevant and unrewarding, educators should close the gap through use of resources and strategies that capture students' interest and spike motivation such as use of mathematics games, TV programmes and educational applications that promote mathematical thinking. Some interview responses were:

**Focus Group 1**: mhhh... (Laughing)

**A1**- Our teacher teaches us well but most times he works out answers on the chalkboard and uses textbook examples to teach us after that he gives class work.

**A2**- Our mathematics lessons are ok, but I rarely understand and am scared to ask questions because other learners will laugh at me.

**A3**- In our class our teacher does more talking and shows all working of the examples on the chalkboard followed by group work and individual work.

**A4**- Our teacher likes mathematics and is always on time, each day he introduces new things, explains to us, and gives us work to do on our own, he does not mark our work most times.

**A5**- Teacher explains on chalkboard then we try in our groups, most times we do not understand but keep quiet until the teacher leaves class.

**Focus Group B**: Participation Eerr (sounding surprised)

**B1**- Very few only two or three out of a class of 40 participate actively in mathematics lessons, most of us we only do group tasks and individual work.

**B2**- Most learners only do group tasks and class work and do not ask the teacher any questions during lessons. A3- Learners find mathematics difficult and do not freely participate in lessons for fear of being laughed at by other learners.

**B4**- Teacher in our class spend most time talking and explaining and there is little time for us learners to do practice tasks and we fail in most of our work.

**B5**- Learners in mathematics class most times are quiet and do not answer the teacher's questions. Mathematics is too difficult and confusing us.

**Focus Group D:** Oh,

**D1**- The way mathematics is taught in my class has impact on my understanding of concepts, my teacher uses textbook worked examples and I rarely understand him but am scared to ask because class will laugh at me.

**D2**- Use of individual tasks before we understand what the teacher would have taught is discouraging as we fail to do the tasks which are given.

**D3**- I fail to understand the teacher's explanations during the lesson period and as such most times I do not get the sums correct.

**D4**- Mathematics lessons in my class are mostly teacher act where the teacher does most talking and showing us on the chalkboard how the concepts are explained.

**6.14 Challenges faced in teaching and learning mathematics.**

Respondents from the five focus groups from the five sampled schools were of the same view that mathematics teaching and learning faces challenges which range from material, pedagogical and forms of assessment and monitoring of work in schools. Focus groups respondents cited that textbooks are not enough as they share them in threes and sometimes in fours which affects how they practice and do homework. Teachers and learners' beliefs and perceptions about teaching and learning of mathematics was also cited as an impediment as negative attitudes diminishes confidence and motivation of both learners and educators. Colgan (2014) suggests that having a positive outlook in mathematics is an important factor in student achievement as it correlates with greater success in mathematics. Akey (2006) prescribes that factors that can change attitudes include teacher support, student-student interactions, positive teacher's expectations, and attitudes towards learners. Thus, teachers are mandated to instill and encourage positive attitudes towards mathematics and demystify held views that it is difficult. Cited examples from respondents were:

**Focus Group C**

**C1:** Teachers must use previously learnt concepts to teach new concepts. They ought to clearly demonstrate the new concepts to the learners. More use of chalkboard illustrations will help, and learners must be given opportunities to work out examples.

**C2**: Teachers use one method in teaching mathematics, Only the teacher demonstrates and illustrates on the chalkboard. Very rarely do any learners work answers on the chalkboard, Teachers use worked textbook examples which they demonstrate to us, Teacher even work out corrections for us.

**C3**: Teachers avoid difficult questions from learners, Teachers only use textbook examples to teach concepts, and little help is given to struggling learners.

**C4:** Only 10 textbooks which we share in our class. Some learners do not want to share textbooks. My textbook was stolen sometime ago, teachers do not care about textbook safety and use in class.

**C5:** Teachers teach mathematics separate from other subjects; I do not see how mathematics relates to real life situations. Our teacher fails to clearly explain what he teaches. We wish we could enjoy mathematics learning if teachers teach us well.

**Focus Group A**: OK.

**A1**-Main problem is that even if our teacher teaches us well, I hardly understand him, and he proceeds to give us tasks as individuals where we again fail to work out the sums.

**A2-** Some of our friends laugh at us when we try to participate in mathematics lessons, and we choose to keep quiet during lessons. Teachers pay attention to learners that are clever and rarely pay attention to some of us who are struggling with mathematics.

**A3-** One big problem we have is that we don't understand our mathematics teacher and when he explains we are left behind and sometimes he does not pay attention to slow learners.

**A4**- Mathematics is enjoyable but difficult to understand, my problem is that I don't get enough time to practice since l share a textbook with three other learners in the class.

**A5-** My friends have said most problems we face but I also think that teacher must mark our books after a task is given because most of the work in our books is not marked and we are not sure is we got the answers correct.

**6.15 Recommendations to improve mathematics teaching and learning.**

**Question 2.5**: How do you think mathematics could be taught and learnt in order to give best results?

**Question 2.6**: Suggest how learners could be actively involved in the teaching and learning of mathematics?

**Question 2.7**: Suggest how use of teaching and learning aids could improve the teaching and learning of Mathematics?

**Question 2.8**: How do you think small group learning could affect quality teaching of mathematics?

Focus group interviewees were elated to air views on how mathematics teaching and learning could be improved in their classrooms. They suggested a number of interventions which are pedagogical and material. Most respondents cited that mathematics must be taught using learner centered methodologies such as group works, projects, investigations, assignments, and tests. Involvement of learners in the phases of the lesson was emphasized. Sofroniou and Poutos (2016) further explain that group work permits students to develop a range of critical thinking, analytical and communication skills, effective teamwork, appreciation and respect for others' views. Learners as recipients of teaching learning engagements must actively participate through demonstrations to peers, group tasks and participating in mathematics games among others. Some of their responses were:

**Focus Group E**

**E1**: All teachers should involve learners in all stages of teaching and learning, I wish the teacher could take me pace by pace in the lesson, Teachers must make assessment that is good, and we pass teacher exercises but fail common assessments.

**E2:** Teaching mathematics must be enjoyable, my teacher must try to make mathematics interesting, mathematics must link with our daily lives, my teacher must link mathematics link with other subjects.

**E3**: Mathematics in our class must teach us to solve daily problems in life, Teacher must help us with problem solving mathematics skills, and group mathematics problem solving tasks may make mathematics enjoyable.

**E4**: Teacher must give us more practice of learnt concepts, more assessments in taught concepts, more monitored homework could help improve mathematics in schools, and teachers must not give easy class tasks.

**E5**: Mathematics will interest us if we do more group tasks. Use of groups makes us share ideas, Learners enjoy group tasks, and much monitoring of group tasks is needed.

**Focus Group A:** Ja,

**A1-** In order for mathematics to be improved our teacher must give enough time for practice before individual tasks are given to the class.

**A2** I also think that as learners we must be given a chance to explain to each other the concepts and practice in groups and share ideas of what has been taught.

**A3-** For mathematics to be improved I think it begins with the teacher who should have enough content and understanding of what is taught, sometimes teacher fail to answer us.

**A4-** Mathematics must be made easy and fun, teachers must give examples and illustrations that are easy to understand and again much practice must be given in groups before we do individual work.

**A5-** Our teacher must give us tasks in groups so we practice a lot and again homework must be there as mathematics needs practice a lot. Various tasks such as projects and assignments where we apply mathematics skills must be explained before given to us.

**Focus Group C**: Yes, yes, (All of the students exclaiming)

**C1-** Learners must be made to understand Mathematics concepts, be involved in the practice of the concepts as groups and individually at home and school.

**C2-** Learners can effectively do mathematics through doing it in groups and pairs as well as individually. Tasks could be made into games, projects, assignments, investigations, videos, and tests.

**C3-** Only way is to give learners chances to practice mathematics concepts, eat mathematics and live it in their lives.

**C4-** Changing beliefs about mathematics is also very important, most of us think that mathematics is difficult and that affects how we learn and do it. Our teacher must make us gain confidence in learning and doing mathematics, make us love it and like to do it daily.

- **C5-** I can add on what others have said that all learners must have own textbook for practice on his or her own and homework as well must be given and marked by our teacher. Team teaching at school level where educators in mathematics rotationally teach topics brings variety in classrooms.

**6.16 Assessment in mathematics as an improvement strategy**

**Question 2.9:** How do you think assessment in mathematics could be improved to result in the effect of understanding of concepts?

Assessment in mathematics emerged as a variable that has impact to either break or make the improvement strategies. Respondents pointed out that teacher must plan assessments, timetable assessment, and give learners ample time to prepare for assessment. Different assessment task that includes projects, investigations and tests must have clear instructions on what is expected of the learners. National Centre for Excellence in the Teaching of mathematics (NECTM) (2010) recommends that through ongoing assessment students get feedback which helps them to track their progress, fix their mistakes and extend learning. Examples of responses were:

**Focus group A**.

**A1-** Assessment is the most important result of teaching and learning and as such it should be done correctly and on time after a concept has been covered. Learners must be given a chance to prepare for assessments so that they revise.

**A2-** Starting point is to make assessment tasks relevant to what was taught and have clear instructions and what learners are expected to do.

**A3-** Assessment should be done within adequate time, quality tasks that are related to covered concepts and done after a revision by the class and the teacher.

**A4-** Assessment must take various forms such as tests, projects, assignments, and informal practice and all should be marked after being done so that learners get feedback.

**A5-** Oh my God my points taken, but one last point is that all assessments must be given on time not in a hurry and marked on time, so we get our marks and feedback on time.

**Focus Group B**

**B1**: Teachers should involve learners in all stages of concept development, practice, and assessment.

**B2**: Integrative mathematics which is linked to other subjects and real-life situations.

**B3**: A problem solving approach where Mathematics skills are used to solve emerging problems.

**B4**: More practices of mathematics sums and quality assessments.

**B5**: Small groups should be used in teaching and learning Mathematics and make Mathematics a social rather than intellectual activity.

### 6.17 Analysis of interviews and questionnaires responses

The above responses from interviews and questionnaires on content, pedagogical approaches, challenges in teaching and learning mathematics, and suggestions on improving teaching and learning of mathematics showed that learners' respondents (100%) have agreed that the critical issues lie in how educators engage learners in mathematics classrooms.

Teacher centeredness was castigated so were routine and traditional processes which make mathematics boring and too abstract. Respondents, both educators and learners, (100%) suggested more social and humanised pedagogical approaches to teaching mathematics which are collaborative, group focused, learner centered and problem solving. Suggestions also model a new type of a teacher, who is consultative, co-operative, and able to share experiences with other educators on best practices that could improve the teaching and learning of mathematics in secondary schools. Further questioned on resource factor as a variable that negatively impacts on mathematics performance, the educator respondents gave responses presented in Fig 6.7 below.

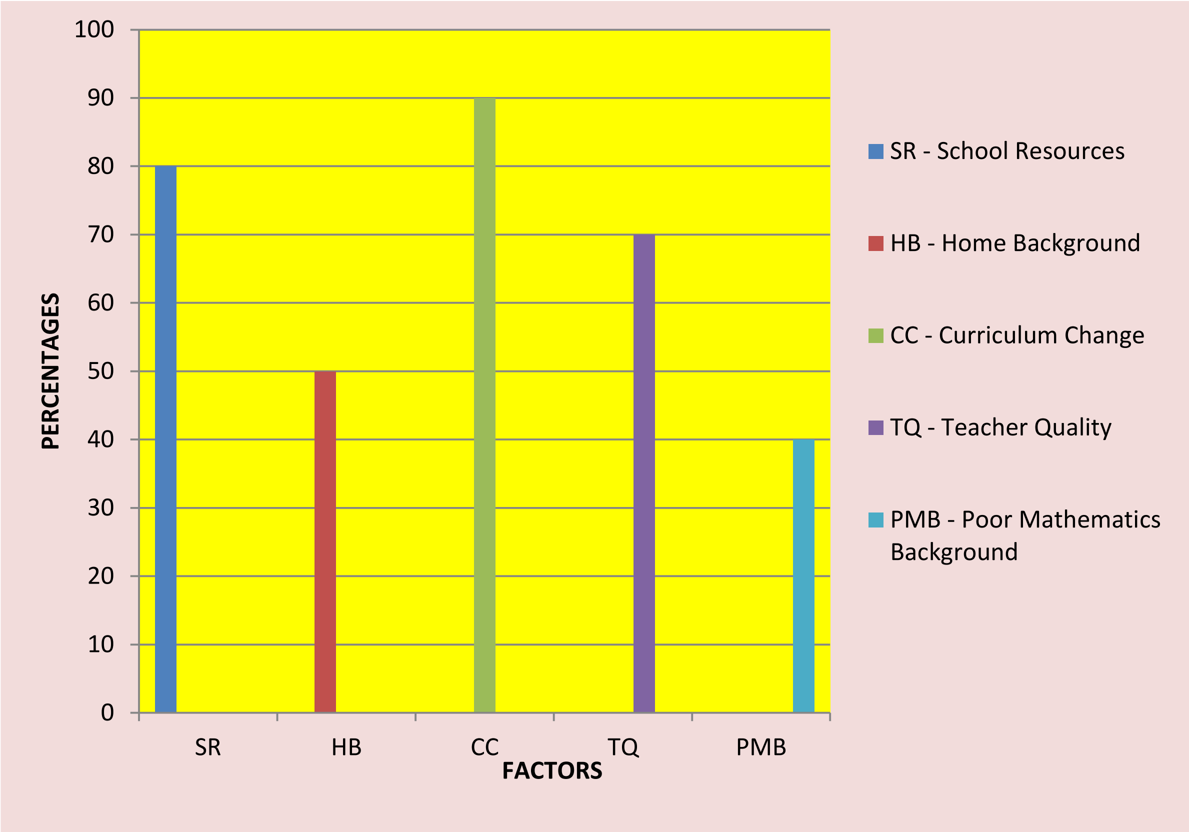


**Figure 6.7 Analysis factors that affect the performance in secondary schools.**

Fig 6.7 depicted answers from respondents on being asked about the factors that could be responsible for under performance of Mathematics, 80% of educator respondents cited lack of school resources such as textbooks and mathematical instruments as impeding on performance. Change in curriculum was cited as the major cause of poor performance as (90%) of respondents (educators) felt the new curriculum has not been fully mastered hence poor results in the subject. Home background accounted for 50% of responses as the home was cited as not supportive of school efforts to improve mathematics performance in secondary school. Teacher quality (70%) and poor mathematics background (40%) were also raised by respondents as factors which cause poor outcomes. Learners cited that mathematics at primary school was not taught very well hence the difficulty at secondary school. Therefore, reference to primary schools' mathematics backgrounds as contributing to poor performance in secondary mathematics Education opened a can of worms on the role foundation knowledge plays in quality performance in secondary schools.

**6.18 Reflections on baseline study results:**

Findings from the baseline study revealed shocking inadequacies and insights into challenges besetting the teaching and learning of mathematics in the Sisonke District of KwaZulu-Natal. Province. Educators' Content Knowledge (TCK), Pedagogical Knowledge

(PK) and Professional attitudes were found very low and below expected standards. The results also revealed a strong correlation between Teacher Content Knowledge (TCK) and Pedagogical Knowledge (PK). Participants in the baseline study not only obtained low marks in the test, but also exhibited poor grasp of Mathematics pedagogies that are learner centered and context specific designed to ensure maximum grasp of content taught. Thus, the assumption was that had the educators possessed in-depth content knowledge of mathematics, then they would have employed appropriate and varied teaching approaches and be responsive to learners needs.

Clinical observations in classrooms also suggested that educators may improve their performance and quality of teaching and learning and employ activity-based methods such as problem solving, group work and projects. Use of textbooks in teaching and learning also constituted a key skill which teachers, given training could incorporate and be effective mathematics teachers.

Findings on professional beliefs and attitudes indicated that educators with the desire to teach mathematics effectively need to transform their attitudes and devote more time to school related work, interventions, on slow learners and scaffolding those struggling with mathematics. Personal, professional development is also a key element of attitude transformation, which if adopted, will improve educators' content knowledge in mathematics which in turn would improve pedagogical approaches.

**6.19. Recommendations from the baseline study**

Baseline Study results regarding mathematics educatrors' Content Knowledge and Pedagogical approaches and Professional Attitudes showed that there were embarrassing deficiencies in all the key dimensions that needed attention and development. Educator commitment to duty in the form of instituting extra and remedial programmes was also observed to impact on professional development and needed to be addressed.Therefore, a massive intervention programme was suggested to capacitate educators in the three identified dimensions. The following activities are suggested:

- ***Content Knowledge:*** To improve Teacher Content Knowledge, the intervention will focus on teacher centred content capacitating programmes, integrating knowledge and pedagogical content knowledge. A Cluster based mathematics educators' intervention programme, initiated by the Department of Education, Sisonke District, which educators attend twice a month over the weekend where classes covering content and how to teach specific concepts occur, would be useful. The subject advisor and invited mathematics experts then take turns to deliver content to the educators.

- ***Pedagogical Approaches:*** Educators of mathematics must be exposed to a variety of mathematics teaching methods, the traditional methods and place-based pedagogies designed by teachers and learners themselves. Activity based teaching of mathematics was also explored.
- ***Workshops:*** Workshops that focus on new pedagogical approaches in mathematics and exploring new ways of disseminating mathematics concepts were to be further explored. Workshops may also incorporate mathematics learners engaging in peer teaching and exploring their own methods of finding solutions to mathematics problems.
- ***Professional beliefs and attitudes:*** Professional ethics and positive beliefs are to be incorporated into the workshop's programmes and content so that educators are socialised to think positively about their profession. Interviews to ascertain why they hold negative attitudes should be conducted and solutions implemented.
- ***Metacognition:*** Professional growth is a big product of continuous reflection and evaluation of one's strength and weaknesses with the view of improving one's performance and capacity to teach and master a discipline simulative activity that encourage self-introspection and evaluating oneself will be incorporated as well.

## 6.20 Collaborative model design improvements informed by research findings: discussion and analysis.

The aim of the study was to conceive and construct a collaborative model for both teaching and learning mathematics in secondary schools. The theoretically designed model (see Chapter 4: Fig 4.5) based on the literature review was subjected to testing and further improvements through a mixed methods concurrent data collection and triangulation strategy using baseline performance tests for both educators and learners, semi structured interviews, questionnaires, and observation. Research findings outlined above were intended to necessitate a relook, re-examination and improvement of the original and theoretically designed collaborative model as represented in Fig 4.5, with the intentions of enabling its structure, activities, and processes to mirror the conceptual frameworks and the aim of the study (see Chapter 3). Key components of the model that research data collection and findings targeted were:

- Need for stakeholders and their unified support.

- Need for informed communication and skills development.
- Roles and responsibilities of each stakeholder
- Shared target, beliefs, and vision
- Context of collaboration a requisite for collaboration

The following deficiencies and gaps were identified in the design, structure, processes, and activities of the model that necessitates change in the original, theoretically designed model (See Fig 4.5).

- **Need for stakeholders and their unified support of teaching and learning.**

The model identified stakeholders in mathematics improvement campaign as principals, educators, learners, Heads of Department, ward managers and subject advisors. However, the home environment is a key complementary component of any school improvement was not incorporated despite that it plays supporting roles in monitoring homework, motivation, and provision of moral and emotional support to learners. Findings from interview data on what could be factors that contribute to poor performance in mathematics, 50% of teacher respondents cited that the home environment was not supportive in monitoring schoolwork and providing learning resources. Further questioning on whether they get support from parents and guardians the respondents in focus group interviews responded:

**Researcher**: Do your parents monitor or assist you in your mathematics tasks?

**Focus Group 1**: Mmmmm (in unison)

**A1**- No one asks us about schoolwork and what I learn is far above my parents' level of education,

**A2**- oh my god, my granny only encourages me to go to school, cannot read my work at all,

**A3-** My mom sometimes looks at my work; she says she used to be good in mathematics,

**A4**- We all by ourselves at home I encourage myself,

**A5**- Weeee, my mom has no idea what high school mathematics involves but encourages me to work hard.

The above responses from learner respondents' points to a detached, non-supportive, less informed, and empowered home environment that gives little or no academic support towards effective teaching, learning, and supporting mathematics education. Notwithstanding, Howie (2001) reiterates that parental involvement is crucial in improving teaching learning processes as homework is supervised from home and material and emotional resources also come from parents and guardians. Thus, the home environment representing parents and guardians had to be added in the refined model as it constitutes a key stakeholder in the mathematics improvement campaign. Support for teachers and learners in the collaborative model are also crucial for success. O'Reilly (2018) expounds that co-teaching and collaborative strategies of teaching require a paradigm shift and effective support from all stakeholders in education. Heads of Departments in mathematics, principals, subject advisors, and parents are obliged to provide support to the teachers and learners engaged in collaboration which in turn results in changed mind-sets and beliefs about mathematics. Increased support from stakeholders means more interactions and provision of feedback from all stakeholders hence in the model arrows are a symbol of interaction between and among stakeholders in the improvement of mathematics education. In the model they depict a one-way communication which may not sufficiently mirror the collaborative thrust of the model. Mac Laughlin (1996) buttresses that classroom practices and conceptions of teaching and learning emerge through dynamic processes of social dimensions and strategic interactions among teachers, students, and subject matter.

The cyclic nature of the model depicts continuity, ongoing engagements of mathematics education stakeholders and, as such, continuous feedback flows to and from the individual participants in the model to result in improved ideas and ultimate performance in mathematics. Hence double two-way arrows need to be infused to reflect the ongoing, two-way communication that should characterise collaborative, supportive and results focused model of mathematics which results in improvement in secondary schools. Findings from observations in sampled classrooms (100%) revealed that there is an absence of planned quality interactions among educators in mathematics classrooms visited. The following were recurringly observed from planning, presentation, delivery of lessons, remedial and assessments among others:

- Teachers lesson plans are shallow and non-reflective of all the elements of a lesson.
- No teaching learning aids are brought in the classrooms except chalk and chalkboards.
- Textbook examples dominate the lessons presentations.
- Learners' exercise books are rarely marked, and corrections are not done as expected by the Department of Education regulations on learner support and effective teaching regime.
- Assessment is haphazardly done without learners ready for it.
- Majority of learners underperform in all given tasks, be they formal or informal.

The above observations mirror a sad reality in the teaching and learning of mathematics in the schools sampled for the study which is pathetic and non-empowering to learners who subsequently develop negative sentiments about the prospects of ever passing the subject. Interventions like the collaborative model seek to close the gaps and improve the planning, and teaching band assessment of in mathematics in schools.

One hundred percent (100%) of learners' responses in focused groups' interviews cited poor assessments and lack of quality in teaching mathematics as responsible for poor outcomes. Some of the responses from focus group interviews are shown below:

**Question**: What do you think is responsible for underperformance in mathematics?

**Focus Group D**

**D1**: I hardly understand my teacher while teaching us.

**D2**: We get good marks in teachers' tests but fail examinations.

**D3**: Teacher rarely gives us chances to work out Mathematics problems in class.

**D4**: Only textbooks examples are used in class.

Responses above mirror Pedagogical Content Knowledge PCK) challenges faced by educators in mathematics classrooms where interactions done in the classrooms are not beneficial in enhancing effective understanding of mathematical concepts by learners and the educators concerned do nothing to capacitate themselves and the learners to correct the underperformance in the subject. Feedback to and from learners is thus crucial to help educators to attend to the challenges that their learners face in classrooms so that remedial classes or re-teaching of concepts could be done as corrective measures hence the double arrows in the improved model as depicted in Fig 6.9.On the other hand, educators responding to semi-structured interviews on suggestions to improve mathematics responded as follows:

**Teacher 1**: Use of a variety of textbooks and resources. Giving learners opportunities to work out examples and solve mathematics problems in class.

**Teacher 2**: Strictly monitored homework and use of groups and sharing of mathematics knowledge in class.

**Teacher 3**: Well, monitored, quality assessments in formal and informal tasks and well-structured revision programs prior to tests and examinations.

One hundred percent (100%) of interview respondents proposed that there should be consistent interactions among educators, learners, parents, subject advisors and Heads of Departments on best practices and effective assessments and monitoring of work coverage. There is unanimous concurrence between the responses from educators and learners that ongoing interactions among mathematics stakeholders are a must to enable quality interventions to be implemented and result in improvements in performance in the subject. Thus, double arrows indicating a two-way interactive process providing multiple feedbacks which are continuous, and enduring are paramount in the improvement of mathematics Education, hence they should be inserted into the model.

- **Need for informed communication and skills development.**

  Math intervention educators and instructional supervisors must be well-informed, communicative, and competent to collaborate effectively. Collaboration educators must be continually taught in a variety of skills and tactics to effectively implement collaboration (O, Reilly, 2018) Communication, collaborative cooperation, interpersonal, and leadership abilities are essential. There is an incomplete link between learners, subject advisors, and the model's intended outcomes, which is the improvement of mathematics outcomes, in the model. A comprehensive cycle connection is required to ensure continuing contact and networking among stakeholders with the common goal of enhancing secondary school mathematics teaching and learning. As seen by data findings, when asked how mathematics teaching and learning could be improved, the following responses were given:

  **Researcher:** Thank you. Suggest different methods/ strategies that could be used to teach Mathematics effectively in secondary schools.

  **Teacher 1**: Eeh…Secondary school mathematics is quite tricky to guarantee that any one method could be used to teach it effectively. I would suggest that not one method should be used in teaching and learning mathematics. Among strategies or methods that could be used are use of clear demonstrations and illustrations, group tasks and pair work where learners are engaged in the actual doing and practice of concepts that they are taught. Allowing learners to teach each other, demonstrate their understanding of concepts to their peers can also instill confidence and improve mathematics performance. Assessment is crucial as well. Different assessment tasks must be given to learners in the form of projects, assignments, investigations, and tests, among others.

  **Researcher**: Thank you. How do you think learners can be actively involved in the teaching and learning of mathematics?

  **Teacher** 1: Ok, mathematics learning and teaching must not be a teacher's task only. It should be a joint venture between the teacher and the students in a mathematics classroom. Teachers must plan a variety of activities that involve learners in actually practicing and doing mathematics. Again, use of tasks such as projects, investigations which will involve learners in groups in actual doing and helping each other to find solutions can effectively improve mathematics teaching and learning. Students should also be given chances to teach each other and demonstrate their understanding of concepts that are taught and tested.

**Researche**r: Thank you. Lastly, how do you think you can collaborate with other teachers in teaching Mathematics effectively?

**Teacher 1**: Mhhuu…mathematics teachers need each other to effectively improve the results in their schools. The starting point is making the orientation workshops more robust and engaging where content is clearly explained, and strategies shared coupled with written subjects' improvement plans. Other strategies could include networking of educators through sharing resources such as tasks, past papers, guidelines, and revision tasks. Teachers should also learn to team teach and peer teach where they alternate and work together to teach each other topics they do not understand well. They can also visit each other on planned exchange programmes and teach each other classes on topics that one is not effective in.

**Researcher**: Thank you, Teacher 1 that concludes our interview. I would like to thank you for the wealth of knowledge that you have contributed to this project.

**Teacher 1**: Thank you very much.

- **Roles and responsibilities of each stakeholder**

Activities and responsibilities of each of the components and stakeholders in the model need to be added to reflect all the findings of the baseline study and mirror the conceptual frameworks of the study. Data from questionnaires for teachers asking about their attitudes towards mathematics revealed that, (66.66%) had negative attitudes and (89%) had phobia to tackle mathematics questions in front of classes they taught. Cobb (1996) explains that teachers' beliefs about mathematics and learning of mathematics infringe on students' beliefs and goals about the subject area. Quizzed on how they think mathematics could be taught (learners) and their attitudes and beliefs about the teaching and learning of mathematics (educators) both learner and educator respondents gave some of the following responses:

**Researcher**: Thank you. How do you think mathematics could be taught and learnt to give best results?

**Focus Group 1:** Ja, **A1**- In order for mathematics to be improved our teacher must give enough time for practice before individual tasks are given to the class.

**A2** I also think that as learners we must be given a chance to explain to each other the concepts and practice in groups and share ideas of what has been taught.

**A3**- For mathematics to be improved I think it begins with the teacher who should have enough content and understanding of what is taught, sometimes the teacher fails to answer us.

**A4-** Mathematics must be made easy and fun, teachers must give examples and illustrations that are easy to understand and again much practice must be given in groups before we do individual work.

**A5-** Our teacher must give us tasks in groups so we practice a lot and again homework must be there as mathematics needs practice a lot. Various tasks such as projects and assignments where we apply mathematics skills must be explained before given to us.

**Researcher**: Thank you. What are your beliefs about the nature of mathematics? (Not just do you like it or not, but more like is it easy or hard, is it a bunch of rules you have to memorize or something that makes sense, etc.

**Teacher 1**: Ja...to be honest with you as a mathematics teacher I love the subject and used to think that it is easy and my learners will pass it but, over the years I have experienced ups and downs in teaching the subject where results are not improving instead, they always get bad. However, despite that I believe mathematics is interesting and enjoyable.

The above excerpts suggest learners and educators have expectations of each other regarding the planned interventions aimed at improving the teaching and learning of mathematics in secondary schools. Thus, each stakeholder in mathematics education must be assigned specific responsibilities and duties that are geared towards bringing out the best results, hence additional roles and tasks are to be put to each of the stakeholders hence the refined model must reflect them as well. Additionally, all stakeholders in the Collaborative model must be guided by a common vision and target which is that of improving the performance of mathematics in secondary schools. The double communicative arrows should converge at the far-right side of the model pointing to the vision and goal as that of getting improved mathematics outcomes. Evidence from performance test represented in Table (6.10) show that only 5 out of 20 learners (25%) got marks above 30% which is the pass mark at Further Education and Training phase (FET). Only one learner obtained a respectable 64% in the test and 15 (75%) failed the test. Educators' performance (Table 6.11) despite at 80% pass was not good enough in terms of quality marks as the highest mark of 59% was less than that of learners at 64%. One educator (20%) failed the test set for learners he or she taught. The above results revealed that teachers do not have adequate content knowledge of mathematics despite being majors in the subject and having experience in teaching the subject. Thus, in the refined model educators have a huge task as reflected in the list of their roles and need to network and get more knowledge and skills on content and pedagogical skills for Mathematics. Subject advisors play a crucial role in organizing cluster workshops and providing support to teachers in classrooms. Principals and Heads of departments also have a crucial role of providing support, supervision, and resources to implement the mathematics curriculum in schools.

- **Context of collaboration a requisite for collaboration**

  O' Reilley (2018) posits that effective systems and routines are paramount to enable effective collaboration in mathematics. These routines include grouping students, timetables, allocation of resources, and administration of consistent and effective assessments. Respondents were asked during interviews their views on conditions for collaboration and assessments as requisites for effective collaboration and some of their responses were:

  **Researcher**: Thank you. How do you think assessment in mathematics could be improved to result in the effect of understanding of concepts?

  **Focus group 1**.: **A1-** Assessment is the most important result of teaching and learning and as such it should be done correctly and on time after a concept has been covered. Learners must be given a chance to prepare for assessments so that they revise.

  **A2**- Starting point is to make assessment tasks relevant to what was taught and have clear instructions and what learners are expected to do.

  **A3-** Assessment should be done within adequate time, quality tasks that are related to covered concepts and done after a revision by the class and the teacher.

  **A4**- Assessment must take various forms such as tests, projects, assignments, and informal practice and all should be marked after done so that learners get feedback.

  **A5**- My points taken, but one last point is that all assessments must be given on time not in a hurry and marked on time, so we get our marks and feedback on time.

  The above responses mirror the gaps on what, when and how to assess, learner respondents above suggest that assessments in their class is mismatched to the content previously taught and is haphazardly done without proper planning and timing. Further assessment in the class is not varied as should be as per mathematics curriculum assessment tasks requirements. Non marking of either formal or informal tasks is also identified as a challenge. Educator respondents paradoxically never cited marking loads as a variable that affect their teaching which could imply that it is because of laziness or improper use of teaching –learning time that impacts on quality assessments in mathematics.

On further probing during interviews and confirmed by questionnaires and performance tests it came out that educators poorly teach mathematics in their classrooms and mostly use boring and traditional pedagogical approaches. Confirming the challenge of conceptual deficiency in learners, Lawson (2007) articulates that there is growing evidence that students develop procedural fluency in mathematics but have difficulty in conceptual understanding hence teachers must dedicate time and emphasis on conceptual understanding as opposed to drills and procedural processes.

Some responses attest to the above as follows:

**Researcher**: Thank you. As mathematics learners, what challenges do you face in the learning of mathematics?

**A1**-Main problem is that even if our teacher teaches us well, I hardly understand him, and he proceeds to give us tasks as individuals where we again fail to work out the sums.

**A2**- Some of our friends laugh at us when we make mistakes as we try to participate in mathematics lessons, and we choose to keep quiet during lessons. Teachers pay attention to learners that are clever and rarely pay attention to some of us who are struggling with mathematics.

**A3-** One big problem we have is that we don't understand our mathematics teacher and when he explains we are left behind and sometimes he does not pay attention to slow learners.

**A4**- Mathematics is enjoyable but difficult to understand, my problem is that I don't get enough time to practice since I share a textbook with three other learners in the class.

**A5-** My friends have said most problems we face but I also think that teacher must mark our books after a task is given because most of the work in our books is not marked and we are not sure is we got the answers correct.

**Researcher**: Thank you. How do you think mathematics could be taught and learnt to give best results?

**Focus Group 1:** Ja, **A1-** In order for mathematics to be improved our teacher must give enough time for practice before individual tasks are given to the class.

**A2** I also think that as learners we must be given a chance to explain to each other the concepts and practice in groups and share ideas of what has been taught.

**A3-** For mathematics to be improved I think it begins with the teacher who should have enough content and understanding of what is taught, sometimes teacher fail to answer us.

**A4**- Mathematics must be made easy and fun, teachers must give examples and illustrations that are easy to understand and again much practice must be given in groups before we do individual work.

**A5**- Our teacher must give us tasks in groups so we practice a lot and again homework must be there as Mathematics needs much practice. Various tasks such as projects and assignments where we apply Mathematics skills must be explained before given to us.

The above responses from Focus Group A mirror the growing recurring challenge in pedagogical approaches, insufficient content and knowledge possessed by educators and absence of diversity of tasks and learner involvement strategies that learners perceive as effective to ensure that they effectively learn Mathematics in their classrooms. Thus, the collaborative model design seeks to alert educators in a collective, collaborative platform with other educators on the best practices in teaching and learning Mathematics where learners enjoy and find actualization in what they learn. Fig 6.8 presents how schools can create effective collaborative teaching and learning environments.

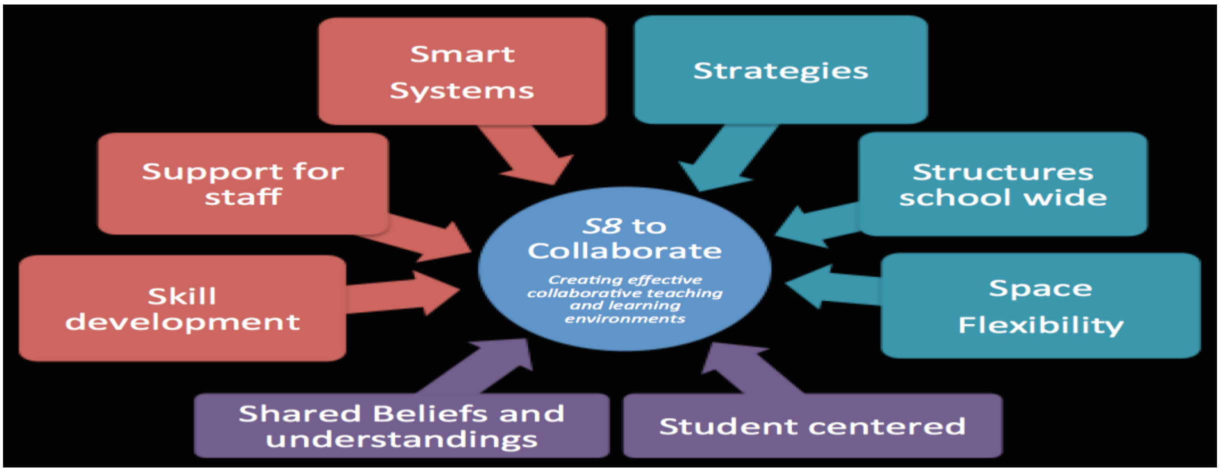

**Fig 6.8 Creating effective Collaborative teaching and learning environments (Researcher's compilation)**

## 6.21 Requisites and conditions for effective collaboration which are central to the collaborative model design and implementation.

Thus, guided by the above findings, the researcher retained and made bold the internal aspects of the model that represent conditions and requisites for implementation of the model which include among others leadership, planning, trust, positive beliefs, hard work and pedagogical soundness. A summary analysis from interviews and questionnaires (See 6.18.3), implies that unless teachers change their pedagogical approaches, perceptions about Mathematics learners and content, engage effectively with the home environment, improved supply of textbooks that are qualitative (suggested Study guide see Chapter 4), provision of practical content and pedagogical support by subject advisors, improved Mathematics performance will sadly remain a pipe dream. Therefore, additional to the theoretical proposed structure and components of the model, (See Fig 4.5) the revised model (See Fig 6.9) must clearly state comprehensively what each stakeholder should provide for coordinated planning, feedback, re-strategising, and ultimate focus on improved mathematics outcomes. The above inputs into the revised structure of the Collaborative model represented in Fig 6.9 reflected need for coordination of stakeholders' activities, presence of supervision, monitoring, mentoring, re-planning, and strategising and continuous evaluation among educators at school and cluster level, Heads of Departments in Mathematics, subject advisory, principals, ward mangers and parents all designed purposely to improving mathematics outcomes (see Fig 6.9)

## 6.22 Refined collaborative model design: Components, activities, and processes.

In line with the above recommendations (See 6.21 above), for further inputting and refining the model presented in Chapter 4 **(Fig 4.5),** the study presents a refined, improved Collaborative model incorporating the changes into the structure, components, activities, and processes of the model depicted in Fig 6.9 below.

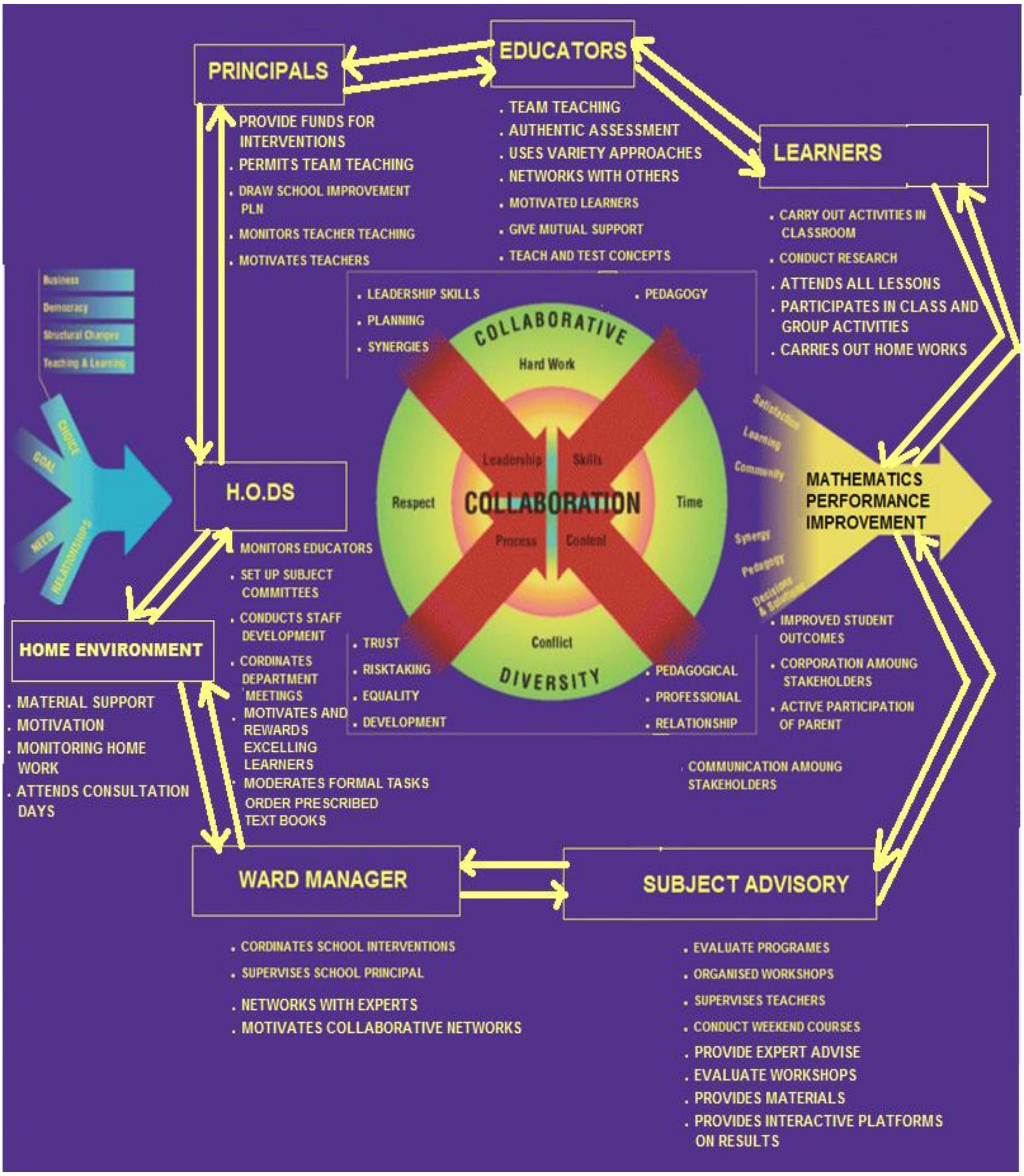


**Fig 6.9: Revised Collaborative Model for Teaching and Learning Mathematics**

## 6.23 Integrated analysis of research findings from mixed methods data collection instruments

The aim of the study was to conceive and construct a Collaborative model for teaching and learning Mathematics in secondary schools in the rural Centocow cluster of KwaZulu-Natal Province of South Africa. The study adopted mixed methods concurrent triangulation in data collection and analysis of data and research findings. The thrust of the study was to construct an interventionist, collaborative model for learning and teaching mathematics initially premised on professional development and constructivism and network theoretical perspectives as well as the researcher's decades of teaching Mathematics in secondary schools.

The second phase of the study involved the implementation of the professional development model through a triangulated data collection plan involving administration of baseline test for 20 learners and 5 educators in a case study of five schools in a cluster. Other instruments that were employed were questionnaires for learners, educators and subject advisors, observation of classrooms practices as well as semi structured interviews for educators and focus groups. The thrust of the data collection phase was intended to provide primary data to refine the model (see Fig 4.5) and either to confirm or dispute literature findings of the study. Concurrent mixed method data collection strategies have been employed to validate one form of data with the other form, to transform the data for comparison, or to address different types of questions (Creswell & Plano Clark 2007). In many cases the same research respondents provided both qualitative and quantitative data which was useful in providing answers to the research questions and broad research problem of the study that of designing a collaborative model for teaching and learning Mathematics in secondary schools.

- The study employed thematic analysis of all collected data implying that from the collected data (Interviews, questionnaires, observations, and baseline test) the researcher identified recurring themes which made up the pillars of the study that are the key components of a Collaborative model the thrust of the overall study. Creswell & Plano Clark (2011) explain that in mixed methods studies, investigators intentionally integrate or combine quantitative and qualitative data rather than keeping them separate. The basic concept is that integration of quantitative and qualitative data maximizes the strengths and minimizes the weaknesses of each type of data. This idea of integration separates current views of mixed methods from older perspectives in which investigators collected both forms of data but kept them separate or casually combined them rather than using systematic integrative procedures. One of the most difficult challenges is how to integrate different forms of data. Three approaches used were merging data, connecting data, and embedding. In the study, as highlighted earlier, four data collection instruments were employed to collect data from respondents namely the interviews, questionnaires, tests, and observations. The instruments were used concurrently implying that data from them was collected separately precisely for triangulation purposes. In the analysis stage of the study, collected data was analysed thematically (see themes below) that is themes that were recurring constituted subtopics under which relevant data was grouped under each theme and data was integrated or merged under each of them regardless of source of the collecting instrument. Further, data under each theme was connected and used as answers to the research questions through an in-depth analysis thereof. Fig 6.10 shows how mixed methods analysis of data is theoretically and practically done respectively.

**6.24 MIXED METHODS MATIRIX ANALYSIS**

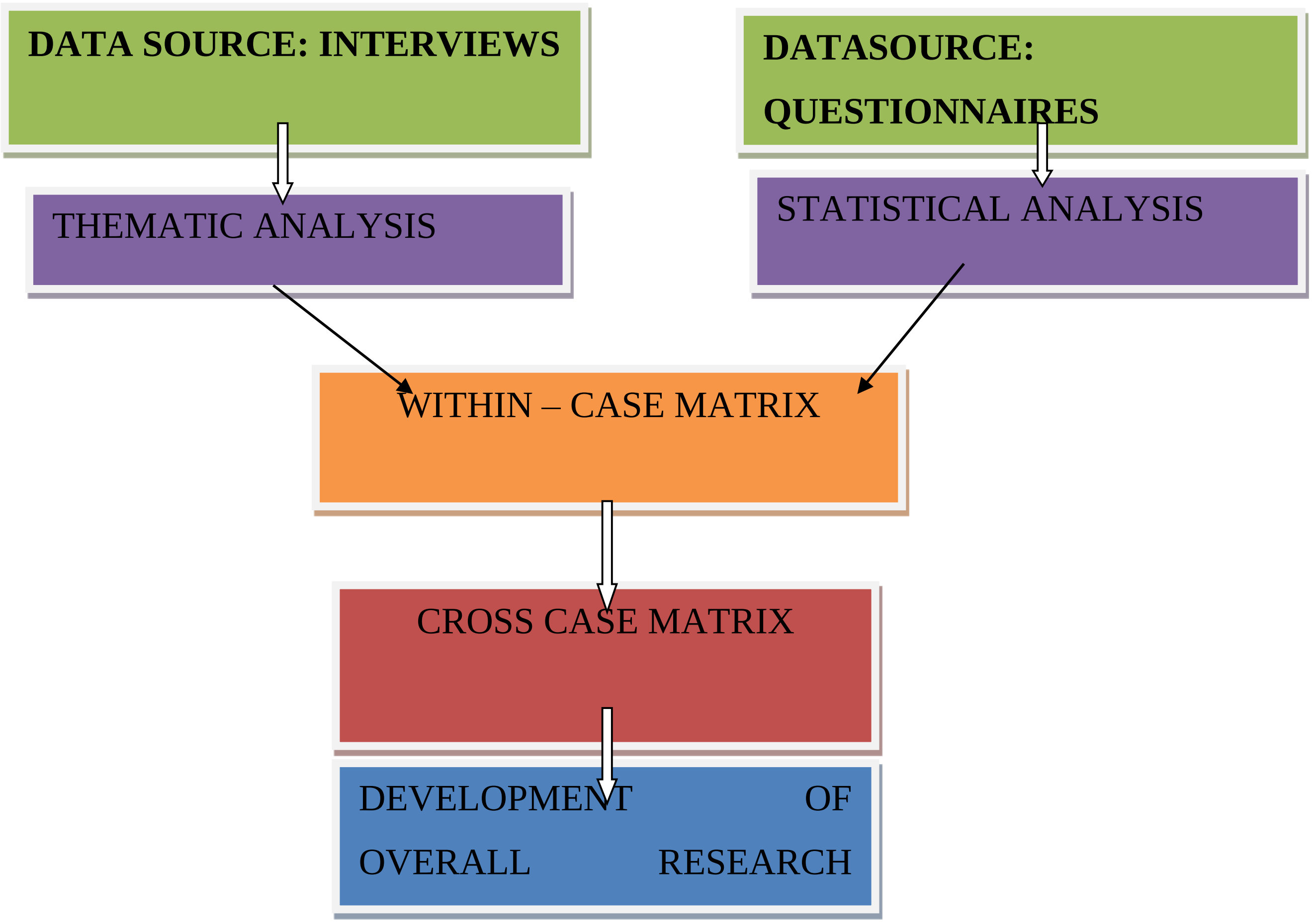


**Fig 6.10 Mixed methods data matrix analysis (Adapted from Creswell, 2014)**

Fig 6.10 presented the actual process of data analysis that was followed in processing, coding, presentation, and discussion of collected data for the current study. Guetterman, Fetters, and Creswell (2015) argue that in a mixed methods data analysis, integration occurs at the analytic and interpretation level, when data in the form of tables and figures is exhibited and discussed concurrently both quantitative and qualitative outcomes. According to Bazeley (2016), in a combined presentation, findings from several data sources are shown together, categorized by parts of the study subject or recurrent themes rather than data gathering techniques. As a result, data from the four data collecting instruments was combined and evaluated within the study framework using visual presentation tools such as tables, figures, and descriptive statistics.

Five themes emerged from literature and in-depth data collection and were used as the lens through which data was analysed. The themes were:

- Pedagogical approaches in teaching and learning Mathematics in secondary schools.
- Assessment and performance in secondary school Mathematics
- Challenges in teaching and learning Mathematics.
- Recommendations to improvement of teaching and learning of Mathematics.
- Collaboration as an emerging intervention and improvement strategy.

The themes listed above relate to the theoretical framework of social constructivism because all resonate from the need to collectively engage stakeholders in the classroom and outsiders notable parents, learners, parents and supervisors in Mathematics education to provide collaborative networks that generate knowledge on methodologies, materials , solutions and support to the challenges and programmes geared towards improving the teaching and learning of Mathematics in Secondary schools in South Africa.

## 6.24 Pedagogical approaches in teaching and learning mathematics in secondary schools.

During the data collection stages respondents were asked (Interviews and questionnaires and observations) about the pedagogical approaches used in teaching and learning Mathematics. Findings were that teachers still use the traditional talk-chalk methodologies where the teacher dominates the classroom discourse through routines and procedural emphasis mostly using textbooks examples. Some of the responses and collected data will be discussed.

**Question 2.3: What did you notice about student engagements during the lessons?**

The respondents were unanimous that most students do not actively engage in the mathematics concepts of teaching and learning citing that few attempts to respond to questions posed and to stand in class to demonstrate their understanding. This could be attributed to inappropriate pedagogical approaches that teachers are using in the classrooms. Teachers must motivate and instill confidence in children to enable them to participate fully in lessons. This view is supported by the following responses:

**Teacher 1:** Oh Yes, quite a lot the financial concept of Mathematics helps the learners to understand investments and how businesses earn interest on their investments. I can tell what they learnt by the way they respond to written tasks. My class has challenges in substituting into a given formula especially exponential aspect of the formula where they change the number of years to months depending on the compounding periods of investments. Very few students engage in lessons, they keep quiet throughout the lessons and as a teacher I find it upsetting because I don't know if they get what I teach. They are indeed passive... eish bad. I do.

**Teacher 2**: Sad on that, only one or two learners participate in lessons. Most learners show little interest in Mathematics, Learner's struggle to understand Mathematics concepts, majority of learners are not mathematically gifted, I don't anticipate high passes in this class.

**Teacher 5:** Participation in lessons depends on the topic that is presented. In the lesson you observed on data handling more learners were participating but few did so in difficult concepts like trigonometry and functions. A lot of practice and motivation will help in that area.

Learner respondents were asked the similarly contextualized questions and responded as detailed below:

**Question 2.1**: How do you learn Mathematics in your class? /Describe how mathematics learning takes place in your class

**Question 2.2:** How do learners participate in the teaching and learning process?

**Question 2.3**: How do methods used in teaching Mathematics affect your understanding of concepts? Explain your answer?

The five focus groups code named A, B, C, D, and E responded interestingly that teaching and learning of Mathematics in their classrooms is routine and predictable as their educators demonstrate on the chalkboard by giving a few examples mostly from the textbooks and then end with class work which from the earlier interview data from teachers few learners perform well in the tasks. Revelations from both educators and learners show that poor, traditional teaching methods could be a hindering factor in the quest to improve the teaching and learning of Mathematics in schools. The poor participation of learners was also cited as constant occurrences so were a non-responsive teaching methods which yields bad results. Some interview responses were:

**Focus Group 1**: mhhh... (Laughing)

**A1**- Our teacher teaches us well but most times he works out answers on the chalkboard and use textbook example to teach us, after that he gives class work.

**A2**- Our Mathematics lessons are ok, but I rarely understand and am scared to ask questions because other learners will laugh at me.

**A3**- In our class our teacher does more talking and shows all working of the examples on the chalkboard followed by group work and individual work.

**A4**- Our teacher likes mathematics and is always on time, each day he introduces new things, explains to us, and gives us work to do on our own, he does not mark our work most times.

**A5**- Teacher explains on chalkboard then we try in our groups, most times we do not understand but keep quiet until the teacher leaves class.

**Focus Group B**: Participation Eerr (sounding surprised)

**B1**- Very few only two or three out of a class of 40 participate actively in mathematics lessons, most of us we only do group tasks and individual work.

**B2**- Most learners only do group tasks and class work and do not ask the teacher any questions during lessons. A3- Learners find mathematics difficult and do not freely participate in lessons for fear of being laughed at by other learners.

**B4**- The teacher in our class spends most of the time talking and explaining and there is little time for us learners to do practice tasks and we fail in most of our work.

**B5**- Learners in mathematics class most times are quiet and do not answer teacher's questions. Mathematics is too difficult and confusing for us.

**Focus Group D:** Oh,

**D1**- The way mathematics is taught in my class has an impact on my understanding of concepts, my teacher uses textbook worked examples and I rarely understand him but scare to ask because class will laugh at me.

**D2**- Use of individual tasks before we understand what the teacher would have taught is discouraging as we fail to do the tasks which are given.

**D3**- I fail to understand the teacher's explanations during the lesson period and, as such most times I do not get the sums correct.

**D4**- Mathematics lessons in my class are mostly teacher act where the teacher does most talking and showing us on the chalkboard how the concepts are explained.

The researcher authenticated the above findings by use of observation data where a personal visit to all sampled classrooms was done to collect primary data on the processes and activities that were taking place in the classrooms during the teaching and learning of Mathematics. In 80% of the classes' educators used routine and traditional teaching methods where textbook examples are written on the chalkboard, explained with emphasis on procedural understanding and steps followed by class task. Venkat and Spaull (2015) lament that no education system can move beyond the quality of its teachers. There is now a large body of evidence in South Africa attesting to the fact that the majority of South African teachers do not have the content knowledge or pedagogical skills necessary to impart the curriculum. In a nationally representative sample of primary schools, it was found that 79% of Grade 6 Mathematics teachers could not score 60% or higher on Grade 6 or 7 level questions.

Thus, it can be concluded that educators in Mathematics classes are a key variable for change hence there is a need to embrace collaborative, learner centered methodologies (See Appendix 10 Focus Group Transcripts, Section 4) that will bring about understanding of concepts behind procedures and make mathematics interesting and enjoyable. Lawson (2007, 2016) concurs that teachers must put efforts to teach for conceptual understanding before procedural understanding so that learners will be able to apply learnt knowledge in new situations.

**6.25 Assessment and performance in secondary school mathematics**

The study situated assessment as an integral part of a Collaborative model and sought views and opinions on how it is done in classrooms that were sampled and further used a baseline test to measure levels of performance of both teachers and learners. Findings were that educators assess without adequate conceptual understanding by learners and in most cases, tasks are routine, none challenging and lack motivation for creativity and problem-solving skills. Inadequate planning of tasks compromised their quality and resultant performances. Some of the responses and data from the findings:

**Question 2.9:** How do you think assessment in mathematics could be improved to result in the effect of understanding of concepts?

**Focus group A**.

**A1**- Assessment is the most important result of teaching and learning and as such it should be done correctly and on time after a concept has been covered. Learners must be given a chance to prepare for assessments so that they revise.

**A2**- Starting point is to make assessment tasks relevant to what was taught and have clear instructions and what learners are expected to do.

**A3**- Assessment should be done within adequate time, quality tasks that are related to covered concepts and done after a revision by the class and the teacher.

**A4**- Assessment must take various forms such as tests, projects, assignments, and informal practice and all should be marked after being done so that learners get feedback.

**A5**- My points taken, but one last point is that all assessments must be given on time not in a hurry and marked on time, so we get our marks and feedback on time.

**Focus Group B**

**B1**: Teachers should involve learners in all stages of concept development, practice, and assessment.

**B2**: Integrative mathematics which is linked to other subjects and real-life situations.

**B3**: A problem solving approach where Mathematics skills are used to solve emerging problems.

**B4**: More practices of mathematics sums and quality assessments.

**B5**: Small groups should be used in teaching and learning mathematics and make mathematics a social rather than intellectual activity.

Baseline performance test was also a barometer to measure effectiveness of teaching and learning. Below is a summary of the performance:

Evidence from performance test represented in Table 6.10 show that only 5 of the 20 learners (25%) got marks above 30% which is the pass mark the Further Education and Training phase (FET). Only one learner obtained a respectable 64% in the test and 15 (75%) failed the test. Educators' performance as represented in Table 5.11 despite at 80% pass was not good enough in terms of quality marks as the highest mark of 59% was less than that of learners at 64%. One educator equivalent to 20% of the whole group of teacher respondents failed the test set for learners he or she taught. The above results revealed that teachers do not have adequate content knowledge of Mathematics despite having Mathematics as a teaching subject in their qualifications or teaching degrees and have taught the subject for a number of years. In the context of the above, Ontario Ministry of Education (2005) highlights that the goal of assessment must be to improve student learning and as such should use varied and engaging tailored towards addressing what students learn and how they learn it, should include assignments, demonstrations, projects, and tests and be ongoing.

**6.26. Challenges in teaching and learning Mathematics.**

Interviews and questionnaires sought to capture the onsite challenges and problem in the teaching and learning of the mathematics curriculum in secondary schools. Key findings were that some educators that teach the subject are not majors in it while some are not qualified enough to effectively teach Mathematics. Absence of adequate support from the home environment also emerged so was material and moral support from schools. Poor teaching and learning methodologies were further identified as predators of quality teaching and learning resulting in negative perceptions about the subject. Typical responses that were captured were as follows:

Asked in a questionnaire on what factors may be accountable for poor results, teacher respondents' findings were that 80% of respondents cited lack of school resources such as textbooks and mathematical instruments as impeding on performance. Change in curriculum was cited as the major cause of poor performance as (90%) of respondents (educators) felt the new curriculum has not been fully mastered hence poor results in the subject. Home background accounted for 50% of responses as the home was cited as not supportive of school efforts to improve Mathematics performance in secondary school. Teacher quality (70%) and poor Mathematics background (40%) were also raised by respondents as factors which cause poor outcomes. Learners cited that Mathematics at primary school was not taught very well hence the difficulty at secondary school. Therefore, reference to primary schools' Mathematics backgrounds as contributing to poor performance in secondary Mathematics Education opened a can of worms on the role foundation knowledge plays in quality performance in secondary schools. (Fig 5.8 displays the pictorial presentation of the factors cited).

Interviews further captured the same question and findings as below:

Respondents from the five focus groups from the five sampled schools were asked about challenges that were faced in the teaching and learning of mathematics and were of the same view that mathematics teaching and learning faces challenges which range from material, pedagogical and forms of assessment and monitoring of work in schools. Focus groups respondents cited that textbooks are not enough as they share them in threes and sometimes in fours which affects how they practice and do homework. Teachers and learners' beliefs and perceptions about teaching and learning of Mathematics was also cited as an impediment as negative attitudes diminishes confidence and motivation of both learners and educators. Below are cited examples from different respondents:

**Focus Group C**

**C1:** Teachers must use previously learnt concepts to teach new concepts. Teachers' ought to clearly demonstrate the new concepts to the learners, and more use of chalkboard illustrations will help. Learners must be given opportunities to work out examples.

**C2**: Teachers use one method in teaching Mathematics, only teacher demonstrates and illustrates on the chalkboard, and very rarely do any learners work answers on the chalkboard. Teachers use worked textbook examples which they demonstrate to us, teacher even work out corrections for us.

**C3**: Teachers avoid difficult questions from learners, Teachers only use textbook examples to teach concepts, and little help is given to struggling learners.

**C4:** Only 10 textbooks which we share in our class, some learners do not want to share textbooks. My textbook was stolen some time ago. Teachers do not care about textbook safety and use in class.

**C5:** Teachers teach Mathematics separately from other subjects, I do not see how Mathematics relates to real life situations, our teacher fails to clearly explain what he teaches, and we wish we could enjoy Mathematics learning if teachers teach us well.

**Focus Group A**:

**A1**-Main problem is that even if our teacher teaches us well, I hardly understand him, and he proceeds to give us tasks as individuals where we again fail to work out the sums.

**A2**- Some of our friends laugh at us when we try to participate in Mathematics lessons, and we choose to keep quiet during lessons. Teachers pay attention to learners that are clever and rarely pay attention to some of us who are struggling with Mathematics.

**A3**- One big problem we have is that we don't understand our Mathematics teacher and when he explains we are left behind and sometimes he does not pay attention to slow learners.

**A4**- Mathematics is enjoyable but difficult to understand, my problem is that I don't get enough time to practice since l share a textbook with three other learners in the class.

**A5**- My friends have said most problems we face but I also think that teachers must mark our books after a task is given because most of the work in our books is not marked and are not sure if we got the answers correct.

## 6.27 Recommendations on improving mathematics teaching and learning in secondary schools.

The thrust of the study was to conceive and construct an interventionist, collaborative model to improve the teaching and learning of mathematics in secondary schools hence soliciting views of respondents on recommendations and way forward was fundamental in providing feedback to refine and improve the model. Questionnaires and interviews triangulated the section on recommendations and below are some of the responses:

Teacher respondents were probed on approaches that they think could improve the teaching and learning of Mathematics and 80% suggested that team teaching could improve Mathematics, 50% suggested weekend and extra classes to enable more practice of concepts, and 100% cited that assessment that is quality could improve delivering of good results. Sixty percent (60%) of responses cited that the subject advisory should be supportive and more hands on to capacitate Mathematics educators in improving teaching and learning of Mathematics. Changing beliefs and attitudes of Mathematics learners was also central as 80% of participants cited that learners suffer from methophobia and need a paradigm shift which could only be done through motivations and demystifying of Mathematics to an interesting and doable subject that has practical benefits in everyday life contexts. Table 6.7 displays the various pedagogical interventions that teachers think could improve the teaching and learning of Mathematics in secondary schools. Further responses from interviews are below:

**Question 2.12 Suggest different methods/ strategies that could be used to teach Mathematics effectively in secondary schools?**

Besides teaching and learning challenges, respondents when asked what strategies could improve the teaching and learning of Mathematics, 100% of them cited that proper planning to teach and use of teaching and learning aids, proper lesson pacing and involvement of learners in all the stages of the lesson are important improvement strategies. Involving learners in groups as they work out group tasks was also cited as crucial while giving learners chances to teach each other and explain concepts was also suggested.

**Teacher 2**: Oh yes, individualised learning and daily practices of concepts, Practice and more practice at home and school, motivation to love and enjoy Mathematics, use of groups in teaching could be a solution and follow up on homework.

**Teacher 5:** A number of strategies could be used such as group learning, pair work, monitored homework, peer coaching, peer reviews, oral presentations by learners, use of standardized assessments, inviting resource persons, practice work.

**Teacher** 1: OK, Mathematics learning and teaching must not be a teacher's task only; it should be a joint venture between the teacher and the students in a mathematics classroom. Teachers must plan a variety of activities that involve learners in actually practicing and doing mathematics. Again, use of tasks such as projects, investigations which will involve learners in groups in actual doing and helping each other to find solutions can effectively improve Mathematics teaching and learning. Students should also be given chances to teach each other and demonstrate their understanding of concepts that are taught and tested.

**Teacher 1**: Eeh…Secondary school Mathematics is quite tricky to guarantee that any one method could be used to teach it effectively. I would suggest that not one method should be used in teaching and learning Mathematics. Among strategies or methods' that could be used are use of clear demonstrations and illustrations, group tasks and pair work where learners are engaged in the actual doing and practice of concepts that they are taught. Allowing learners to teach each other, demonstrate their understanding of concepts to their peers can also instill confidence and improve Mathematics. Assessment is crucial as well; different assessment tasks must be given to learners in the form of projects, assignments, investigations, and tests, among others.

### 6.28 Collaboration among educators as an emerging intervention strategy

**Question 2.13: How do you think teachers can effectively collaborate in teaching Mathematics?**

Another emerging strategy which respondents were interviewed on was the use of collaboration among educators as a solution to poor performance in Mathematics. One hundred percent respondents acknowledged the need to open the classroom and embrace collaboration through engaging in team teaching, co-teaching, and peer teaching among educators. Respondents further said that collaboration enables sharing of resources and experiences which could be transferred from a different school to the other through assisted and joint implementation. Cited responses are as follows:

**Teacher 3:** Help from other teachers helps, there are topics I cannot teach and assistance in them is necessary, I appreciate help from a cluster network of teachers. Content workshop helps me a lot, I grow a lot through help from my colleagues in Mathematics from other schools.

**Teacher 1**: Mhhuu…Mathematics teachers need each other to effectively improve the results in their schools. The starting point is making the Orientation workshops more robust and engaging where content is clearly explained and strategies shared, coupled with written subjects' improvement plans. Other strategies could include networking of educators through sharing resources such as tasks, past papers, guidelines, and revision tasks. Teachers should also learn to team teach and peer teaching where they alternate and work together to teach each other topics they do not understand well. They can also visit each other on planned exchange programmes and teach each other classes on topics that one is not effective in.

**Teacher 3:** Oh, quite a question, collaboration as in working together for common goal is the 'buzz' word in improvement literature as through its teachers can share resources, they can share experiences, tasks and strategies that could be useful in teaching and learning Mathematics in secondary schools.

Learner respondents are cited in the examples below:

**Question 2.5**: How do you think Mathematics could be taught and learnt to give best results?

**Question 2.6**: Suggest how learners could be actively involved in the teaching and learning of Mathematics?

**Question 2.7**: Suggest how use of teaching and learning aids could improve the teaching and learning of Mathematics?

**Question 2.8**: How do you think small group learning could affect quality teaching of Mathematics?

Focus group interviewees were elated to air views on how Mathematics teaching and learning could be improved in their classrooms. They suggested a number of interventions which are pedagogical and material. Most respondents cited that Mathematics must be taught using learner centered methodologies such as group work, projects, investigations, assignments, and tests. Involvement of learners in the phases of the lesson was emphasized. Learners as recipients of teaching learning engagements must actively participate through demonstrations to peers, group tasks and participating in mathematics games among others. Some of their responses were:

**Focus Group E**

**E1**: All teachers should involve learners in all stages of teaching and learning, I wish the teacher could take me pace by pace in the lesson, teachers must make assessment that is good, and we pass teacher exercises but fail common assessments.

**E2**: Teaching Mathematics must be enjoyable, my teacher must try to make Mathematics interesting, and Mathematics must link with our daily lives. My teacher must link Mathematics link with other subjects.

**E3**: Mathematics in our class must teach us to solve daily problems in life, teachers must help us with problem solving Mathematics skills, and group Mathematics problem solving tasks may make Mathematics enjoyable.

**E4**: Teacher must give us more practice of learnt concepts, more assessments in taught concepts, more monitored homework could help improve Mathematics in schools. Teachers must not give easy class tasks.

**E5**: Mathematics will interest us if we do more group tasks. Use of groups makes us share ideas, Learners enjoy group tasks, and much monitoring of group tasks is needed.

**Focus Group A:** Ja,

**A1-** In order for Mathematics to be improved our teacher must give enough time for practice before individual tasks are given to the class.

**A2** I also think that as learners we must be given a chance to explain to each other the concepts and practice in groups and share ideas of what has been taught.

**A3-** For Mathematics to be improved I think it begins with the teacher who should have enough content and understanding of what is taught, sometimes teacher fail to answer us.

**A4-** Mathematics must be made easy and fun, teachers must give examples and illustrations that are easy to understand and again much practice must be given in groups before we do individual work.

**A5-** Our teachers must give us tasks in groups so we practice a lot and again homework must be there as Mathematics needs practice a lot. Various tasks such as projects and assignments where we apply Mathematics skills must be explained before given to us.

**Focus Group C**: Yes, yes, (All of the students exclaiming)

**C1-** Learners must be made to understand Mathematics concepts, be involved in the practice of the concepts as groups and individually at home and school.

**C2-** Learners can effectively do Mathematics through doing it in groups and pairs as well as individually. Tasks could be made into games, projects, assignments, investigations, videos, and tests.

**C3-** Only way is to give learners chances to practice Mathematics concepts, eat Mathematics and live it in their lives.

**C4-** Changing beliefs about Mathematics is also very important, most of us think that mathematics is difficult and that affects how we learn and do it. Our teacher must make us gain confidence in learning and doing Mathematics, make us love it and like to do it daily.

**C5-** I can add on what others have said that all learners must have own textbook for practice on his or her own and homework as well must be given and marked by our teacher. Team teaching at school level where educators in Mathematics rotationally teach topics brings variety in classrooms.

In the light of the above findings from the mixed methods data collection and analysis, it can be concluded that Mathematics teaching and learning in secondary schools is beset by challenges ranging from material, human resources, negative perceptions, and low expectations as well as absence of support to learners and educators and poor pedagogical approaches among other impediments. Recommendations for improvements include adopting new mindsets that demystify Mathematics and making it easy and enjoyable. The use of collaborative pedagogical approaches and quality assessments that are varied and promoting creativity and reasoning. Importantly the findings served as feedback to input and refine the collaborative model (see Fig 6.9 and a detailed summary of findings in Chapter)

## 6.29 Chapter Summary

The chapter presented the core data findings of the study which were in the form of research activities and processes that were undertaken in pragmatically constructing and implementing a Collaborative model. A baseline study of Centocow cluster of five schools namely Ginyane, Centocow, Leshman, Emshibeni and Sonyongwane respectively was conducted, and its findings constituted the pillars of the collaborative model. The Louckes-Horsely et al., (1998) Professional Development framework, as outlined in Chapter 5, was utilized to structure the discussion of the study results and interpretation. This chapter also completed the necessary processes for the thesis's second goal, which was to develop a Research Strategy that would be useful to any future researchers in the field who wanted to test the effects of the collaboration model of teaching and learning Mathematics in secondary schools in rural areas. The introduction to the last chapter of this thesis contains a quick overview of the previous chapters. The findings are reviewed, as well as the study's limitations.

# CHAPTER SEVEN: SUMMARY, FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

## 7.1. Introduction and Synopsis

In this final chapter of the thesis, a brief synopsis of the research given in the first six chapters was outlined with the emphasis on designing of a Collaborative Model of teaching Mathematics in poor, rural secondary schools in the Sisonke area of KwaZulu-Natal Province. The study was driven by the professional and academic desire to search and contribute towards a pedagogical solution to the persistent and embarrassing under achievement in Mathematics in secondary schools in KwaZulu Natal Province. The purpose of this mixed methods grounded theory study was to formulate, develop and construct an interventional Collaborative Development Model for teaching and learning Mathematics in secondary schools. The research journey as intended and outlined in the aims and objectives in chapter two (2.2.3) created an opportunity to construct or design a collaborative, participatory model which was subjected to a user system testing for applicability through a baseline study of Mathematics educators and learners respectively.

The first chapter described the setting of the South African educational system, including mathematics instruction, as well as its difficulties and prospects. The research challenge, goals, objectives, questions, rationale, and importance of the study to diverse professional and academic audiences were all stated in the second chapter. The third and fourth chapters included an in-depth overview of the literature on collaborative models and participatory techniques, as well as the model's design framework developed from Horsely- Locke (1998). Constructivism and network theories served as conceptual frameworks for the study, which are outlined in Chapter 4, where the Collaborative model was theoretically constructed based on literature and the researcher's experiences as a Mathematics educator. Collaboration and networking among educators, learners, and other stakeholders in Mathematics education were used to create a diagrammatical presentation of the model with its essential components, activities, and results.

Against a background of constructive philosophy, the literature informed the researcher of the collaborative model of teaching and learning, which attends to the first goal of the thesis. Chapter five outlined in depth the Research Methodology and Design to seek the data to inform the Collaborative Model of teaching and learning. This Research Methodology gave a comprehensive discussion of the research paradigm, approach, and methods to use, how to validate the data and give a thorough description of a mixed method design including the data collection instruments. All the instruments used are included in the Appendix section at the end of the thesis. These included in the semi-structural interviews, focus groups, observational evaluations, questionnaires, and performance tests, amongst others. Triangulation of measurement results was also described to ensure reliability. A diagnostic test as part of baseline study data collection instrument was administered to both educators and learners in the sample with the motive of gathering data on Pedagogical Content Knowledge (PKC) of educators in comparison to the concepts and content grasp of learners. Additional data were collected using triangulated instruments as highlighted above. Very poor results were achieved which confirmed the urgent need for an intervention strategy such as the collaborative method. The ethical considerations which are essential in any research were also discussed. This all informed the second goal of the thesis.

The thrust of the data collection process was guided by the baseline study goals which are outlined in section 3.3 of the thesis. A baseline study using the sampled participants was conducted to collect data on pedagogical approaches, beliefs and attitudes towards Mathematics, performance in standard tests and interactions in the teaching and learning of Mathematics in classrooms visited.

Chapter six presented an in-depth presentation and analysis of results thematically informed by Lockes- Horsely *etal.,* (1998) framework for Professional Development. The focus of the chapter was to outline the research activities in the testing and refining of the theoretically constructed collaborative model (see Chapter 4) through inputting and refining the model for use in teaching and learning Mathematics in secondary schools. Gaps between theory and application of the model were identified and set aside in chapter 6 (6.6) and suggestions for improvement as well outlined thereby resulting in an improved model design as presented in section 6.8 (Fig 6.8) of Chapter 6. This baseline study`s results were used in the information required in especially the four pillars of the collaborative model. It provided valuable information. Therefore, it may be stated that the goals of the study (Goal 1 and Goal 2 See subsection 2.5.1) were achieved successfully. The Collaborative model was conceived, developed, constructed and tested (See Chapter 4 Fig 4.6 and Chapter 5 Fig 5.8) Broader application and testing of the refined model above is an object of further research as recommended in a later section of this chapter (7.4).

## 7.2. Study aims objectives and research questions.

The study's chief aim was to construct or design a collaborative model for teaching and learning Mathematics in secondary schools and present recommendations for its application as the model's final testing in its refined state was beyond the scope of the study due to time and financial constraints and length of the thesis.

Participants of the study were Grade 10 learners and their educators from Centocow cluster and two subject advisors in charge of Further Education and Training (FET) Mathematics in the Sisonke District of KwaZulu Natal Province. The objectives of the study outlined in section 2.2.3 sought to formulate intervention strategies for curbing Mathematics underperformance, suggest how collaboration could be done and conditions for implementation of the model.

It is with a substantive voice to conclude that both the aim and objectives of the study were attained as the envisaged model was designed and developed and refined, using baseline study findings and serves (model) as a reference for further improvements of pedagogies in Mathematics education.

### 7.2.1 Research Questions

The study was premised on the key question and sub-questions as outlined in sections 2.2.1 and 2.2.2 and restated below:

**a.** What are the possible factors that contribute to low performance in Mathematics education in secondary schools?

**b.** What intervention strategies and activities can education stakeholders use (those involved in teaching and learning of Mathematics) who are educators, learners and subject advisors who collectively use a stakeholder's approach to curb poor performance in Mathematics?

**c.** How can the concept of collaboration be used in developing a model for teaching and learning Mathematics in secondary schools?

**d.** What conditions should be put in place to implement and measure the effectiveness of the intervention strategies of a Collaborative model effectively?

The main question was answered as literature review in (Chapter 3 and 4) provided in-depth information on the processes, activities and design of the collaborative model as presented in Fig 4.5 and 6.5 respectively. The four sub-questions were equally answered through grounded and in-depth literature review (Subsections 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, and 3.10) respectively on Professional development initiatives, Collaborative approaches, and conditions for implementation of strategies that can improve Mathematics performance in secondary schools. A detailed synopsis of literature and data findings used to answer the questions is described below for each of the sub-questions of the study.

#### 7.2.1.1 Research Question one

The research study sought to design a collaborative model for teaching and learning Mathematics in secondary schools and as such the starting point was to diagnose the possible factors that contribute to lower performance in Mathematics education in secondary schools. Based on literature and data findings from a baseline of five schools in Centocow Cluster of Sisonke District of KwaZulu Natal Province, the following emerged as possible factors:

- School resources (80%), Home backgrounds (50%), Curriculum change (90%), and Teacher quality (70%) were cited as some of the factors that possibly cause underperformance (Refer to Table 6.6).
- Observations from the visited classrooms revealed that 100% of educators use outdated, teacher centered pedagogical approaches which do not accommodate learners with various learning differences.
- Mathematics educators who were sampled hold a mixed bag of qualifications with only 28.57 % majoring in Mathematics while 71.43% were non majors despite teaching Mathematics (Refer Table 6.5). Spaull (2013) confirms in a study that the quality of educators is still a major factor in the teaching and learning of Mathematics in schools.
- Responses from interviews and observations revealed that 100% of the schools have limited quality textbooks, calculators, instruments, and rulers for use during teaching and learning of Mathematics. The above is further confirmed by Borg (2008) and World Bank Report (2004) citing that resource constraint push good teachers away from poor rural schools.
- Poor Pedagogical Content Knowledge (PCK) of Mathematics educators came under scrutiny as data findings from the Performance Test show that 20% of educators failed the test while 80% passed. On the contrary 90% of learners failed, paradoxically the top learner had 64% while the top teacher had 59%, a scenario which may be attributed to low content and in ability to employ effective pedagogical and motivational approaches in teaching and learning Mathematics.

Given the above data and literature findings it is reasonable to conclude that the first question was addressed and answered.

#### 7.2.1.2 Research Question two

The research question is restated in Section 6.2 and sought to find out the various intervention strategies that could be used to address the factors cited in answer to Question 1 and engage user system (school) stakeholders collectively in curbing poor performance in Mathematics education in secondary schools. Data findings revealed the following answers:

- Hundred percent (100%) teacher respondents suggested that use of teacher networks in clusters and engaging educators in content workshops, moderations and collective setting of assessment tasks can have a positive impact in improving teaching and learning of Mathematics in secondary schools. **Fig 6.19** on Educator organizational skills revealed that supervision of learners was 80% poor, classroom management was 40% poor, and motivation of learners was 80% poor. The above is further confirmed by Spaull (2013) and the National Planning Commission (2012) citing that improving accountability, training of teachers, time on task, ability to teach content and professionalism are the pillars of a sound education system.
- Targeting educators' professional and learners' attitudes towards Mathematics also emerged as non-negotiable on the road to pedagogical improvement in the subject. 100 % teacher respondents cited the fact that they are very uncomfortable with teaching Mathematics, while 60% cited that they were neutral in responding to the question on worthwhileness of Mathematics in life. Flavell (1997) in a study on professional attitudes recommended that educators must develop metacognition awareness so that they open room for improving their professional competency.
- Homework supervision through involving parents was cited by 100% educators and learners' respondents as a panacea to reinforcing concepts and practice of learnt material. Thus, the home environment was positioned as an important variable and was subsequently included in the revised Collaborative Model (see Fig 6.8) Parents in collaboration with the school must play a supportive role to inculcate positive attitudes towards Mathematics and further provide additional emotional and material support needed by the learners to excel in Mathematics.

Therefore, based on the above citations and data findings, one can draw a conclusion that the question was answered.

#### 7.2.1.3 Research Question three

The research question is restated in Section 6.2.1 above and sought to find out how the concept of collaboration, from a conceptual and praxis perspective can be used to develop and design or construct a teaching and learning model for Mathematics. Based on collected data and literature findings the following emerged:

- One hundred percent (100%) teacher and subject advisory respondents concurred that the use of cluster professional networks of Mathematics educators who converge on a weekly basis to plan, set tasks and evaluate content and pace setting of topics should be encouraged and effectively implemented as it results in sharing of experiences, resources and expertise in Mathematics. West and Ainscow (2010) reiterate that professional social networks are characterized by contacts between staff across schools who meet regularly with the sole purpose of capacitating and improving quality of teaching and learning.
- Data from the subject advisory questionnaire revealed that 100% suggested as strategies for collaboration that Mathematics educators need to meet regularly in planned workshops that the Department of Education sanctions as part of mandated professional development. Educators who regularly attend the workshops were cited to have improved in their Pedagogical Content Knowledge (PCK) of Mathematics. Loucks- Horsely *etal.*, (1998) in their framework for designing a Professional model for science cite that goal setting, planning, doing and reflection (Refer to Fig 3.1) are cornerstones of teaching and learning improvements. Data from educator interviews attest that 100% respondents agree that they need support from parents, School Management Teams, cluster Mathematics educators, Mathematics subject advisors and learners in order to work collaboratively as per revised model (Refer to Fig 6.8) Through working in teams and collaboratively Mathematics knowledge will be constructed, planned, implemented and evaluated with the ultimate aim of improving teaching and learning the subject in secondary schools. Conclusively, based on the above data and literature the question was answered.

#### 7.2.1.4 Research Question four

The last research question restated in Section 6.2 uniquely sought answers as to what user systems (School Communities) can do to maximise on physical, professional, expertise and experience to enable effective implementation of a Collaborative Model for teaching and learning Mathematics in secondary schools. Evidence from data findings and literature suggests the following:

- One hundred percent (100%) teacher respondents cited that schools need to create conducive environments for effective teaching of Mathematics through a supply of relevant textbooks and materials and support. Asked on suggestions for Mathematics improvement, 100% advisory respondents cited that effective supervision of schools, subjects and proper and monitored assessments are key to implementation of any Mathematics intervention strategies in secondary schools.

- Eighty percent of learner respondents cited that the home environment does not support Mathematics learning as none in their families has a career in Mathematics nor knowledge of the subjects. Thus, the inclusion of the home environment in the revised model (See Fig 6.8) is an emphasis of the urgent need to position the home environment as a key stakeholder to provide emotional and material support for effective teaching and learning of Mathematics in secondary schools. Glenn (2000) cites that better Mathematics teaching and learning depends on improving the standard and professional attitudes of its educators. Fullan and Muller (2000) reiterate that teachers need to discover and try new pedagogical approaches that result in improved teaching and learning.
- School Management Teams (SMTs) were cited (100%) in teachers and subject advisor interviews and questionnaires as tone setters of effective teaching in schools. SMTs must plan, implement, and monitor as well as evaluate Mathematics improvement programs (cited examples were weekend classes, holiday classes, revision programmes and after school as well as daily periods for teaching and learning Mathematics). Smith and Edwards (2008) in their findings cite that effective leadership is critical to effective programme implementation for modification and sustaining interventions. Thus, the inclusion of School Management Teams or Heads of Department (HODs) as collaborators in the revised model (See Fig 6.8) attest to the need for creating sound leadership in Mathematics education management and supervision if it has to result in improvements in performance.
- Further data to answer the research question was derived from the professional experiences of the researcher as a classroom Mathematics educator such as daily need to give learners practice of concepts taught and problem solving, use of groups in teaching and practice of Mathematics concepts, use of remediation as a scaffolding strategy for backward learners and slavish monitoring of extra work and homework. Interventions to curb underperformance were suggested which culminated into a collaborative model designed in Chapter 3 and refined in Chapter 4 respectively. Conditions for its implementation and actual use were further expounded in Chapter 6.

### 7.3 Results and Theoretical frameworks of the study

Constructivism and network theories, two social, participatory frameworks, guided the research (Chapter 4) As stated in section 4.1 of the thesis, the two informative conceptual frameworks were beneficial to the investigation. Constructivism and network theories formed the backbone of the model's design, with constructivism providing understanding that educators and learners in mathematics classrooms generate knowledge via an interactive process among themselves, mathematical material, and learning contexts. Individuals create knowledge in constructivist discourse through engaging with one another and cooperatively establishing little cultures based on shared meanings, according to Kuklu (2000). Thus, according Bryke et al. (2010), establishing networks of professional Mathematics educators improves classroom teaching and learning processes. Network theories on the other hand informed the model that it is through professional and collegial networks of educators in adjacent schools who meet to share content, expertise, and positive experiences in the teaching of Mathematics that results may be improved. Schools were identified as nerve centres for effective school improvement as all processes of teaching and learning take place within the user system or school and as such collaboration among educators, learners, home environment (parents), circuit management and subject advisory may result in improved Mathematics outcomes as envisaged in the model designed.

Results of the study are aligned to the theoretical frameworks of social constructivism and Network theories, findings from observations of teaching – learning processes in classrooms visited (100%) points to the gap that group learning, interactions can play in sharing ideas and views on Mathematics performance in secondary schools.

Responding to interview questions on, what challenges they face in the teaching and learning of Mathematics, some of the verbatim responses from learners were:

- I fear to ask questions in class even if I do not understand the teacher.
- I am very scared of tackling Mathematics questions because I always get them wrong.
- Our teacher can hardly be understood when teaching us Mathematics.
- There are few textbooks in our class and share we them in groups of five.
- Tests and exams are always very difficult compared to tasks given by educators.

On further posing an interview question to educators on: Question 14: What are your beliefs about the nature of Mathematics? Some of the responses were:

- I fear teaching Mathematics to my class.
- Mathematics is very difficult for learners in rural areas.
- I have lost hope that my class will ever do well in Mathematics.

Both educators and learners were asked which strategies they think best suit the improvement of Mathematics in secondary schools. Some of the responses were:

- Use of a variety of textbooks and resources

- Giving learners opportunities to work out examples and solve Mathematics problems in class.
- Strictly monitored homework.
- Use of groups and sharing of mathematics knowledge in class
- Well monitored, quality assessments in formal and informal tasks
- Well-structured revision programs prior to tests and examinations.
- Motivation to change attitudes about Mathematics teaching and learning.

Eighty nine percent (89%) of learners in focus group interviews pointed out that they fear Mathematics and tackling problems while eighty percent (80%) of teachers in response to interview questions also expressed suffering from methophobia and lack of confidence in the subject. 100 % of respondents (teachers and learners) on asked to suggest best strategies to solve the challenges, suggested more use of groups in the classroom and monitoring of homework and assessments as well as networking and use of cluster workshops as learning platforms geared towards creating a community of networked Mathematics professionals, tied together with common vision and goals of improving learners' performance.

**7.4 Major findings of the study**

Designing a general teaching and learning model for Mathematics was a very grey area as most research has centered on in-depth studies on how to teach specific Mathematics topics such as fractions (Simelane, 2016) functions and Algebra (Owusu, 2015) among others. Presenting a teaching and learning strategy for Mathematics involving different educators and learners in different schools was a daunting task as it meant that all educators in sampled schools had to be visited, observed, interviewed, and tested together with their learners so as to provide data to input and refine the model design and processes. Findings from data collection were of immense value as they assisted in refining and improving the structure and components as well as the processes and activities of the model to reflect the theoretical frameworks underpinning it.

**7.4.1 Findings on data from Questionnaires from Educators and Subject Advisors**

Taking into account that the research made use of questionnaires, semi-structured interviews, focus group interviews, observations, and performance tests in a concurrent triangulation approach, as was explained in chapter 5, the researcher thought it would be prudent to unpack the summary of the findings from each of the research tools, which was then followed by an overall discussion of the research findings. The concurrent and thematic approach that was employed in both the data collecting process and the analysis of research data will not be ignored, despite the fact that discussion of each of the research techniques, data, and subsequent findings will do so. The questionnaires were administered to educators and subject advisors mainly targeting mathematics knowledge, pedagogical approaches, attitudes and beliefs and possible interventions to improve Mathematics in secondary schools. Findings were that most educators are male (87.71 %) and (60 %) learners are also male, a trend that dominates gender imbalances in Mathematics and Sciences. Teacher qualifications were revealed to be a mixed bag with 28.7% majors in Mathematics at bachelor's degree level, and over 59, 14 % not majors and some not qualified to teach the subject. In the study 100 % of educators had teaching experience of more than 5 years, a trend that reflected low staff turn over a positive status towards improvement of Mathematics. The above findings are in harmony with those of Bretts, Zen and Rice (2003) which showed a positive correlation between teacher qualifications and students' performances in Mathematics. Rice (2003) further confirmed that teachers' qualifications have a bearing on learners' performances. It was on the basis of the outcomes of the poor teaching and learning of Mathematics that the study conceived a Collaborative model aimed at assisting educators to close gaps in attitudes and knowledge of Mathematical concepts they teach in classrooms.

### 7.4.2 Findings on data from Performance test administered on educators and Learners.

Fundamental mathematical ideas and the capacity to apply them in everyday settings were tested using performance assessments developed from the TIMSS (2011) and TIMSS (2012), respectively. A total of 90 percent of learners failed the test, compared to 80 percent of educators who passed the examination. The top student received 64 percent of the total points, while the top instructor received just 59 percent. When educators do poorly on exams meant for learners, as shown by Spaull (2013) in his research where instructors failed a Grade 6 Mathematics test and were surpassed by some of their students, there is reason for worry. According to the findings, which are consistent with previous research studies conducted by Spaull (2013) and Metcalfe (2008), the quality of education in South Africa has a long way to go and suffers from low teacher supply capacity, mismatch, and underutilization of teachers in subjects in which they are not specialized, among other problems. Bernstein's (2015) research found that a qualified teacher is not always a competent teacher, which supports the notion that an increase in mathematics performance is dependent on a teacher development approach. Pedagogical Content That Is Insufficient Mathematics knowledge is a contributing reason to underperformance; hence, the suggested strategy makes use of cluster professional learning communities to capacitate by sharing information, methodologies, and best practices.

### 7.4.3 Findings on data from Interviews

Interviews were part of the triangulation matrix designed to corroborate data from questionnaires, observations and performance tests and respondents were learners in a focus group and each of the five educators teaching Mathematics in the five schools. Findings were that most learners had negative attitudes towards Mathematics and were scared of it (mathophobia), hence correlationally underperformed in achievement tests. Group dynamics and peer pressures seemed to influence choice of subjects in high school as learners who are not capable often find themselves studying Mathematics. Educators (100%) showed that they teach Mathematics using traditional, teacher centred pedagogical approaches and have little hope in achieving improved results in the subject. Negative attitudes and uncertainty coupled with feelings of being uncomfortable in teaching the subject seemed to impact on their confidence and professional growth which the constructivist model seeks to instill among Centocow Mathematics educators.

Findings of the study are congruent to those of previous studies by Erick and Reed (2002) on the influence of teachers' beliefs and attitudes who found that there is a strong influence between teachers' beliefs about teaching and learning and how they subsequently teach Mathematics. On traditional and ineffective pedagogical approaches used by educators, the findings concur with earlier studies by Festus (2013), who found that teachers still use the lecture method despite that it has been found to be ineffective as it does not give learners an opportunity to think and contribute to the learning process. Ukeje (1979) reiterates that a poor teacher tells, an average teacher informs, a good teacher teaches, and an excellent teacher inspires. Poor pedagogical approaches and negative attitudes account for poor performance in Mathematics and the model sought to change that trend.

### 7.4.4 Findings on data from Classrooms Observations

Primary data for the study was to be gathered through observations of classroom interactions and knowledge exchanges between learners and educators. Every one of the sampled schools had five classes, and the researcher went into each one and observed the students. In this study, it was discovered that certain educators (40 percent) adopt activity-based and learner-centered pedagogies and include learners in the creation of their knowledge, and that learners in such classes liked Mathematics teaching and learning, as well. Teachers (60 percent) were found to be using conventional – teacher-centered approaches and to have difficulty with explaining topics to students, which resulted in some students becoming confused. Quality assessment is still a pipe dream, as evidenced by the fact that 100 percent of classrooms were observed, and learner exercise books revealed that informal and formal tasks administered did not comply with the taxonomy levels of the grade, and that the majority of exercise books were left unmarked, with corrections not being completed or monitored, Earlier research by Bretts et al. (2011), who recommend that instructors be trained in administering effective assessments that are aimed to determine how well pupils have acquired the subject matter given and assessed, found that the following results are accurate. According to the findings above, mathematical content and pedagogical approaches that are learner and activity based are required for improvement in Mathematics results, as is the need for effective and planned assessments that are geared toward effective learner performances in order to improve mathematics results.

Equally related to assessments and teaching and learning is the absence of effective monitoring and supervision of work in schools. Findings from observations showed that 100% of classrooms were never visited nor monitored in any way by the Heads of Departments or principals. There were no comments with regards to unmarked work and undone corrections or presence of any official date stamp as evidence of supervision routines. The above findings are consistent with Gibbons and Cobb (2010) studies that concluded that effective delivery of educational outcomes lies in the development of shared responsibility for instructional improvement at school level where school leaders and coaches meet regularly to plan and share improvement strategies and observations about quality of teachers' instructional practices. Nelson and Sassi (2005) in a study counsel that effective principals are those that are professionally updated as instructional leaders in subjects taught in their schools. Therefore, educators working in professional learning communities within clusters can develop and improve their professional competencies and result in improved performances. The Collaborative model (Fig 5.8) highlights the different roles and networks and communication channels that are task focused on improvement of Mathematics outcomes in secondary schools.

#### 7.4.5 Application and Significance of the Collaborative Model in Reforming Teaching and Learning of Mathematics in Secondary Schools

The construction of a Collaborative model for teaching and learning Mathematics in secondary schools was a reform and intervention strategy which, if implemented in secondary schools, will capacitate educators in content, Pedagogical-Content Knowledge and reforming beliefs and attitudes towards Mathematics. Thus, the application of a Collaborative model of teaching Mathematics in secondary schools demands a gradual restructuring and reforming of the school conditions to create time and space for colleagues to collaborate and share experience and expertise in improving the teaching and learning of Mathematics. McLaughlin (2001:125) warns that the challenge to restructuring school conditions to use collaboration is to engender worms of inquiry, innovation, and shared accountability. This implies that unless the school system ceases to applaud and promote mediocrity and instead, encourages and instills excellency, hard work and problem-solving skills, Mathematics underperformance will remain a culture in our schools rendering generations of children dysfunctional in scientific driven economies of the 21st century.

Despite the research study being only centered in the Centocow cluster and a small-scale case study, the researcher envisages that the study will be of academic relevance and significance to policy makers, school leaders and Mathematics practitioners. It provides a real account of the complex nature but beneficial concept of collaboration in teaching and learning Mathematics in secondary schools. Multi-faceted factors are, however, required to develop and sustain the designed model such as time, leadership, training, strong collegial and professional communication based on shared vision and trust among educators and learners.

**7.5. Recommendations for Future Research Studies on a Collaborative Model for Teaching Mathematics in Secondary Schools**

Due to the cyclic nature of educational and academic research, the researcher, in developing a Collaborative model broke new ground and as such the model is a continuous cycle coupled with feedback and reflection with the ultimate goal of resulting in improved Mathematics education outcomes. The success of the implementation of the last phase of the model relies on a constant need for new knowledge, new teaching, new adaptations, hence continuous research is paramount to provide much needed feedback which improves the processes and activities in the model. The researcher identifies the following possibilities for further research and improvement of the model:

- **Expanded opportunities for collaboration among stakeholders in the school c.ommunity.**

Collaboration in the study centred on educators and learners who are but few of the stakeholders in the school community. Without further research into roles and responsibilities of other stakeholders who include parents, principals, teacher unions, Heads of Departments and businesspeople evaluation of the pragmatic collaboration matrix and envisaged outcomes on educational processes will not be authentically done as excluded stakeholders also have direct or indirect influence on learners' performance in Mathematics. Therefore, ways must be developed through consultative and meaningful engagements among key education players to work better with a single vision of developing Mathematics educators who in turn will bring about improved Mathematics outcomes in secondary schools in South Africa.

- **Elevation of education to be a social issue**

  Findings from the baseline study showed that some educators pointed out that the social environments where they teach are hostile and wear support of positive Mathematics outcomes. Education as a social tool to transform society needs joint effort by all stakeholders and government to elevate and prioritise provision of quality learning and teaching environments. Provision of qualitative and current textbooks to educators and learners is non negotiable as it impacts on quality teaching and learning of Mathematics in secondary schools.

- **Need for further mathematical knowledge.**

  The baseline data showed that some educators (20%) failed the performance test and (90%) of learners sampled failed the test while the top learner scored (64%) outclassing the educators who had top mark of (59%). It could be that educators have outdated content knowledge which is not relevant nor taught in the current syllabus but features in textbooks and is sometimes taught for its own sake. Educators using the problem-solving driven study guides need to develop in-depth conceptual understanding of Mathematics concepts so that they will be able to adapt the content to learner centred learning practices in classrooms.

Designing a constructivist teaching and learning model is informed by a pre-condition for stakeholders to display commitment to reform and collaborate among themselves to bring about improved Mathematics results in secondary schools.In using the Collaborative model, Mathematics educators must shun professional isolationism and embrace networking and constructivism, and share expertise, resources and experience as envisaged in the model. The concept of the teacher as a lifelong learner must be professionally conceived and accepted, that teachers, like their learners must construct ongoing knowledge about Mathematics, emerging pedagogies and assessment techniques though interacting with their peers in schools adjacent to them.

### 7.6 Limitations of the Research Study

Conventional academic research studies are affected by numerous constraints which may have negatively affected the validity and authenticity of the research output. In this study the following were limitations:

- Time and cost restrictions precluded the researcher from examining a much wider and more representative sample. Despite that, the research was a case study of both educators and learners numbered five and twenty respectively which produced several valid results and conclusions. However, the researcher was prompted by Desimone et al., (2002) who emphasized that for in-depth professional development efforts to result in high quality of activities that result in changing classroom practices they should include few participants. Triangulation of data where a variety of instruments were employed to gather data was also a quality improvement strategy to allow the researcher to acquire trustworthy and valid data.
- Due to the limitation of part time Doctoral studies and full-time work, the main study data collection process was held within a short period considering that a number of instruments were used to collect data. Concurrent data collection within a limited time might have compromised the quality of collected data and subsequent conclusions from the findings. In mitigation, the researcher triangulated the data collection instruments and data analysis process to authenticate data collected.
- The possibility of bias might have existed in data collection since the researcher interviewed some of his own students and educators and advisors were all familiar to him. However, triangulation was used to mitigate possible negative effects on findings of the study.
- Another methodological limitation was the decision to make use of audio recordings rather than visual recordings. Absence of visual recordings limited the analytical possibilities both in relation to the participation framework and the relational behaviour of participants of the study. However, as earlier stated the interviews were not the sole data collection instruments as other instruments such as the observations, questionnaires and performance tests were used in triangulation to authenticate data findings.
- The researcher used self-made research instruments which may have impacted on the validity and reliability of collected research data and subsequent conclusions and recommendations. Despite that, triangulation of instruments and guidance from ethical principles of conducting research studies were used to secure the quality of collected data as same participants were subjected to different instruments.

- In accordance with the design framework of Loucks-Horsely et al. (1998), which served as the design process driver, the last step of model creation was to be the implementation and modification or reflection on the model in order to better its applicability to a classroom context. Because academic studies are restricted in their scope and must be completed within a certain time period, the above-mentioned critical stage could not be completed in its entirety. Despite this, the researcher advised that more study be carried out in order to complete the design and demonstrate the applicability of the collaborative model in practice.
- The study was conducted in rural research sites where schools are distances apart from each other and some travelled distances to the central venue where the staff developments workshops were organized and conducted. Some research participants arrived late or left earlier than scheduled times. This may have affected continuity and quality of envisaged changes brought by the collaborative model in reforming teaching and learning of Mathematics. In mitigation, the researcher provided after workshop notes and follow up questions to participants as a consolidation measure.
- ***Professional Isolation*****:** Individualism versus collegiality was a salient but significant constraint, as most educators have not professionally accepted the spirit of collective, collegiality in addressing problems in mathematics teaching and learning in secondary schools, despite the fact that this is the case in most countries (Huberman, 1993). In the Independent Artesian Model, it is explained that conventional conceptions of professionalism are centered on the fundamentals of professional procedures that allow individuals to effectively use their own good judgment and expertise. As a result, the majority of educators in the survey expressed hesitancy, which might indicate that collaborative methods posed a danger to their individual agency competence. Assuring and convincing educators that meaningful professional interaction with colleagues would result in enhanced pedagogical methods and material understanding, as well as improved curriculum implementation in secondary schools' mathematics, the researcher conducted a study.
- ***Fragmented beliefs*** and attitudes about the teaching and learning of Mathematics were also a hindrance as both educators and learners held varying views (baseline data). Hindui (2007) explains that pre-existing relationships among participants and their beliefs about teaching can shape teachers' interactions in unpredictable ways. The researcher explained the benefits of collaboration to the participants and helped them imbibe the spent or

underlying assumptions of collective, collegiality as an approach to finding lasting solutions to underperformance in Mathematics in secondary schools.

- The theoretically designed collaborative model lacked a random assignment of an experimental group where the model could have been tested comparatively before and after refining following baseline study findings. Hence the model is work in progress and is inconclusive as it may require future research to test its refined state for feasibility and applicability to a bigger sample.
- There were no interview specific questions in research instruments which were tailored towards capturing data on how learners could work in groups and pairs to improve the teaching and learning of Mathematics and how educators in schools and clusters could strengthen the community of practice concept and partner within a school network and generate knowledge on best practices in improving Mathematics outcomes in Centocow cluster.

**7.7 Possible Gaps in the current study**

It was the final goal of the research to develop and create a Collaborative model that was informed by a literature review, personal experiences, data results, and observations from sampling schools and classrooms, as shown in Chapter 6 via the data presentation and analysis. According to Fig 6.8 in Chapter 6, the baseline study, which served as the primary data gathering platform for the research, produced valuable feedback that was fed back into the model. Due to the fact that the validation of the model was conducted theoretically using baseline data, the actual large-scale testing of the refined model is only recommended for future studies. This is due to the fact that it may have required a two or three phased data collection process, which was not feasible due to time and financial constraints. Testing the modified and restructured model, which the study suggests for future research, may have offered valuable insight into the practicality and implementation of the model in the context of mathematics instruction in secondary schools in South Africa, according to the findings. The study concentrated on a sample of five schools, five educators, twenty learners, and two Mathematics subject advisors in a rural setting in Centocow black areas. Because the sample was limited, it was difficult to generalize the findings to Indians, Whites, Coloreds, farm, and urban communities, among other things. It may be necessary to use a considerably bigger demographically representative sample in order to offer credibility to the final outcome of the research, the collaborative model that was developed.

## 7.8. Chapter Summary

It was still in its infancy and early stages when it came to researching and developing a collaborative model for teaching and learning mathematics in secondary schools. It was motivated by the challenge of global underperformance in mathematics and science education, as well as the dilemma that educational contexts are not homogeneous because they are shaped by socioeconomic contexts, technological influences, and user systems motivational initiatives to propel excellence in mathematics education performance Despite this, the model targeted key variables in professional development dimensions such as content, pedagogical-content approaches, beliefs and attitudes, enhancing learner participation in teaching and learning processes, assessment in Mathematics, and remediation of struggling learners, among other things. The intervention program was cyclic, reflective, and progressive, and it was founded on grounded theory as its foundation. Collaboration as the guiding principle de-individualizes mathematics teaching and learning and fosters a collective, collegial engagement that, if properly implemented, leads to improved outcomes for all students and teachers.

The collaborative model may be illustrated visually using an adaptation of Krirk's (2005:265) diagrammatic presentation on the effect of intervention models. Professional aspects are detailed in Chapter 6 subsections 6.10–6.12, and treatments reflect the model's actions and processes, which are covered in further detail in Chapters 4 and 5. The figure 7.1 displays the collaborative model's professional aspects and the issues it tries to solve in an effort to revolutionize mathematics teaching and learning in South Africa.

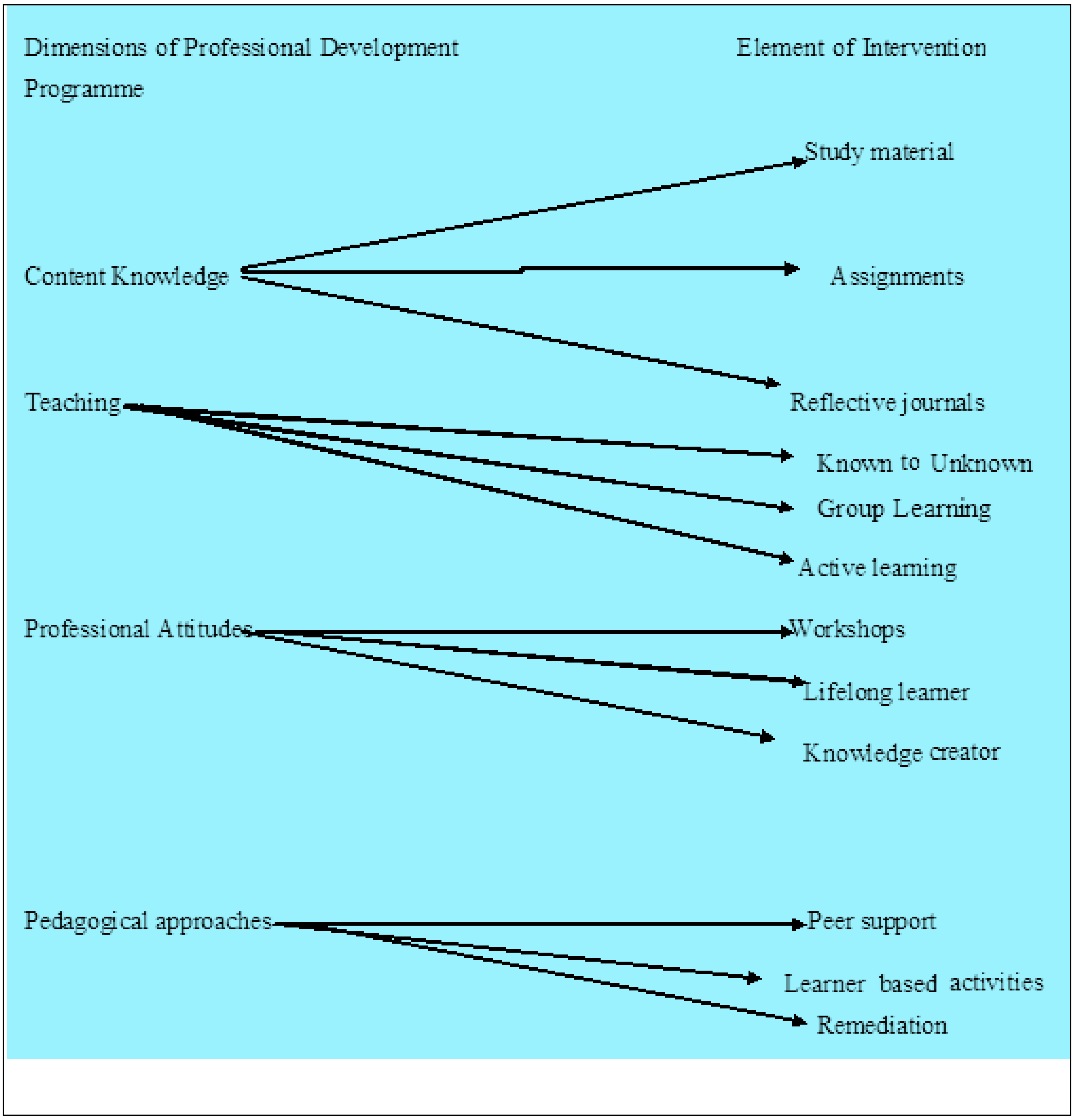


**Figure 7.1 Relationship between professional Development Dimensions and Elements of the Intervention Programme**

In the illustration in Fig 7.1 a collaborative intervention model is shown interacting with critical professional aspects that constitute the teaching profession. The concept aims to free Mathematics educators from a vicious cycle in which insufficient material, ineffective educational techniques, negative beliefs and attitudes, and pessimism result in a lack of confidence, motivation, burnout, and a reluctance to spend time on task. Effective implementation of the collaborative model creates a virtuous cycle (Krirk 2005), in which increased Pedagogical-Content Knowledge, positive beliefs and attitudes ultimately result in collegiality, increased confidence, more effective teaching approaches, and a willingness to continuously improve outcomes in athematics teaching and learning.

The experience of doing this research project has been both informative and beneficial. This experience provided me with invaluable insight into the nature of study, which is cyclical and sometimes unpleasant and tiresome, but can also be enormously gratifying and even exciting in certain circumstances. A number of noteworthy and insightful insights emerged from this study, which helped me to review my own professional values and rules, which will help me to improve my own future research practices. In spite of the many constraints, including time, resources, and cash, it was an honor to be able to put together this model. This thesis, however, will be of great assistance to anyone considering further study on this topic because it contains a wealth of useful and valid information that will help to continuously improve the outcomes of both teaching and learning in the mathematics classroom in poor rural areas of South Africa.

**DEO GRATIAS – Thanks be to God.**

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**APPENDICES**

**1. APPENDIX 1 LETTER TO THE KZN DEPARTMENT OF EDUCATION**

P.O Box 168

CREIGHTON

3263

1 February 2016

Department of Research, Strategy, Policy Development and ECMIS

Private Bag X05

ROSSBURG

4072

Dear Sir

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN KZN SCHOOLS

My name is Vusani Ngwenya. I am studying towards the Doctor of Education (Curriculum Studies) degree at the University of South Africa. The research study is entitled: **A Collaborative model for teaching and learning Mathematics in secondary schools.** As part of my research, I have to collect data from schools. I have already identified five schools at the Sisonke district as sites for my research. The target group for this study is the grade 10 learners and educators in Mathematics.

I will be working in collaboration with the mathematics teachers at the selected schools. There will definitely be no disturbance of normal teaching and learning at these schools because the programme will run during the normal mathematics lessons. The learners will be involved in the intervention programme for four (4) weeks of the first term of the 2016 academic year as the researcher will collect data through lesson observations, interviews, questionnaires, checklists of documents and writing a diagnostic test.

I seek your permission to conduct the research study in these schools at the Sisonke district. I undertake to abide by the ethical code and the principles of anonymity and confidentiality. I am currently working for the KwaZulu-Natal Department of education as high school educator teaching Mathematical Literacy and History at Ginyane High school.

In line with the procedures and guidelines for conducting research in KwaZulu-Natal Department of education institutions, a copy of the completed thesis and a synopsis of the most important findings and recommendations will be provided to the Director: Research Planning upon completion of the study.

Regards,

Yours faithfully

............................................................

Vusani Ngwenya

**APPENDIX 2 LETTER TO THE SCHOOL PRINCIPAL**

P.O BOX 168

CREIGHTON

3263

1 February 2016

THE PRINCIPAL

XXX SECONDARY SCHOOL

P.O. BOX XXX

CREIGHTON

3263

Dear Sir/Madam

RE: REQUEST TO CONDUCT RESEARCH IN YOUR SCHOOL

My name is Vusani Ngwenya. I am studying towards a Doctor of Education (Curriculum Studies) degree at the University of South Africa. The research study is entitled**: A Collaborative Model of teaching and learning Mathematics in secondary schools.** As part of my research, I have to collect data from schools and your school has been selected as a site for this research study. The target group for this study is the grade 10 learners and educators in Mathematics.

I will be working in collaboration with the mathematics teacher of your school. The learners will be involved in the intervention programme for four (4) weeks of the first term of the 2016 academic year. I will be collecting data on the topic through lessons observations, questionnaires, interviews, documents checklists and writing a diagnostic test. There will definitely be no disturbance of normal teaching and learning at your school. Instead, the Mathematics teacher will be capacitated with new teaching approaches and strategies.

I seek permission to conduct the research study in your school. I promise to abide by the ethical code and the principles of anonymity and confidentiality.

I am currently working for the KwaZulu-Natal Department of Education as an educator in Mathematical Literacy and History at Ginyane high school at Sisonke district.

Regards,

Yours faithfully

...............................................................

Vusani Ngwenya

**APPENDIX 3 LETTER TO THE MATHEMATICS TEACHER**

P.O BOX 168

CREIGHTON

3263

01 February 2016

THE MATHEMATICS TEACHER

XXX SECONDARY SCHOOL

P. O.BOX XXX

CREIGHTON

3263

Dear Sir/Madam

RE: REQUEST TO PARTICIPATE IN A RESEARCH STUDY

My name is Vusani Ngwenya. I am studying towards the Doctor of Education (Curriculum Studies) degree at the University of South Africa. The title of my research study is**: A Collaborative Model of teaching and learning Mathematics in secondary schools.** As part of my research, I have to collect data from schools. The target group for this study are the grade 10 learners and educators in Mathematics. I seek your permission to work with me to conduct this research study in your school.

We will work together to administer diagnostic tests; collect data through lesson observations, questionnaires, interviews, and documents checklists. There will definitely be no disturbance of normal teaching and learning in your school. Instead, I will be working in collaboration with you towards the development and implementation of an intervention model for the teaching and learning of Mathematics in secondary schools.

I promise to abide by the ethical code and the principles of anonymity and confidentiality.

Should you require further information please feel free to telephone me, Mr. V Ngwenya at Ginyane High school at 0719425356 or email ngwenyavee@yahoo.ca or my dissertation supervisor, Professor Nkopodi Nkopodi at 0828554384.

For questions, concerns, or complaints about the research ethics of this study, contact the CEDU REC Chairperson: Dr Madaleen Claassensat mcdtc@netactive.co.za.

Regards,

Yours faithfully

......................................................

Vusani Ngwenya

**APPENDIX 4 LETTER TO PARENT/GUARDIAN**

P.O BOX 168

CREIGHTON

3263

01 February 2016

Dear Parent/Guardian

RE: REQUEST TO USE YOUR CHILD AS A PARTICIPANT IN A RESEARCH STUDY

My name is VUSANI NGWENYA I am currently studying towards a Doctor of Education (Curriculum Studies) degree at the University of South Africa (UNISA). To fulfill all the requirements for my studies I have to select schools that are offering Mathematics in grade 10 in the Sisonke education district. Your child's school has been selected as a potential site and I hereby invite you to give consent for your child to participate in this study. The research is on the development of a Collaborative model to improve the teaching and learning of Mathematics in grade 10.

If you give consent for your child to participate in the programme, he/she will be part of the research for four weeks of the second term. The research programme will run during the usual mathematics lessons.

Please note that:

Your child's participation in this study will be voluntary and he/she is free to withdraw at any time of the study without a penalty.

Your school's and child's identity will remain strictly confidential and anonymous.

There are no anticipated risks or benefits to learners resulting from this study.

After the completion of the research, the findings may be accessed, upon request, through the school principal.

Should you require further information please feel free to telephone me, Mr. V Ngwenya at Ginyane secondary school or my thesis supervisor, Professor Nkopodi Nkopodi on 0828554384.

For questions, concerns, or complaints about the research ethics of this study, contact the CEDU REC Chairperson: Dr Madaleen Claassensat mcdtc@netactive.co.za.

Thanking you in anticipation

Yours sincerely

......................................................

Vusani Ngwenya (Mr)

**APPENDIX 5 LETTER TO PARTICIPANTS**

P.O BOX 168

CREIGHTON

3263

01 February 2016

Dear Participant

My name is Vusani Ngwenya. I am currently studying towards a Doctor of Education (Curriculum Studies) degree at the University of South Africa (UNISA). To fulfill all the requirements for my studies I have to select schools that are offering mathematics in grade 10 at Sisonke education district. Your school has been selected as a potential site and I hereby invite you to be a participant in this study. The research is on developing **a Collaborative model for teaching and learning Mathematics in secondary schools**. If you are willing to participate in the programme, you and your parent or guardian will be required to sign a consent form before the commencement of the study. The research programme will run four weeks of the second term during the usual Mathematics lessons.

Please note that:

Your participation in this study will be voluntary and you are free to withdraw at any time of the study without a penalty.

Your identity will remain strictly confidential and anonymous.

There are no anticipated risks or benefits to you resulting from this study.

After the completion of the research study, the findings may be accessed, upon request, through the school principal.

Should you require further information please feel free to telephone me, Mr V Ngwenya at Ginyane secondary school on 0719425356 or email ngwenyavee@yahoo.ca or my thesis supervisor Professor Nkopodi Nkopodi on 0828554384.

For questions, concerns, or complaints about the research ethics of this study, contact the CEDU REC Chairperson: Dr Madaleen Claassensat mcdtc@netactive.co.za.

Thanking you in anticipation

Yours sincerely

...............................................

Vusani Ngwenya (Mr)

**APPENDIX 6 PARENT CONSENT**

I have read and retained a copy of the letter requesting participation in a research study entitled: **A Collaborative model of teaching and learning Mathematics in secondary schools.**

The purpose of the study is explained, and my questions have been answered to my satisfaction.

I understand that my child's identity will never be revealed, and that all the data collected during the research process will be held confidentially and destroyed after the research is completed.

I understand that participation is voluntary, and that my child is free to withdraw from this study at any time without negative consequences.

I understand that my child will only be considered as a participant in this study if both I and my child give a written consent.

I am aware that I can contact the researcher Mr V Ngwenya at Ginyane High school on 0719425356 or email: ngwenyavee@yahoo.ca or his thesis supervisor, Professor Nkopodi Nkopodi on 0828554384 if I have any questions about this study.

For questions, concerns, or complaints about the research ethics of this study, contact the CEDU REC Chairperson: Dr Madaleen Claassens at mcdtc@netactive.co.za.

I, ________________________________________________ (full name of parent/guardian), give my permission for my child ___________________________________ (name of child) to be included in the research study. I have read and understood the letter addressed to me. I understand that my child's identity will not be made public. I have kept a copy of the letter.

Parent's/guardian's signature Researcher's signature

_________________________ ______________________

Date Date

**APPENDIX 7 LETTER OF ASSENT**

Title of Thesis: A Collaborative model for teaching and learning Mathematics in secondary schools

I, ________________________________________, give my permission to participate in the research study. I understand that my identity will not be made public, and I am free to withdraw from this study at any time without giving reasons and no penalties will be incurred.

__________________________ __________________________

Signature of learner Signature of researcher

__________________________ __________________________

Date Date

**APPENDIX 8: EDUCATORS ATTITUDES TOWARDS MATHEMATICS INVENTORY (Adapted from: SCHACKOW, 2005)**

Direction: This inventory consists of 40 statements about your attitude towards Mathematics. There are no correct or incorrect responses. Read each item carefully. Please think about the items that the best describes your attitude. Use the following response scale to respond to each item.

Please circle a response for each of 40 items

Mathematics is a very worthwhile and necessary subject.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

I want to develop my mathematics skills.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

Mathematics helps develop the mind and teaches a person to think.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

Mathematics is important in everyday life.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

Mathematics is one of the most important subjects for people to study.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

Mathematics courses would be very helpful no matter what grade level I taught.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

I think of many ways that I use mathathematics outside of school.

Strongly Disagree Disagree Neutral Agree Strongly Agree

I think studying advanced mathematics is useful.

Strongly Disagree Disagree Neutral Agree Strongly Agree

1. I believe studying maths helps me with problem solving skills in other areas.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

A strong mathematics background could help me in my professional life.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

I get a great deal of satisfaction out of solving mathematics problem.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

I have usually enjoyed studying mathematics in school.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

13. I like to solve new problems in mathematics.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

14. I would prefer to do an assignment in mathematics than to write an essay.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

15. I really like Mathematics.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

16. I am happier in a Mathematics class than in any other class.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

17. Mathematics is a very interesting subject.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

18. Mathematics is a very interesting subject.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

19. I am comfortable expressing my own ideas on how to look for solution to a difficult problem in mathematics

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

20. Mathematics is dull and boring

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

21. Mathematics is one of my dreaded subjects

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

22. When I hear the word mathematics, I have a feeling of dislike.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

23. My mind goes blank, and I am unable to think clearly when working with mathematics.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

24. Studying mathematics make me feel nervous

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

25. Mathematics makes me feel uncomfortable

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

26. I am always under terrible strain in mathematics class.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

27. It makes me nervous to even think about having to do a mathematics problem

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

28. I am always confused in my mathematics class.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

29. I feel a sense of insecurity when working out Mathematics problems

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

30. Mathematics does not scare me at all. /I love mathematics

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

31. I have a lot of self –confidence when it comes to mathematics. /I have confidence in solving mathematics problems

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

32. I can solve problems without too much difficulty

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

33. I expect to do well in any mathematics class I take

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

34. I learn mathematics easily.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

35. I believe I am good at solving problems.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

36. I am confident that I could learn advanced mathematics

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

37. I plan to take as much mathematics I can during my education. / I plan to study mathematics.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

38. The challenge of mathematics appeals to one. /I enjoy challenges I get in mathematics

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

39. I am willing to practice more Mathematics concepts beyond the activities given in class by the teacher to improve my performance.

Strongly Disagree

Disagree

Neutral

Agree

StronglyAgree

40. I would like to avoid teaching mathematics.

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

---

**APPENDIX 9: CLASSROOM OBSERVATION PROTOCOLTO COLLECT DATA ON TEACHING METHODS, TASKS AND LEARNERS' INTERACTIONS IN MATHEMATICS CLASSROOMS IN SECONDARY SCHOOLS**

CODE OF TEACHER OBSERVED:
DATE OF OBSERVATION:
PRE OBSEVERTION-INTERVIEW QUESTIONS:

What has this class been covering recently? (What unit are you working on)?

What would you like the student to learn during this class?

3. In a paragraph or two describe the lesson you observed, including where this lesson fits in the overall unit of study. Include the general lesson structure and enough detail to provide a context for your ratings of this lesson.

1. CLASSROOM DEMOSTRATION AND CONTEXT

What is the number of students in the class? (Give exact count)

What is the number of students in the class at the time of observation?

Indicate the primary content area of this lesson or activities. (In general, choose just one.)
Numeration and number theory
Computation (please specify:
Trigonometry
Measurement (please specify:
Patterns and relationship
Pre- algebra
Algebra
Geometry and sp9. Function (including trigonometric functions) and pre-calculus concept.
Data collection and analysis
Probability
Statistics (eg. hypothesis tests, curve – fitting and regression)

Topic from discrete mathematics (eg. combinatorial, graph theory, recursion)

Mathematical structure (eg, vector, group, rings, fields)

Calculus

None of the above (please explain)

Indicate the primary intended purpose (s) of this lesson or activity based on the pre and /or post–observation interviews with the teacher. (In general, choose just one.)

Identifying prior student knowledge

Introducing new concepts

Developing conceptual understanding

Developing problem–solving skills

Learning vocabulary / specific facts

Assessing student understanding

Indicate the major way (s) in which students engaged in class activities.

As a whole group

As small groups

As pairs

As individuals

Indicate the major way (s) in which students engaged in class activities.

Entire class was engaged in the same activities at the same time.

Groups of students were engaged in different activities at the same time (eg. centres).

Please provide specific time in percentage for each lesson component : Please note: Duration of a lesson is 1hour(60 minutes)

Minutes whole group instruction/ discussion (generally teacher – led instruction)

Minutes small group work on experiments /tasks that are part of lesson / instruction.

Minutes individual work on experiment /tasks that are part of lesson /instruction.

Rate the adequacy of the physical environment.

Classroom resources:

1 2 3 4 5

Sparsely equipped Rich in resources

Classroom space:

1 2 3 4 5

Crowded Adequate space.

SECTION B

**LESSON DESIGN AND IMPLEMENTATION** (1=NEVER, 2 =VERY LITTLE, 3= SOME, 4 = MOSTLY, 5=CONSISTENTLY)

| | | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 1 | The design of the lesson reflected careful planning and organising | | | | | |
| 2 | The design of the lesson incorporated the task and interaction consistent with investigative mathematics | 1 | 2 | 3 | 4 | 5 |
| 3 | The lesson had a problem / investigation – centered structure (eg teacher launched a problem /investigation, student explored and teacher led a synthesizing discussion | 1 | 2 | 3 | 4 | 5 |
| 4 | The instructional objectives of the lesson were clear, and the teacher was able to articulate clearly what mathematics ideas and/ or procedures the student were expected to learn | 1 | 2 | 3 | 4 | 5 |
| 5 | The lesson design provided opportunities for student discourse around important concepts to mathematics | 1 | 2 | 3 | 4 | 5 |
| 6 | Mathematics was portrayed as a dynamic body of knowledge continually.<br>Enriched by conjectures, investigation analysis, and or proof/ justification | 1 | 2 | 3 | 4 | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 7 | The teacher appeared confident in his/her ability to teach mathematics | 1 | 2 | 3 | 4 | 5 |
| 8 | The instructional strategies were consistent with investigative mathematics | 1 | 2 | 3 | 4 | 5 |
| 9 | The teacher ‘s questioning strategies for eliciting student thinking promoted discourse around important concept in mathematics | 1 | 2 | 3 | 4 | 5 |
| 10 | The pace of the lesson was appropriate for the developmental level/ need of the students and the purpose of the lesson | 1 | 2 | 3 | 4 | 5 |
| 11 | The teacher ‘s was flexible and able to take advantage of teachable moment, (including building from student ideas – both mathematics and nonmathematical) | 1 | 2 | 3 | 4 | 5 |
| 12 | The teacher’s classroom management style/strategies enhance the quality of the lesson | 1 | 2 | 3 | 4 | 5 |
| 13 | The vast majority of the students were engaged in the lesson and remained on tasks | 1 | 2 | 3 | 4 | 5 |
| 14 | Appropriate connection was made to other areas of mathematics to other discipline and/or to real-world contexts | 1 | 2 | 3 | 4 | 5 |

MATHEMATICAL DISCOURSE AND SENSEMAKING

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | Students asked questions to clarify their understanding of mathematical ideas or procedures. Logical questions- may I sharpen my pencil? don’t count. | 1 | 2 | 3 | 4 | 5 |
| 2 | Students shared their observation or prediction | 1 | 2 | 3 | 4 | 5 |
| 3 | Students explained mathematical ideas and/ or procedures | 1 | 2 | 3 | 4 | 5 |
| 4 | Students justified mathematical ideas and/ procedures | 1 | 2 | 3 | 4 | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | Students listened intently and actively to the idea and or procedure of the others for the purpose of understanding someone 's methods or reasoning | 1 | 2 | 3 | 4 | 5 |
| 6 | Students challenged each other's and their own view ideas that did not seem valid | 1 | 2 | 3 | 4 | 5 |
| 7 | Students defended their mathematical ideas and or procedures | 1 | 2 | 3 | 4 | 5 |
| 8 | Students determine the correctness/ sensibility of ideas or procedure based on the reasoning presented | 1 | 2 | 3 | 4 | 5 |
| 9 | Students made generations or made generalized conjectures regarding mathematical procedures | 1 | 2 | 3 | 4 | 5 |
| 10 | Students drew upon a variety of methods (verbal, visual, numerical, algebraic, graphical, etc.) to present and communicate their mathematical ideas and/or procedures | 1 | 2 | 3 | 4 | 5 |
| 11 | The teacher and student engaged in meaning making at the end of the activity/instruction. (There was synthesis or discussion about what was intended to be learned from doing the activity). | 1 | 2 | 3 | 4 | 5 |
| 12 | The teacher productivity probed."Pushed "on the mathematics in the student s' responses (including both correct and incorrect responses). | 1 | 2 | 3 | 4 | 5 |

C. TASK IMPLEMENTATION

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | Tasks focused on understanding of important and relevant mathematical concept , processes and relationship | 1 | 2 | 3 | 4 | 5 |
| 2 | Tasks stimulated complex, no algorithmic thinking | 1 | 2 | 3 | 4 | 5 |
| 3 | Tasks successfully created mathematically productive disequilibrium among student | 1 | 2 | 3 | 4 | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | Tasks encouraged student to search for multiple solution strategies and to recognized task constraints that may limits solution possibilities | 1 | 2 | 3 | 4 | 5 |
| 5 | Tasks encourage student to employ multiple representation and tools support their learning, ideas and or procedures | 1 | 2 | 3 | 4 | 5 |
| 6 | Tasks encourage students to think beyond the immediate problem and make connections to other related mathematics concepts | 1 | 2 | 3 | 4 | 5 |

D. CLASSROOM CULTURE

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. | Active participation of all students was encouraged and valued. | 1 | 2 | 3 | 4 | 5 |
| 2 | The teacher displayed respect for student ideas, questions, and contribution | 1 | 2 | 3 | 4 | 5 |
| 3 | Interactions reflected a productive working relationship among student | 1 | 2 | 3 | 4 | 5 |
| 4 | Interactions reflected a collaborative working relationship between the teacher and the student | 1 | 2 | 3 | 4 | 5 |
| 5 | Wrong answers were treated as worthwhile learning opportunities | 1 | 2 | 3 | 4 | 5 |
| 6 | Student were willing to discuss their thinking and reasoning openly | 1 | 2 | 3 | 4 | 5 |
| 7 | The classroom climate encourages student engage in mathematical discourse. | 1 | 2 | 3 | 4 | 5 |

## APPENDIX 10 TEACHER INTERVIEW PROTOCOL ON LESSON PLANNING, PRESENTATION AND PEDAGOGICAL APPROACHES IN MATHEMATICS IN SECONDARY SCHOOLS

**Researcher: V Ngwenya**

**Student Number: 47289902**

**Project: Developing a Collaborative model for teaching and learning mathematics in secondary schools**

**Part 1: Biographical Questions**

1.9 What is your name?

1.10 How old are you?

1.11 What is your position at this educational institution?

1.12 How long have you been a Mathematics educator?

1.13 What is your academic qualification?

1.14 What is your professional qualification?

1.15 Have you attended any workshops on Mathematics content and pedagogical strategies?

1.16 If yes, who organised the workshop?

**Part 2: Research Questions**

1) Can you briefly describe what you planned for the lesson I observed? (Can you tell me more about what you mean by that?)

2) How do you think the lesson went? (Can you push on what do you mean by that? or what do you mean by good?) What was good about the lesson?

3) I'm interested in what and how students learn in your classroom

What do you think students learned from these lessons? How can you tell what students learned?

What do you think students had difficult learning –or were there things they didn't learn? How can you tell?

What did you notice about student engagement during the lesson?

4) How do you think students learn mathematics? Has this lesson influenced your thinking about how students learn mathematics? How does your students learn influence your teaching?

5) What do you think went particularly well in these lessons?

What would you change next time you teach it? Why?

Would you spend more or less time on this unit (or topic) next time?

6) I 'm interested in understanding the instructional strategies that teachers use.

What instructional strategies did you use? (If they ask what it means …methods or structures you used)

Why did you use those strategies?

7) What do you think about how mathematics should be taught? Has this programme affected the way you think about teaching mathematics? If yes, how has your view on teaching mathematics changed?

8) What are your beliefs about the nature of mathematics? (Not just do you like it o not, but more like is it easy or hard, is it a bunch of rules you have to memorize or something that makes sense, etc.

9) Has cluster workshop programme affected your views of mathematics? What, specifically about the programme has helped you change your mind about student learning, or how to teach mathematics or what mathematics is?

10) What mathematics did you learn the most about in this lesson? Do you ever have moments when teaching mathematics where you are challenged by concepts you teach learners?

Describe some of those moments…

11) How do you think learners can be actively involved in the teaching and learning of Mathematics?

12) Suggest different methods/ strategies that could be used to teach Mathematics effectively in secondary schools?

13) How do you think you can collaborate with other teachers in teaching Mathematics effectively?

Thank you for your participation in the interview**.**

**APPENDIX 11**: FOCUS **GROUP INTERVIEW FOR MATHEMATICS LEARNERS (PARTICIPANT AND NON-PARTICIPANTS) ON HOW MATHEMATICS IS TAUGHT, PEDAGOGICAL APPROACHES USED AND THEIR VIEWS ON HOW MATHEMATICS TEACHING AND LEARNING IN SECONDARY SCHOLS COULD BE IMPROVED**

INTRODUCTION:

My name is **VUSANI NGWENYA,** and I am a Doctor of Education Curriculum studies) Degree research student at the University of SOUTH AFRICA (UNISA) I am carrying out a research study on **A COLLABORATIVE MODEL FOR TEACHING AND LEARNING MATHEMATICS IN SECONDARY SCHOOLS.** You are, therefore, requested to take part in a group interview on the research topic.

Respondents are guaranteed that:

All the information supplied will be strictly confidential.

All the information supplied will be used for research purposes only and all respondent's identity shall remain anonymous.

**Part 1: Biographical Questions**

1.1 What are your names?

1.2 How old are you?

1.3 How long have been in this school?

1.4 Who do you stay with at home?

1.5 What are the educational levels of your parents?

1.6 Do your parents monitor or assist you in your Mathematics tasks?

**Part 2: Research Questions**

2.1 How do you learn Mathematics in your class? /Describe how mathematics learning takes place in your class

2.2 How do learners participate in the teaching and learning process?

2.3 How do methods used in teaching Mathematics affect your understanding of concepts? Explain your answer?

2.4 What challenges do you face in the learning of Mathematics?

2.5 How do you think Mathematics could be taught and learnt to give best results?

2.6 Suggest how learners could be actively involved in the teaching and learning of Mathematics?

2.7 Suggest how use of teaching and learning aids could improve the teaching and learning of Mathematics?

2.8 How do you think small group learning could affect quality teaching of Mathematics?

2.9 How do you think assessment in Mathematics could be improved to result in the effect of understanding of concepts?

Thank you for participation in the interview.

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**APPENDIX 12**

**Interview Transcript for Mathematics Educators**

**Date**: 06 June 2016

**Interviewee**: Mathematics educator School A

**Place**: School A Guest lounge

**Researcher**: Right, we may begin. Good afternoon, Sir.

**Teacher 1**: Good afternoon.

**Researcher**: My name is Vusani Ngwenya. I'm conducting a study for a Doctorate's degree at the University of South Africa. The topic of my project is "A Collaborative model for teaching and Learning Mathematics in secondary schools." I'm here to conduct interviews with mathematics educators in the cluster. The interview is going to be divided into two types of questions. The first one will be biographical questions, where I will be asking questions of a personal nature and the second type will be research questions. The interview normally lasts for less than thirty minutes, for all the pilot studies that I have conducted, it has never exceeded thirty minutes and I would like to state on record that the study is conducted confidentially, the name of the school is kept confidentially- we use pseudo-names instead and the names of the participants are also kept confidential. Also in response to all the questions, what the study seeks are just the experiences of educators and strategies they use in teaching and learning of Mathematics in secondary schools and as such there are no correct or incorrect answers. I will start with biographical questions.

**Researcher:** What are your names, Sir?

**Teacher 1**: OK. I am Teacher 1. (Pseudonym)

**Researcher**: How old are you?

**Teacher 1**: I am thirty years.

**Researcher:** What is your highest academic qualification?

**Teacher 1**: I have a Bed Honours in education (Sciences), Post-graduate certificate in education majoring in Mathematics.

**Researcher**: How long have you been teaching Mathematics at high school?

**Teacher 1**: I think it's from 2009. Nhuu… it's 8 years now.

**Researcher**: 8 years?? Quite experienced. Have you attended any workshops on Mathematics content and teaching strategies?

**Teacher 1:** Mhuuu…Oh yes, each beginning of year first week or second the Department organizes what they call orientation workshops for engaging teachers in new content or additional content in Annual Teaching plans for the year and sharing strategies on how best learners could pass.

**Researcher**: Who organise these workshops?

**Teacher 1**: It’s the circuit management in conjunction with subject advisors in respective subjects.

**Researcher**: Thank you. Now we gonna proceed to research questions. The questions are a follow up of the lesson observation I carried out in your Grade 10 class recently. The first question. As a Mathematics educator, can you briefly describe what you planned for the lesson I observed?

**Teacher 1**: mhhh.The lesson you saw was on Financial Mathematics where my objective was for learners to calculate interest on investments using a given formula. I began the lesson by explaining concepts that relate to the task such as: interest, investments, investment period and percentage interest. After defining concepts, I went on to present an example on the chalkboard and engaged the class before giving group task and concluded by individual learner work.

**Researcher:** Thank you. How do you think the lesson went? (Can you push on what do you mean by that? or what do you mean by good?) What was good about the lesson?

**Teacher 1**: Eerr...Not really. Most learners hardly understand concept of substituting into a given formula and as a result they do not get all the tasks questions given. At face value learners understand concept of interest on an investment but working out sums seem a challenge. **Researcher**: Thank You. I’m interested in what and how students learn in your classroom.

What do you think students learned from these lessons? How can you tell what students learned?

What do you think students had difficult learning –or were there things they didn’t learn? How can you tell?

What did you notice about student engagement during the lesson?

**Teacher 1:** Oh Yes, quite a lot the financial concept of mathematics helps the learners to understand investments and how businesses earn interest on their investments. I can tell what they learnt by the way they respond to written tasks. My class has challenges in substituting into a given formula especially exponential aspect of the formula where they change the number of years to months depending on the compounding periods of investments. Students very few engage in lessons, they keep quiet throughout the lessons and as a teacher l find it upsetting because l don't know if they get what l teach. They are indeed passive... eish bad. I do.

**Researcher**: Thank you. As a Mathematics educator, how do you think students learn mathematics? Has this lesson influenced your thinking about how students learn mathematics? How do your students learn influence your teaching?

**Teacher 1**: Come Again.

**Researcher**: As a Mathematics educator, how do you think students learn mathematics? Has this lesson influenced your thinking about how students learn mathematics? How do your students learn influence your teaching?

**Teacher 1**: OK. Ja. As a mathematics teacher to me it is a practical subject meaning students must practice it by doing it. In the classroom I think learner involvement in all lesson and concept explanation is crucial. Involving students in group work where they help and explain concepts to each other is also one strategy I have found helpful. Oh yes from this lesson l learnt that learner involvement in practical doing of mathematics is important. The way students learn is important, it sets the pace of the lesson and what activities to cover during the lesson and examples and teaching aids to use among other variables.

**Researcher**: Thank you. What do you think went particularly well in these lessons?
What would you change next time you teach it? Why?

**Teacher 1:** Ja, to tell the truth lesson pacing went very well as well as explaining and demonstration of concept to the class. In my next lesson I will increase chances for the involvement of learners in groups and pairs in the actual doing of Mathematics during the teaching and learning sessions and for practice sessions. Giving homework for further practice is also one good strategy that I think works.

**Researcher**: Thanks.) I 'm interested in understanding the instructional strategies that teachers use. What instructional strategies did you use? (If they ask what it means …particular methods or structures you used) Why did you use those strategies?

**Teacher 1**: Ja, Eem, Teaching mathematics like l earlier said, demands involving learners in actual doing of mathematics. In the lesson u observed I used Teacher- class concepts explanation for introductory purposes and went on to use group work for practice of learnt concepts before I gave students individual class work on the concepts. Teacher demonstration and use of illustrations is very crucial as it helps students to understand the concepts taught in depth and have a chance to practice it in groups before they do individual work. The Involving learners in actual doing of mathematics concepts further helps them to understand the concepts and make it sink deep into their minds.

**Researcher**: Thank You. What do you think about how mathematics should be taught? Has this involvement in the study affected the way you think about teaching mathematics? If yes, how has your view on teaching mathematics changed?

**Teacher 1:** (clears his throat). Mathematics teaching and learning is quite a contested area as results in all grades are very low. But as an experienced teacher I think teaching of mathematics has remained static, traditional, and routine which makes mathematics boring and difficult to learners. Mathematics teachers still use textbook examples that are worked out and rarely take questions from learners who in most classes do not ask nor answer any questions. Taking part in mathematics improvement research makes me proud and encourages me to change my methods and help improve teaching and learning of mathematics.

**Researcher**: Thank you. What are your beliefs about the nature of mathematics? (Not just do you like it o not, but more like is it easy or hard, is it a bunch of rules you have to memorize or something that makes sense, etc.

**Teacher 1**: Ja...to be honest with you as a mathematics teacher I love the subject and used to think that it is easy, and my learners will pass it but over the years I have experienced ups and downs in teaching the subject where results are not improving instead they always get bad. However, despite that I believe mathematics is interesting and enjoyable.

**Researcher**: Thank you. Has cluster workshops programme affected your views of mathematics? What, specifically about the programme has helped you change your mind about student learning, or how to teach mathematics or what mathematics is?

**Teacher 1**.: oh yes, Cluster orientation and strategizing workshops are very helpful in that they help new and old teachers to remind themselves on content they will teach during the year. It also helps teachers share strategies on how to improve pass rates in mathematics in different schools as educators share their contextual experiences from the schools. Materials from subject advisors are also shared including formal tasks.

**Researcher**: Thank you. What mathematics did you learn the most about in this lesson? Do you ever have moments when teaching mathematics where you are challenged by concepts you teach learners? Describe some of those moments…

**Teacher 1**: Eer...This lesson which you observed taught me that unless students are involve in the practice of concepts, they may not do well in individual work tasks. I also learnt that key to teaching mathematics concepts lie in clear explanation of concepts before learner's attempt answering questions. Involving learners in groups tasks work is also very important.

**Researcher**: Thank you. How do you think learners can be actively involved in the teaching and learning of Mathematics?

**Teacher** 1: Ok, mathematics learning and teaching must not be a teacher's task only; it should be a joint venture between the teacher and the students in a mathematics classroom. Teachers must plan a variety of activities that involve learners in actually practicing and doing mathematics. Again, use of tasks such as projects, investigations which will involve learners in groups in actual doing and helping each other to find solutions can effectively improve mathematics teaching and learning. Students should also be given chances to teach each other and demonstrate their understanding of concepts that are taught and tested.

**Researcher:** Thank you. Suggest different methods/ strategies that could be used to teach Mathematics effectively in secondary schools?

**Teacher 1**: Eeh…Secondary school mathematics is quite tricky to guarantee that any one method could be used to teach it effectively. I would suggest that not one method should be used in teaching and learning mathematics. Among strategies or methods' that could be used are use of clear demonstrations and illustrations, group tasks and pair work where learners are engaged in the actual doing and practice of concepts that they are taught. Allowing learners to teach each other, demonstrate their understanding of concepts to their peers can also instill confidence and improve mathematics. Assessment is crucial as well; different assessment tasks must be given to learners in the form of projects, assignments, investigations, and tests among others.

**Researche**r: Thank you. And lastly, how do you think you can collaborate with other teachers in teaching Mathematics effectively?

**Teacher 1**: Mhhuu…Mathematics teachers need each other to effectively improve the results in their schools. The starting point is making the Orientation workshops more robust and engaging where content is clearly explained, and strategies shared coupled with written subjects' improvement plans. Other strategies could include networking of educators through sharing resources such as tasks, past papers, guidelines, and revision tasks. Teachers should also learn to team teach and peer teaching where they alternate and work together to teach each other topics they do not understand well. They can also visit each other on planned exchange programmes and teach each other classes on topics that one is not effective in.

**Researcher**: Thank you Teacher 1 that concludes our interview. I would like to thank you for a wealth of knowledge that you have contributed to this project.

**Teacher 1**: Thank you very much.

**APPENDIX 13: 1**

**Interview Transcript for Grade 10 Mathematics Learners**

**Date**: 10 June 2016

**Interviewee**: Focus Group School A

**Place**: School A Guest lounge

**Researcher**: Right, we may begin. Good afternoon learners.

**Focus Group 1**: Good afternoon.

**Researcher**: My name is Vusani Ngwenya. I'm conducting a study for a Doctorate's degree at the University of South Africa. The topic of my project is "A Collaborative model for teaching and Learning Mathematics in secondary schools." I'm here to conduct interviews with mathematics educators in the cluster. The interview is gonna be divided into two types of questions. The first one will be biographical questions, where I will be asking questions of a personal nature and the second type will be research questions. The interview normally lasts for less than thirty minutes, for all the pilot studies that I have conducted, it has never exceeded thirty minutes and I would like to state on record that the study is conducted confidentially, the name of the school is kept confidentially- we use pseudo-names instead and the names of the participants are also kept confidential. Also, in response to all the questions, what the study seeks are just the experiences and views of mathematics learners regarding the teaching and learning of Mathematics in secondary schools and as such there are no correct or incorrect answers. I am gonna start with biographical questions.

**Researcher**: What are your names, Students?

**Focus Group 1**: OK. We are Student A1, A2, A3, A4, and A5 (Pseudonym)

**Researcher**: How old are you?

**Focus Group 1**: We are 15, 18,16,15,19 years respectively.

**Researcher:** How long have been in this school?

**Focus Group 1**: We have been learning at this school since 2013, 2014, that is 4 years and 3 years.

**Researcher**: Who do you stay with at home?

**Focus Group 1: I** stay with **A1**- my parents,

**A2**- my grandmother because both my parents are now late,

**A3**- my stepmom,

**A4**- with my siblings our parents are no more,

**A5**- my mother.

**Researcher**: What are the educational levels of your parents?

**Focus Group 1:** Mhuuu, Wooow (all exclaiming)

**A1**-My parents went to school up to Grade 5,

**A2-** My granny eish did not go to school and cannot even write her name,

**A3-** My stepmom went up to matric but failed it,

**A4-** We all are attending school and l am the oldest,

**A5-** My mom dropped from school at Grade 6.

**Researcher**: Do your parents monitor or assist you in your Mathematics tasks?

**Focus Group 1**: Mmmmm (in unison)

**A1-** No one asks us about school work and what I learn is far above my parents level of education,

**A2-** oh my god, my granny only encourages me to go to school, cannot read my work at all,

**A3-** My mom sometimes looks at my work, she says she used to be good in mathematics,

**A4-** We all by ourselves at home I encourage myself,

**A5-** Weeee, my mom has no idea what high school mathematics involves but encourages me to work hard.

**Researcher**: Thank you. Now we gonna proceed to research questions. The questions are an intended to get your views and experiences on how Mathematics is taught in your classrooms and how you think you can improve in it. The first question. As a Mathematics learner, how do you learn Mathematics in your class? /Describe how mathematics learning takes place in your class?

**Focus Group 1**: mhhh... (Laughing)

**A1-** Our teacher teaches us well but most times he works out answers on the chalkboard and use textbook example to teach us after that he gives classwork.

**A2-** Our mathematics lessons are ok, but I rarely understand and is scared to ask questions because other learners will laugh at me.

**A3-** In our class our teacher does more talking and shows all working of examples on the chalkboard followed by group work and individual work.

**A4-** Our teacher likes mathematics and is always on time, each day he introduces new things, explains to us, and gives us work to do on our own, he does not mark our work most times.

**A5-** Teacher explains on chalkboard then we try in our groups, most times we do not understand but keep quiet until the teacher leaves class.

**Researcher:** Thank you. How do learners participate in the teaching and learning process?

**Focus Group 1**: Participation Eerr (sounding surprised)

**A1**- Very few only two or three out of a class of 40 participate actively in mathematics lessons, most of us we only do group tasks and individual work.

**A2**- Most learners only do group tasks and class work and do not ask the teacher any questions during lessons. A3- Learners find mathematics difficult and do not freely participate in lessons for fear of being laughed at by other learners.

**A4**- Teacher in our class spend most time talking and explaining and there is little time for us learners to do practice tasks and we fail in most of our work.

**A5**- Learners in mathematics class most times are quiet and do not answer teachers' questions. Mathematics is too difficult and confusing us.

**Researcher**: Thank You. How do methods used in teaching Mathematics affect your understanding of concepts? Explain your answer?

**Focus Group 1:** Oh,

**A1**- The way mathematics is taught in my class has impact on my understanding of concepts, my teacher uses textbook worked examples and I rarely understand him but scare to ask because class will laugh at me.

**A2**- Use of individual tasks before we understand what the teacher would have taught is discouraging as we fail to do the task which are given.

**A3**- I fail to understand the teacher's explanations during the lesson period and as such most times I do not get the sums correctly.

**A4**- Mathematics lessons in my class are mostly teacher act where the teacher does most talking and showing us on the chalkboard how the concepts are explained.

**Researcher**: Thank you. As Mathematics learners, what challenges do you face in the learning of Mathematics?

**Focus Group A**: OK.

**A1**-Main problem is that even if our teacher teaches us well l hardly understands him and he proceeds to give us tasks as individuals where we again fail to work out the sums.

**A2**- Some of our friends laugh at us when we try to participate in mathematics lessons, and we choose to keep quiet during lessons. Teacher pays attention to learners that are clever and rarely pay attention to some of us who are struggling with mathematics.

**A3**- one big problem we have is that we don't understand our Mathematics teacher and when he explains we are left behind and sometimes he does not pay attention to slow learners.

**A4**- Mathematics is enjoyable but difficult to understand, my problem is that I don't get enough time to practice since l share a textbook with three other learners in the class.

**A5**- My friends have said most problems we face but I also think that teacher must marks our books after a task is given because most of the work in our books is not marked and we are not sure is we got the answers correct.

**Researcher**: Thank you. How do you think Mathematics could be taught and learnt to give best results?

**Focus Group 1:** Ja, **A1**- In order for mathematics to be improved our teacher must give enough time for practice before individual tasks are given to the class.

**A2** I also think that as learners we must be given a chance to explain to each other the concepts and practice in groups and share ideas of what has been taught.

**A3**- For mathematics to be improved I think it begins with the teacher who should have enough content and understanding of what is taught, sometimes teacher fail to answer us.

**A4-** Mathematics must be made easy and fun, teachers must give examples and illustrations that are easy to understand and again much practice must be given in groups before we do individual work.

**A5-** Our teacher must give us tasks in groups so we practice a lot and again homework must be there as mathematics needs practice a lot. Various tasks such as projects and assignments where we apply mathematics skills must be explained before given to us.

**Researcher**: Thanks. Suggest how learners could be actively involved in the teaching and learning of Mathematics?

**Focus Group 1**: Yes, yes, (All of the students exclaiming)

**A1**- Learners must be made to understand Mathematics concepts, be involved in the practice of the concepts as groups and individually at home and school.

**A2-** Learners can effectively do mathematics through doing it in groups and pairs as well as individually. Tasks could be made into games, projects, assignments, investigations, videos, and tests.

**A3**- Only way is to give learners chances to practice mathematics concepts, eat mathematics and live it in their lives.

**A4**- Changing beliefs about mathematics is also very important, most of us think that mathematics is difficult and that affects how we learn and do it. Our teacher must make us gain confidence in learning and doing mathematics, make us love it and like to do it daily.

**A5**- I can add on what others have said that all learners must have own textbook for practice on his or her own and homework as well must be given and marked by our teacher.

**Researcher**: Thank You. Suggest how use of teaching and learning aids could improve the teaching and learning of Mathematics?

**Focus Group 1:A1**- Interesting, teacher does not bring any teaching aids to class. Teaching and learning aids must be brought to the classroom to help teacher to explain the things we learn. **A2-** Teaching aids help us to understand concepts and teacher must use them at the concept introduction and explanation stage effectively, so we see easily how the concepts unfolds.

**A3-** All our lessons must have teaching and learning aids so that the help us to understand easily the concepts taught. So, aids must be relevant, big enough and easy to understand and use so that they help explain what we learn.

**A4-** Teaching and learning aids help to make real the mathematical concepts taught in class and make mathematics real and interesting.

**A5-** My ideas taken kkkk (laughing), but I think learning aids simplify mathematics in that they can be seen and touched and as a result we understand better what is taught.

**Researcher**: Thank you. How do you think small group learning could affect quality teaching of Mathematics?

**Focus Group 1**: **A1-** Working in groups helps us to share ideas on what is taught, the challenges and wins of getting answers right.

**A2-** Small groups motivates us to do more, to express ourselves in a way we cannot do especially in a whole class.

**A3-** Group work helps teacher to monitor class work or task effectively as groups are small and easier to mange that whole class.

**A4**- Small groups help to mange discipline in class as everyone gets engaged in the task that is given.

**A5**- Small groups teach leadership as in them one has to lead, that helps to have mathematics tasks done on time and with everyone participating. But in some groups only few participate while others do most of the work.

**Researcher**: Thank you. How do you think assessment in Mathematics could be improved to result in the effect of understanding of concepts?

**Focus group 1**.: **A1-** Assessment is the most important result of teaching and learning and as such it should be done correctly and on time after a concept has been covered. Learners must be given a chance to prepare for assessments so that they revise.

**A2-** Starting point is to make assessment tasks relevant to what was taught and have clear instructions and what learners are expected to do.

**A3-** Assessment should be done within adequate time, quality tasks that are related to covered concepts and done after a revision by the class and the teacher.

**A4-** Assessment must take various forms such as tests, projects, assignments, and informal practice and all should be marked after done so that learners get feedback.

**A5-** Oh my God my points taken, but one last point is that all assessments must be given on time not in a hurry and marked on time, so we get our marks and feedback on time.

**Researcher**: Thank you students that concludes our interview. I would like to thank you for a wealth of knowledge that you have contributed to this project.

**Focus Group 1**: Thank you very much too.

**APPENDIX 13**

**Interview Transcript for Grade 10 Mathematics Learners**

**Date**: 07 June 2016

**Interviewee**: Focus Group School B

**Place**: School A Guest lounge

**Researcher**: Right, we may begin. Good afternoon learners

**Focus Group 1**: Good afternoon.

**Researcher**: My name is Vusani Ngwenya . I'm conducting a study for a Doctorate's degree at the University of South Africa. The topic of my project is "A Collaborative model for teaching and Learning Mathematics in secondary schools." I'm here to conduct interviews with mathematics educators in the cluster. The interview is gonna be divided into two types of questions. The first one will be biographical questions, where I will be asking questions of a personal nature and the second type will be research questions. The interview normally lasts for less than thirty minutes, for all the pilot studies that I have conducted, it has never exceeded thirty minutes and I would like to state on record that the study is conducted confidentially, the name of the school is kept confidentially- we use pseudo-names instead and the names of the participants are also kept confidential. Also in response to all the questions, what the study seeks are just the experiences and views of mathematics learners regarding the teaching and learning of Mathematics in secondary schools and as such there are no correct or incorrect answers. I am gonna start with biographical questions.

**Researcher**: What are your names, Students?

**Focus Group 2**: OK. We are Student B1, B2, B3, B4, and B5 (Pseudonym)

**Researcher**: How old are you?

**Focus Group 2**: We are 15, 18,16,15,19 years respectively.

**Researcher:** How long have been in this school?

**Focus Group 2**: We have been learning at this school since 2013, 2014, that is 4 years and 3 years.

**Researcher**: Who do you stay with at home?

**Focus Group 2: I** stay with **B1**- my parents,

**B2**- my grandmother because both my parents are now late,

**B3**- my step mom,

**B5**- my mother. And my two other sisters.

**Researcher**: What are the educational levels of your parents?

**Focus Group 2:** Mhuuu, Wooow (all exclaiming)

**B1**-My parents went to school up to Grade 5, left school due to fail of their parents to pay fees during those years ago before 1994.

**B2**- My granny eish did not go to school and cannot even write her name, she says girls did not attend school in their days and schools were very few and far.

**B3**- My stepmom went up to matric but failed it, did not continue and just sits at home looking after us.

**B4**- We all are attending school and l am the oldest, so it's me with high level of education which is Grade 9.

**B5**- My mom dropped from school at Grade 6 and opted to get married, she never went back to school after that level.

**Researcher**: Do your parents monitor or assist you in your Mathematics tasks?

**Focus Group 2**: Mmmmm (in unison)

**B1**- No one asks us about schoolwork and what I learn is far above my parent's level of education, my mom only asks if teachers teach us well and see that we are on time to school and have uniforms and things needed in school.

**B2**- oh my god, my granny only encourages me to go to school, cannot read my work at all, she does not even look at our schoolwork since she cannot read nor write kkkkk (laughing at that)

**B3**- My mom sometimes looks at my work; but the sums we do are so difficult that she does not help me when l seek help, l struggle on my own but she says she used to be good in mathematics. I think if I had some help I could be better in mathematics than now.

**B4**- We all by ourselves at home I encourage myself, no one helps me, but I help my brother and sis with their mathematics. I think could have been better if my parents were around schoolwork could be much easier I guess.

**B5**- Weeee, my mom has no idea what high school mathematics involves but encourages me to work hard. She always says she was good in mathematics at primary level and had she gone to high school she could have been of help. But shame she is supportive of schoolwork and gives me time to do school work.

**Researcher**: Thank you. Now we gonna proceed to research questions. The questions are an intended to get your views and experiences on how Mathematics is taught in your classrooms and how you think you can improve in it. The first question. As a Mathematics learner, how do you learn Mathematics in your class? /Describe how mathematics learning takes place in your class?

**Focus Group 2**: mhhh... (Laughing)

**B1**- Our teacher teaches us well but most times he works out answers on the chalkboard and use textbook example to teach us after that he gives class work. Teacher puts more trying on how the sums are done even if we do not understand the actual sums or what is being taught. Teacher does not give us time to understand and practice in our own as group or pairs. I tell you sir had our teacher be patient to help us understand content woow we could be far.

**B2**- Our mathematics lessons are ok; teacher is always on time and teaches us but I rarely understand and am scared to ask questions because other learners will laugh at me. But again, our learning of mathematics lacks fun; I think games and talking about mathematics can help to make our learning interesting and fun.

**B3**- In our class our teacher does more talking and shows all working of examples on the chalkboard followed by group work and individual work. Eish sometimes I don't get anything on what is actually shown on the chalk board, our teacher must put more time in helping us to understand what is taught before showing how we must do it. Other plan could be to give us more practice on metal mathematics skills like we used to do at primary and that can help things we are taught to sink deep, and we understand better. My other problem eish this one (laughing) I make mistakes in using the calculator properly. Teacher must help us with such skills which are useful.

**B4**- Our teacher likes mathematics and is always on time, each day he introduces new things, explains to us, and gives us work to do on our own, he does not mark our work most times. This problem of not marking our work yooo (grinning) makes us not to know our levels of performance in work that is not marked. Teacher again always tells us how difficult mathematics is and that we will fail and that discourages us and make us not happy, teacher must motivates us who struggle in mathematics to like it and practice it most times.

**B5**- Teacher explains on chalkboard then we try in our groups, most times we do not understand but keep quiet until the teacher leaves class. You can laugh if u visit our class during mathematics lessons, most learners' heads down no one asks any questions or answers when the teacher teaches. Same way teacher teach makes mathematics boring wish games on our phones could be used to teach as well and make teaching and learning of mathematics fun and interesting.

**Researcher:** Thank you. How do learners participate in the teaching and learning process?

**Focus Group 2**: Participation Eerr (sounding surprised)

**B1**- Very few only two or three out of a class of 40 participate actively in mathematics lessons, most of us we only do group tasks and individual work. Our mathematics class is always quiet during mathematics as no learner is able to ask or answer questions. Thinks is because we understand little of what our teacher says but fear our friends will laugh if we expose ourselves. Only one learner called X (not real name) is good and was not learning here until this year yoo he is good but does not get chance to help us, teacher should give him the chance.

**B2**- Most learners only do group tasks and class work and do not ask the teacher any questions during lessons. Mathematics learning in our class to say truth is boring and not interesting at all, same style of teaching daily, teacher must try games we see on cell phones and TV to help us to understand mathematics content. Other big, big problem is that teacher does not make us understand the content taught but rushes to show us how answers are worked out which makes it difficult to do sums on our own and in groups.

**B3**- Learners find mathematics difficult and do not freely participate in lessons for fear of being laughed at by other learners. Weee(expressing sadness) mathematics learning in our class is bad just disaster because most of us do not understand the content even when the teacher shows us on the board. I think more time must be put on explaining content before shown how to work out the sums. I also think teacher must encourage us and increase our expectations in mathematics. More problem solving and project tasks can make us work together is groups as we do tasks.

**B4**- Teacher in our class spend most time talking and explaining and there is little time for us learners to do practice tasks and we fail in most of our work. Much time in class should be for us learners to show what the teacher was teaching us so teacher must give us clear steps of how we should do sums. Its all writing and calculating, and most sums are just difficult yoo wish games could also be used to help us understand mathematics.

**B5**- Learners in mathematics class most times are quiet and do not answer teachers' questions. Mathematics is too difficult and confusing us. Only child X and Y (not real names) are the ones who answer and ask questions in our mathematics class, most of us we honestly do not follow and me is got low expectations of myself in mathematics.

**Researcher**: Thank You. How do methods used in teaching Mathematics affect your understanding of concepts? Explain your answer?

**Focus Group 2:** Oh,

**B1**- The way mathematics is taught in my class has impact on my understanding of concepts, my teacher uses textbook worked examples and I rarely understand him but scare to ask because class will laugh at me. Same methods that the teacher uses to teach and are boring to say the least, teacher talk and shows on chalkboard how one sum is done and gives us more difficult ones is not enough for us, we want more explanation on understanding content before calculations on it, games are not used yet they are fun and can help us to understand.

**B2-** Use of individual tasks before we understand what the teacher would have taught is discouraging as we fail to do the task which is given. Our teacher rushes us to do give us task before we understand what was taught, I need to understand content before calculations on sums from it. Again our teacher eish all the time (showing hopelessness) does not encourage us but always say mathematics is difficult and we will fail it. That discourages us a lot.

**B3-** I fail to understand the teacher's explanations during the lesson period and as such most times I do not get the sums correctly. Teacher takes little time to explain content that he wants us to learn and gives us an example that is worked out from the textbook then after that yooo hard sums come which are difficult, we try them but get stuck on way, Teacher frightens us that mathematics will teach us hard lessons because it is difficult so we have low motivation. Teacher must give us hope in mathematics and support us as we learn it.

**B4-** Mathematics lessons in my class are mostly teacher act where the teacher does most talking and showing us on the chalkboard how the concepts are explained. Teacher gives same sums type and makes our assessment boring we can maybe just thinking is we get other types of assessment such as projects or task where we can find solution to a problem or work in group and be creative using our things and books. My other complaint is that our class must be busy with things to do things that we can use to learn mathematics and again chance to help each other on our own can help us. We love mathematics and want to enjoy it.

**Researcher**: Thank you. As Mathematics learners, what challenges do you face in the learning of Mathematics?

**Focus Group 2**: OK.

**B1-**Eish eish quite a lot of sir, Main problem is that even if our teacher teaches us well l hardly understands him and he proceeds to give us tasks as individuals where we again fail to work out the sums. Our class does not offer support and create room for us learners to do and enjoy mathematics. There is little dialogue in our class and that makes us not to understand it as only the teacher talks most times in our class. Again, this mathematics was difficult from primary and l never understood it so now worse and teacher has no time to walk with us who are struggling.

**B2-** Some of our friends laugh at us when we try to participate in mathematics lessons, and we choose to keep quiet during lessons. Teacher pays attention to learners that are clever and rarely pay attention to some of us who are struggling with mathematics. Most of us fear to ask or raise hands in class because some will laugh at us. Teacher must give us attention say in groups or on our own come to us as we do the work, so we ask him questions where we are not clear. Little time is put on helping us to understand the content I see the teacher putting more time and emphasis on how the sum is worked out than on its content.

**B3-** One big problem we have is that we don't understand our Mathematics teacher and when he explains we are left behind and sometimes he does not pay attention to slow learners. Sums that are given are always difficult may be some sums must be easier to do so that we can try difficult ones. Teacher does not teach us to reason in mathematics as most sums only want us to follow the steps that the teacher will have shown us on the board. Tasks we do some must be like problems to some situations and we work out solutions to them that can make us happy. So, teacher must give us projects and investigations more often so that we improve our problem-solving skills through mathematical skills.

**B4-** Mathematics is enjoyable but difficult to understand, my problem is that I don't get enough time to practice since l share a textbook with three other learners in the class. Our class does not support working in groups on tasks that are given, and our tasks are the same not interesting or involving all of us to help find solutions. Teacher must support us in working together on tasks like projects and investigations where we will share ideas and our abilities in finding solutions to a problem. Eish sir we want to help each other in class as we learn mathematics.

**B5-** My friends have said most problems we face but I also think that teacher must marks our books after a task is given because most of the work in our books is not marked and we are not sure is we got the answers correct. Teacher does not make us participate in mathematics lessons through giving us tasks that will involve us in solving problems that we are given and give back our solutions to the class. Again, how about using technology, teacher insults you if you carry a cell phone to class so games and other applications that can help work mathematics are not given space to be tried in our classes. Mathematics could be more fun if we use the games and share skills and understanding in our groups and class.

**Researcher**: Thank you. How do you think Mathematics could be taught and learnt to give best results?

**Focus Group 2:** Jah yes (all at once)

**B1**- Eish, hope this works, in order for mathematics to be improved our teacher must give enough time for practice before individual tasks are given to the class. Teacher must spend more time on helping us to understand the concept or content that is taught before engaging us into doing sums as a class or individuals. Techer must also create an environment in class that promotes investigation and make our class a family that helps each other in finding solutions to mathematics problems given. Another of my view is that our teacher must have more knowledge of mathematics and give us answers where we are unclear and give us motivation to keep trying despite being difficult.

**B2** I also think that as learners we must be given a chance to explain to each other the concepts and practice in groups and share ideas of what has been taught. Our teacher must always maintain a positive attitude about mathematics and not give up on us struggling learners. Again, I think stress must be put on understanding content compared to how sums are worked out, more time on content explanation is crucial. Mathematics must also teach us learners to reason through identifying things and exercising out thinking skills.

**B3**- Sir it's a huge hope, For mathematics to be improved I think it begins with the teacher who should have enough content and understanding of what is taught, sometimes teacher fail to answer us. Teacher must also allow us to be creative, to work out problems on our own but for that to happen we need to be clear on what to do and how to do it with the help of the teacher. Some of us have been failing mathematics for ages and have little motivation so our teacher must give us hope and encourage us to do more more practice and more thinking and engaging in mathematics tasks. Sir l am not sure on this one, but I think our teacher must help us to use technology in class to improve our mathematics.

**B4**- Mathematics must be made easy and fun, teachers must give examples and illustrations that are easy to understand and again much practice must be given in groups before we do individual work. Again our teacher must give us problems that will help us to use our mathematics skills to solve problems in our communities not always doing solve for x problems kkkkkkk (laughing aloud). Use of other approaches such as mental mathematics can help us because it will help us to memorise important content and steps by head. We as learners also want to enjoy mathematics and I think using games can do wonders; teacher must bring mathematics games to increase our attention and make us focused.

**B5**- Our teacher must give us tasks in groups so we practice a lot and again homework must be there as mathematics needs practice a lot. Various tasks such as projects and assignments where we apply mathematics skills must be explained before given to us. Our teacher must always help us to grow positive attitudes towards mathematics to make us believe that mathematics is fun and easy. Our teacher must also make assessment varied and interesting include more tests and quizzes to foster practice and understanding of concepts and content that is taught in class.

**Researcher**: Thanks. Suggest how learners could be actively involved in the teaching and learning of Mathematics?

**Focus Group 2**: Yes, yes, (All of the students exclaiming)

**B1-** Learners must be made to understand Mathematics concepts, be involved in the practice of the concepts as groups and individually at home and school. One condition for involvement of learners is to create activities that are varied and interesting, these could include games quizzes, tests and projects that will involve all of us to think and contribute ideas that are useful to find solutions.

**B2-** Learners can effectively do mathematics through doing it in groups and pairs as well as individually. Tasks could be made into games, projects, assignments, investigations, videos, and tests. Learners need encouragement to do mathematics and as such teacher must motivate us to like mathematics by making it enjoyable and helping us to do tasks that are set. We as learners need to be given high hopes that mathematics is doable and easy so teachers must keep on motivating us to like the subject.

**B3-** Only way is to give learners chances to practice mathematics concepts, eat mathematics and live it in their lives. Mathematics must be lived experience in that activities we do in class must be related to our life experiences and help us understand what we learn in school. Problem solving tasks must be designed and given to us and the teacher helps us to work them out in our groups as we share our ideas.

**B4-** Changing beliefs about mathematics is also very important, most of us think that mathematics is difficult and that affects how we learn and do it. Our teacher must make us gain confidence in learning and doing mathematics, make us love it and like to do it daily. Minneri (Sir) our teacher sometimes say we will never pass mathematics and I think that is not good because it discourages us who struggle and love mathematics. So, working together in our class understanding ourselves and sharing ideas can help lot to make mathematics nice and interesting.

**B5**- I can add on what others have said that all learners must have own textbook for practice on his or her own and homework as well must be given and marked by our teacher. Sir, sad on this one, we need textbooks each one of us and stop this sharing, we want to practice at home and on our own so school must supply us with textbooks. Another one... what is it (pausing) teacher must give us chance to come out with our own methods of coming out with answers and opine the lesson to various approaches to a problem instead of one only. One relevant idea is to make mathematics classrooms very friendly for teaching and learning of mathematics by encouraging learners to be active as they do and discuss mathematics in the classroom.

**Researcher**: Thank You. Suggest how use of teaching and learning aids could improve the teaching and learning of Mathematics?

**Focus Group 2:**

**B1**- Interesting, teacher does not bring any teaching aids to class. Teaching and learning aids must be brought to the classroom to help teacher to explain the things we learn. Teaching and learning aids must aid the teacher and us to understand what is taught so the teacher must make them big enough to be seen from the back of the classroom and must be motivating to us to use to help our understanding.

**B2-** Teaching aids help us to understand concepts and teacher must use them at the concept introduction and explanation stage effectively, so we see easily how the concepts unfolds. These are pointers of what the lesson parts are about and should increase our understanding of what the teacher is teaching in a topic. Teaching aids simplify what is taught into smaller easier to understand parts of the topic.

**B3-** All our lessons must have teaching and learning aids so that the help us to understand easily the concepts taught. So, aids must be relevant, big enough and easy to understand and use so that they help explain what we learn. Yes, with teaching and learning aids learners can easily understand a concept as they sink deeper even after the lesson has been finished.

**B4-** Teaching and learning aids help to make real the mathematical concepts taught in class and make mathematics real and interesting. Through using teaching and learning aids learners will touch, smell, and use the aids to aid understanding of the learnt concepts. So, teacher must bring enough of the teaching aids and helps the learners to muse the aids for better understanding.

**B5**- My ideas taken kkkk (laughing), but I think learning aids simplify mathematics in that they can be seen and touched and as a result we understand better what is taught. Teaching aids make us relate to mathematical concepts that are taught and easier to follow through the use of teaching aids. But eeee(pausing) the teacher must be clear how they fit or are used in class lest they confuse us if he is not clear on how they relate to what us taught.

**Researcher**: Thank you. How do you think small group learning could affect quality teaching of Mathematics?

**Focus Group 2**:

**B1**- Working in groups helps us to share ideas on what is taught, the challenges and wins of getting answer right. Groups sirs are also good to increase our confidence and make us enjoy learning as a team and encouraging dialogue and sharing views on what is learnt in class. Through a mathematics talk that encourages working together to find mathematics solutions.

**B2**- Small groups motivates us to do more, to express ourselves in a way we cannot do especially in a whole class. Being in groups make us to feel wanted and makes mathematics a social activity that all of us can be free to engage in and learn from each other. So, Sir when we work in groups, we enjoy sharing ideas, but we need to first fully understand the task that is to be done in groups.

**B3**- Group work helps teacher to monitor class work or task effectively as groups are small and easier to manage that whole class. Working in groups is making a classroom a community where mathematics problems are everyone's challenge and as such everyone is actively involved in finding a solution. Group work encourages participation and giving out ideas towards a solution.

**B4**- Small groups help to manage discipline in class as everyone gets engaged in the task that is given. Small groups' sir can also be used in class to encourage learners to work towards finding solutions and live mathematics in real life situations and come out with new ideas on how to solve mathematics problems. In group setups learners can create and solve their problems easily.

**B5**- Small groups teach leadership as in them one has to lead, that helps to have mathematics tasks done on time and with everyone participating. But in some groups only few participate while others do most of the work. Again, in small groups teacher can help more people at the same time and that makes understanding of the concept much faster within a given space of time.

**Researcher**: Thank you. How do you think assessment in Mathematics could be improved to result in the effect of understanding of concepts?

**Focus group 2**:

**B1**- Assessment is the most important result of teaching and learning and as such it should be done correctly and on time after a concept has been covered. Learners must be given a chance to prepare for assessments so that they revise. Again, assessments must vary and cater for different learner levels of understanding. Assessment task must not all be difficult, some should be simple while others difficult. Further assessment must be ongoing and related to expectations per grade and help learners to be better in mathematics and related concepts.

**B2**- Starting point is to make assessment tasks relevant to what was taught and have clear instructions and what learners are expected to do. Sir I also think that through assessments the teacher can plan how to help learners who are struggling with schoolwork because their performance is informing the teacher on how many understood and how many are struggling in a concept. Other forms of assessments must be used that are not tests but could be games, quizzes, or projects. Group leaders could present the outcomes to the class as well.

**B3-** Assessment should be done within adequate time, quality tasks that are related to covered concepts and done after a revision by the class and the teacher. Assessment in mathematics must be well planned and done not in a hurry but on time this means teacher must teach and give practice time after which learners get themselves ready for assessment which will show how they understood the content that was taught and is being tested.

**B4-** Assessment must take various forms such as tests, projects, assignments, and informal practice and all should be marked after done so that learners get feedback. Assessment mark must be given back to learners as feedback or what they got from a given topic and using the feedback teachers can plan how to help a learner who is struggling. So, assessment must not be used for the sake of it but to let the teacher know of how the lesson was taught and how the learners understood what was taught to them.

**B5**- Oh my God my points taken, but one last point is that all assessments must be given on time not in a hurry and marked on time, so we get our marks and feedback on time. Mathematics assessments are important to help plan remedial work and may be re-teaching of a topic by the teacher if most learners did not do well in it. Some assessments like projects and investigations must have clear instructions as they are designed to help learners to think of ways of solving problems and thinking skills that may help us in life.

**Researcher**: Thank you students that concludes our interview. I would like to thank you for a wealth of knowledge that you have contributed to this project.

**Focus Group 2**: Thank you very much too.

**APPENDIX 13:3**

**Interview Transcript for Grade 10 Mathematics Learners**

**Date**: 07 June 2016

**Interviewee**: Focus Group School C

**Place**: School C Guest lounge

**Researcher**: Right, we may begin. Good afternoon learners.

**Focus Group 3**: Good afternoon.

**Researcher**: My name is Vusani Ngwenya. I'm conducting a study for a Doctorate's degree at the University of South Africa. The topic of my project is "A Collaborative model for teaching and Learning Mathematics in secondary schools." I'm here to conduct interviews with mathematics educators in the cluster. The interview is gonna be divided into two types of questions. The first one will be biographical questions, where I will be asking questions of a personal nature and the second type will be research questions. The interview normally lasts for less than thirty minutes, for all the pilot studies that I have conducted, it has never exceeded thirty minutes and I would like to state on record that the study is conducted confidentially, the name of the school is kept confidentially- we use pseudo-names instead and the names of the participants are also kept confidential. Also, in response to all the questions, what the study seeks are just the experiences and views of mathematics learners regarding the teaching and learning of Mathematics in secondary schools and as such there are no correct or incorrect answers. I am gonna start with biographical questions.

**Researcher**: What are your names, Students?

**Focus Group 3**: OK. We are Student C1, C2, C3, C4, and C5 (Pseudonym)

**Researcher**: How old are you?

**Focus Group 3**: We are 15, 18,16,15,19 years respectively.

**Researcher:** How long have been in this school?

**Focus Group 3**: We have been learning at this school since 2013, 2014, that is 4 years and 3 years.

**Researcher**: Who do you stay with at home?

**Focus Group 2: I** stay with **C1-** my parents,

**C2-** my grandmother because both my parents are now late,

**C3**- my stepmom,

**C4**- with my siblings our parents are no more,

**C5**- my mother. And my two other sisters.

**Researcher**: What are the educational levels of your parents?

**Focus Group 3:** Mhuuu, Wooow (all exclaiming)

**C1**-My parents went to school up to Grade 5, left school due to fail of their parents to pay fees during those years ago before 1994.

**C2-** My granny eish did not go to school and cannot even write her name, she says girls did not attend school in their days and schools were very few and far.

**C3-** My stepmom went up to matric but failed it, did not continue and just sits at home looking after us.

**C4-** We all are attending school and l am the oldest, so it's me with high level of education which is Grade 9.

**C5-** My mom dropped from school at Grade 6 and opted to get married, she never went back to school after that level.

**Researcher**: Do your parents monitor or assist you in your Mathematics tasks?

**Focus Group 3**: Mmmmm (in unison)

**C1-** No one asks us about schoolwork and what I learn is far above my parent's level of education, my mom only asks if teachers teach us well and see that we are on time to school and have uniforms and things needed in school.

**C2-** oh my god, my granny only encourages me to go to school, cannot read my work at all, she does not even look at our schoolwork since she cannot read nor write kkkkk (laughing at that)

**C3-** My mom sometimes looks at my work; but the sums we do are so difficult that she does not help me when l seek help, l struggle on my own but she says she used to be good in mathematics. I think if I had some help I could be better in mathematics than now.

**C4-** We all by ourselves at home I encourage myself, no one helps me, but I help my brother and sis with their mathematics. I think could have been better if my parents were around schoolwork could be much easier I guess.

**C5-** Weeee, my mom has no idea what high school mathematics involves but encourages me to work hard. She always says she was good in mathematics at primary level and had she gone to high school she could have been of help. But shame she is supportive of schoolwork and gives me time to do school work.

**Researcher**: Thank you. Now we gonna proceed to research questions. The questions are an intended to get your views and experiences on how Mathematics is taught in your classrooms and how you think you can improve in it. The first question. As a Mathematics learner, how do you learn Mathematics in your class? /Describe how mathematics learning takes place in your class?

**Focus Group 3**: mhhh... (Laughing)

**C1-** Our teacher teaches us well but most times he works out answers on the chalkboard and use textbook example to teach us after that he gives class work. Teacher puts more trying on how the sums are done even if we do not understand the actual sums or what is being taught. Teacher does not give us time to understand and practice in our own as group or pairs. I tell you sir had our teacher be patient to help us understand content woow we could be far.

**C2-** Our mathematics lessons are ok; teacher is always on time and teaches us but I rarely understand and am scared to ask questions because other learners will laugh at me. But again, our learning of mathematics lacks fun; I think games and talking about mathematics can help to make our learning interesting and fun.

**C3-** In our class our teacher does more talking and shows all working of examples on the chalkboard followed by group work and individual work. Eish sometimes I don't get anything on what is actually shown on the chalk board, our teacher must put more time in helping us to understand what is taught before showing how we must do it. Other plan could be to give us more practice on metal mathematics skills like we used to do at primary and that can help things we are taught to sink deep, and we understand better. My other problem eish this one (laughing) I make mistakes in using the calculator properly. Teacher must help us with such skills which are useful.

**C4-** Our teacher likes mathematics and is always on time, each day he introduces new things, explains to us, and gives us work to do on our own, he does not mark our work most times. This problem of not marking our work yooo (grinning) makes us not to know our levels of performance in work that is not marked. Teacher again always tells us how difficult mathematics is and that we will fail and that discourages us and make us not happy, teacher must motivates us who struggle in mathematics to like it and practice it most times.

**C5-** Teacher explains on chalkboard then we try in our groups, most times we do not understand but keep quiet until the teacher leaves class. You can laugh if u visit our class during mathematics lessons, most learners' heads down no one asks any questions or answers when the teacher teaches. Same way teacher teach makes mathematics boring wish games on our phones could be used to teach as well and make teaching and learning of mathematics fun and interesting.

**Researcher:** Thank you. How do learners participate in the teaching and learning process?

**Focus Group 3**: Participation Eerr (sounding surprised)

**C1-** Very few only two or three out of a class of 40 participate actively in mathematics lessons, most of us we only do group tasks and individual work. Our mathematics class is always quiet during mathematics as no learner is able to ask or answer questions. Thinks is because we understand little of what our teacher says but fear our friends will laugh if we expose ourselves. Only one learner called X (not real name) is good and was not learning here until this year yoo he is good but does not get chance to help us, teacher should give him the chance.

**C2-** Most learners only do group tasks and class work and do not ask the teacher any questions during lessons. Mathematics learning in our class to say truth is boring and not interesting at all, same style of teaching daily, teacher must try games we see on cell phones and TV to help us to understand mathematics content. Other big, big problem is that teacher does not make us understand the content taught but rushes to show us how answers are worked out which makes it difficult to do sums on our own and in groups.

**C3-** Learners find mathematics difficult and do not freely participate in lessons for fear of being laughed at by other learners. Weee(expressing sadness) mathematics learning in our class is bad just disaster because most of us do not understand the content even when the teacher shows us on the board. I think more time must be put on explaining content before shown how to work out the sums. I also think teacher must encourage us and increase our expectations in mathematics. More problem solving and project tasks can make us work together is groups as we do tasks.

**C4**- Teacher in our class spend most time talking and explaining and there is little time for us learners to do practice tasks and we fail in most of our work. Much time in class should be for us learners to show what the teacher was teaching us so teacher must give us clear steps of how we should do sums. Its all writing and calculating, and most sums are just difficult yoo wish games could also be used to help us understand mathematics.

**C5-** Learners in mathematics class most times are quiet and do not answer teachers' questions. Mathematics is too difficult and confusing us. Only child X and Y (not real names) are the ones who answer and ask questions in our mathematics class, most of us we honestly do not follow and me is got low expectations of myself in mathematics.

**Researcher**: Thank You. How do methods used in teaching Mathematics affect your understanding of concepts? Explain your answer?

**Focus Group 3:** Oh,

**C1**- The way mathematics is taught in my class has impact on my understanding of concepts, my teacher uses textbook worked examples and I rarely understand him but scare to ask because class will laugh at me. Same methods that the teacher uses to teach and are boring to say the least, teacher talk and shows on chalkboard how one sum is done and gives us more difficult ones is not enough for us, we want more explanation on understanding content before calculations on it, games are not used yet they are fun and can help us to understand.

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**C1-** Learners must be made to understand Mathematics concepts, be involved in the practice of the concepts as groups and individually at home and school. One condition for involvement of learners is to create activities that are varied and interesting, these could include games quizzes, tests and projects that will involve all of us to think and contribute ideas that are useful to find solutions.

**C2-** Learners can effectively do mathematics through doing it in groups and pairs as well as individually. Tasks could be made into games, projects, assignments, investigations, videos, and tests. Learners need encouragement to do mathematics and as such teacher must motivate us to like mathematics by making it enjoyable and helping us to do tasks that are set. We as learners need to be given high hopes that mathematics is doable and easy so teachers must keep on motivating us to like the subject.

**C3-** Only way is to give learners chances to practice mathematics concepts, eat mathematics and live it in their lives. Mathematics must be lived experience in that activities we do in class must be related to our life experiences and help us understand what we learn in school. Problem solving tasks must be designed and given to us and the teacher helps us to work them out in our groups as we share our ideas.

**C4-** Changing beliefs about mathematics is also very important, most of us think that mathematics is difficult and that affects how we learn and do it. Our teacher must make us gain confidence in learning and doing mathematics, make us love it and like to do it daily. Minneri (Sir) our teacher sometimes say we will never pass mathematics and I think that is not good because it discourages us who struggle and love mathematics. So, working together in our class understanding ourselves and sharing ideas can help lot to make mathematics nice and interesting.

**C5-** I can add on what others have said that all learners must have own textbook for practice on his or her own and homework as well must be given and marked by our teacher. Sir, sad on this one, we need textbooks each one of us and stop this sharing, we want to practice at home and on our own so school must supply us with textbooks. Another one... what is it (pausing) teacher must give us chance to come out with our own methods of coming out with answers and opine the lesson to various approaches to a problem instead of one only. One relevant idea is to make mathematics classrooms very friendly for teaching and learning of mathematics by encouraging learners to be active as they do and discuss mathematics in the classroom.

**Researcher**: Thank You. Suggest how use of teaching and learning aids could improve the teaching and learning of Mathematics?

**Focus Group 3:**

**C1**- Interesting, teacher does not bring any teaching aids to class. Teaching and learning aids must be brought to the classroom to help teacher to explain the things we learn. Teaching and learning aids must aid the teacher and us to understand what is taught so the teacher must make them big enough to be seen from the back of the classroom and must be motivating to us to use to help our understanding.

**C2**- Teaching aids help us to understand concepts and teacher must use them at the concept introduction and explanation stage effectively, so we see easily how the concepts unfolds. These are pointers of what the lesson parts are about and should increase our understanding of what the teacher is teaching in a topic. Teaching aids simplify what is taught into smaller easier to understand parts of the topic.

**C3**- All our lessons must have teaching and learning aids so that the help us to understand easily the concepts taught. So, aids must be relevant, big enough and easy to understand and use so that they help explain what we learn. Yes, with teaching and learning aids learners can easily understand a concept as they sink deeper even after the lesson has been finished.

**C4**- Teaching and learning aids help to make real the mathematical concepts taught in class and make mathematics real and interesting. Through using teaching and learning aids learners will touch, smell, and use the aids to aid understanding of the learnt concepts. So, teacher must bring enough of the teaching aids and helps the learners to muse the aids for better understanding.

**C5**- My ideas taken kkkk (laughing), but I think learning aids simplify mathematics in that they can be seen and touched and as a result we understand better what is taught. Teaching aids make us relate to mathematical concepts that are taught and easier to follow through the use of teaching aids. But eeee(pausing) the teacher must be clear how they fit or are used in class lest they confuse us if he is not clear on how they relate to what us taught.

**Researcher**: Thank you. How do you think small group learning could affect quality teaching of Mathematics?

**Focus Group 3**:

**C1**- Working in groups helps us to share ideas on what is taught, the challenges and wins of getting answer right. Groups sirs are also good to increase our confidence and make us enjoy learning as a team and encouraging dialogue and sharing views on what is learnt in class.

Through a mathematics talk that encourages working together to find mathematics solutions.

**C2-** Small groups motivates us to do more, to express ourselves in a way we cannot do especially in a whole class. Being in groups make us to feel wanted and makes mathematics a social activity that all of us can be free to engage in and learn from each other. So, Sir when we work in groups we enjoy sharing ideas but we need to first fully understand the task that is to be done in groups.

**C3-** Group work helps teacher to monitor class work or task effectively as groups are small and easier to manage that whole class. Working in groups is making a classroom a community where mathematics problems are everyone's challenge and as such everyone is actively involved in finding a solution. Group work encourages participation and giving out ideas towards a solution.

**C4-** Small groups help to manage discipline in class as everyone gets engaged in the task that is given. Small groups' sir can also be used in class to encourage learners to work towards finding solutions and live mathematics in real life situations and come out with new ideas on how to solve mathematics problems. In group setups learners can create and solve their problems easily.

**C5-** Small groups teach leadership as in them one has to lead, that helps to have mathematics tasks done on time and with everyone participating. But in some groups only few participate while others do most of the work. Again, in small groups teacher can help more people at the same time and that makes understanding of the concept much faster within a given space of time.

**Researcher**: Thank you. How do you think assessment in Mathematics could be improved to result in the effect of understanding of concepts?

**Focus group 3**:

**C1-** Assessment is the most important result of teaching and learning and as such it should be done correctly and on time after a concept has been covered. Learners must be given a chance to prepare for assessments so that they revise. Again, assessments must vary and cater for different learner levels of understanding. Assessment task must not all be difficult, some should be simple while others difficult. Further assessment must be ongoing and related to expectations per grade and help learners to be better in mathematics and related concepts.

**C2-** Starting point is to make assessment tasks relevant to what was taught and have clear instructions and what learners are expected to do. Sir I also think that through assessments the teacher can plan how to help learners who are struggling with schoolwork because their performance is informing the teacher on how many understood and how many are struggling in a concept. Other forms of assessments must be used that are not tests but could be games, quizzes, or projects. Group leaders could present the outcomes to the class as well.

**C3-** Assessment should be done within adequate time, quality tasks that are related to covered concepts and done after a revision by the class and the teacher. Assessment in mathematics must be well planned and done not in a hurry but on time this means teacher must teach and give practice time after which learners get themselves ready for assessment which will show how they understood the content that was taught and is being tested.

**C4-** Assessment must take various forms such as tests, projects, assignments, and informal practice and all should be marked after done so that learners get feedback. Assessment mark must be given back to learners as feedback or what they got from a given topic and using the feedback teachers can plan how to help a learner who is struggling. So, assessment must not be used for the sake of it but to let the teacher know of how the lesson was taught and how the learners understood what was taught to them.

**C5-** Oh my God my points taken, but one last point is that all assessments must be given on time not in a hurry and marked on time, so we get our marks and feedback on time. Mathematics assessments are important to help plan remedial work and may be re-teaching of a topic by the teacher if most learners did not do well in it. Some assessments like projects and investigations must have clear instructions as they are designed to help learners to think of ways of solving problems and thinking skills that may help us in life.

**Researcher**: Thank you students that concludes our interview. I would like to thank you for a wealth of knowledge that you have contributed to this project.

**Focus Group 3**: Thank you very much too.

**APPENDIX 13: 4**

**Interview Transcript for Grade 10 Mathematics Learners**

**Date**: 07 June 2016

**Interviewee**: Focus Group School D

**Place**: School D Guest Lounge

**Researcher**: I think we should start now. A very good afternoon to you all.

**Focus Group 4**: Good afternoon.

**Researcher**: I am Vusani Ngwenya, and I am currently doing a survey for my doctorate studies with the University of South Africa. My thesis is entitled: *A Collaborative model for teaching and learning Mathematics in secondary schools*. I am here to conduct interviews with mathematics educators in this cluster.

The interview comprises biographical and research questions. The first set of questions will focus on the personal profiles of the interviewees, while the second type is made up of questions that are directly related to the study. I expect the interview to be no more than thirty minutes. I have conducted some pilot studies and I noted that none of the interviews lasted longer than half an hour.

Let me also state on record that the findings of this study will be treated confidentially, so the names of the respondents and the school will not be revealed. Instead, pseudo-names will be used. When responding to the research questions, please note that the study simply seeks to record the experiences and views of high school learners about how they are taught and how they learn of Mathematics. Thus, no view would be regarded as either right or wrong.

We will start with biographical questions. What are your names, students?

**Focus Group 4**: OK. We are Student D1, D2, D3, D4, and D5 (Pseudonyms)

**Researcher**: Please state your ages in respective order?

**Focus Group 4**: 15, 16,18,17 and 19.

**Researcher:** How long have you been at this school?

**Focus Group 4**: Since 2013 for some and 2014 for others. That makes it 4 and 3 years, respectively.

**Researcher**: Who do you stay with at home?

**Focus Group 4: I** stay with:

**D1**- My parents.

**D2**- My grandmother because my parents passed away.

**D3**- My stepmother.

**D4**- My siblings; our parents are no more.

**D5**- My mother and my two sisters.

**Researcher**: What are the educational levels of your parents or guardians?

**Focus Group 4:** [All exclaiming] Muumuu! Wow!

**D1**- Mine went up to Grade 5 but left school due to failure by their parents to pay fees. That was before independence in 1994.

**D2-** Eish! My grandmother never went to school and cannot even write her name. She says that girls did not attend school in their days and schools were very few and far.

**D3**- My stepmother went up to matric, but she failed it. She is a full-time housewife.

**D4**- My siblings and I are all in school. Being the eldest and doing Grade, I am the one who has the highest level of education in the family.

**D5-** My mother dropped out of school when she was in Grade 6 because she was getting married. After her marriage, she never went back to school.

**Researcher**: Do you get any help in your Mathematics tasks from your parents/guardians/siblings?

**Focus Group 2**: [In unison] Mmm!

**D1-** They never ask about schoolwork! To say the truth, the content that we are doing is beyond my parents' comprehension. My mother only asks if the teachers are treating and teaching us well. She is mostly concerned about us having clean uniform and adequate stationery whenever we leave home for school. She also wants us to be punctual all the time.

**D2 -** My God! My grandmother cannot read or write so she never checks my books, haha! However, she shows her support by encouraging me to attend all classes.

**D3**- From time to time, my mother checks my work, but she is not able to help me with my maths homework although she claims that she was very good at mathematics in primary school, so I struggle on my own. I believe I could be doing better if I had extra help after school.

**D4-** I live with my younger siblings, so I do not get any extra academic support at home. As a result, I do all my homework and studies on my own and I also help my siblings with their schoolwork. I guess I would be doing much better in schools if I had parental support.

**D5**- In my case, my mother has no idea what high school mathematics is like. She says she used to do well in maths at primary school, but she never got an opportunity to go to secondary school. However, she is always there to support me morally and materially. She also gives me time and space to study.

**Researcher**: Thank you. Now we are going to research questions, whichfocus on recording your thoughts and experiences pertaining to the teaching of Mathematics in your classrooms. Your suggestions on how best the teaching of the subject can be improved are also welcome. My first question is: *How do you learn Mathematics in your class?* In other words, the question requires you to describe how mathematics learning takes place in your class?

**Focus Group 4** [Laughing] Ha-ha!

**D1-** Our teachergenerally teaches well. He mostlydemonstrates on the chalkboardbefore giving us class work. The teacheralways puts emphasis onmark allocation, but rarely checks whether or not we have all grasped the concepts. The teacher does not give us a chance to understand and practice individually as a group or combines. It would be of muchhelpif he exercises patience by giving us individual attention as we practiseas this would enable us to understandbetter.

**D2-** Our mathematics lessons are alright; the teacher is constantly on time and encourages us. However, sometimes Ifeel uncomfortable to ask questions because I am afraid that my classmates will laugh at me. Be that as it may, again mathematicslearning needs much motivation; I wish it can be made moreexciting and fun.

**D3-** In our class, our teacherdoes all the talking and demonstrates with workedexamples on the chalkboard, followed by groupor individual tasks. Eish, here and there I fail tofollowas hewrites on the blackboard. I think our teacher must take time in helping us to understandconcepts before askingus todo the work on our own. We also need more practice time like we used to have at primary school, and this can help us to understand the things we are taughtin a better way. The other issue is, eish, [laughing]I often commit errors whenusing the calculator, so I need the teacherto assist me and othersto master the rightskills, which are valuable.

**D4-** Our teacher likes mathematics, and he is punctual. He presents new concepts and assigns us individual work. However, he seldom marks our work, and this demotivates us as we would not be able to know how we would have performed. The teacher also constantly tells us that the subject isso difficult that not many of us will get good grades and thisweakensand unsettles us. It would be best if the teachercould encourage those of us who are weak in mathematics to like the subject and constantly practise it.

**D5-** The teacher explainsand demonstrates by writing on the board, after which we are tasked to do groupactivities. On most occasions we fail to perform the tasks, yetnone of us dares to ask the teacheruntil he leaves the classroom. You wouldlaugh if you were to come to our class during mathematics lessons. You are likely to find most learners looking confused and none of them would pose any question or give a response when the teacher asks questions. I think the teacher can make mathematics more exciting by introducing games, some of which are accessible on our cellphones. This is likely to make the teaching and learning of mathematics fun and captivating.

**Researcher:** Thank you. How do learners participate in the teaching and learning process?

**Focus Group 4:** Participation Eerr [sounding surprised]

**D1- Just** a few out of a class of 40 seem to have any meaningful interest in mathematics lessons and the majority of us hardly contribute to group tasks or complete individual work. Our mathematics class is, in every case, quiet and boring as no learner can ask or answer questions because we hardly understand what our teacher says and also fear that our friends will laugh at us if we ask or answer questions. Only one student (codenamed X), who transferred from another school is good at mathematics. Maybe the teacher should allow him to help us.

**D2- Most** learners just do gather and pretend to be doing tasks and don't ask the teacher for clarity in the course of the lessons. Mathematics learning in our class is not fascinating by any stretch of the imagination. The teacher never varies his teaching style; we would be glad to learn through mobile phone-mediated games which will assist us to understand mathematical concepts. Another huge issue is that the teacher does not check to see if we have understood the content. Instead, he hurries to demonstrate how answers are arrived at, which makes it hard for us to practice, whether alone or in groups.

**D3-**Learners find mathematics difficult and don't openly participate in lessons due to fear of being laughed at by other learners. [Expressing misery] Mathematics learning in our class is awful because many of us don't understand the content, even when the teacher demonstrateson the board. I figure additional time must be put on explaining content before allocating tasks. Likewise, I think that the teacher should do more to encourage us to love mathematics. I prefer challenging tasks that compel us to think critically, whether working in groups or individually.

**D4-**Our maths teacher takes his time to explain concepts before giving us brief periods to do practice tasks, but we mostly fail to complete them correctly. I think we need more time for individual and group practice. Also, the teacher should clearly show the steps of how we arrive at solutions. It is difficult to figure on our own, in the little practice time that we are given, what and how exactly should be done, yoh! I wish the teacher could also make use of games to help us understand mathematical concepts better.

**D5-**The learners in my class are usually very quiet during mathematics classes, but they don't respond to teacher's questions. We generally find the subject excessively difficult and confusing. Students X and Y [not their real names] are the only ones who answer and pose questions in our mathematics class, since most of us sincerely don't follow and lack the right motivation.

**Researcher**: Thank You. How do the methods used in teaching Mathematics affect your understanding of concepts? Explain your answer?

**Focus Group 4:** Oh!

**D1-** The manner in which mathematics is taught in my class affects my understanding of concepts. Our teacher uses textbook worked examples and I seldom follow what he would be saying, yet I am fearful to ask as my peers might mock me. Some of the strategies that the teacher uses demotivate me. Although he shows examples on the blackboard before giving us progressively difficult tasks, this isn't sufficient for us. We need more explanations we can effectively understand concepts before doing tasks. Games are not used, yet they are fun and can assist us to clearly comprehend.

**D2-** The use of individual tasks before we understand what the teacher would have taught is demoralizing. Consequently, we neglect doing assigned tasks. Our teacher wants us to perform tasks before we understand what is taught, but I believe that we have to understand the content first. Again, the teacher does not sufficiently support us, but he always says that mathematics is difficult, and we will fail. That demoralises us a lot.

**D3-** I don't understand the teacher's explanations during the lesson and, on most occasions, I get the answers wrong. The teacher briefly explains the content that he needs us to learn then gives us a worked example from the textbook. Finally, we are given difficult tasks, which we obviously fail to complete correctly. The teacher puts fear and doubt in us by telling us that mathematics will is tough. As a result, we become demotivated. It would be good to have teachership gives us inspiration to study mathematics.

**D4-** Mathematics lessons in my class are, for the most part, teacher-centred. This means that the teacher does most of the talking and writing on the key concepts on the board. The teacher does not assess our work fairly and uniformly, which is very demoralizing, given that students who write the same answer receive different feedback. My other complaint is that our classroom environment is not conducive for learning mathematics, and we are not given opportunities for group or individual practice during the course of the lesson. We love mathematics, but we need a more supportive environment to appreciate it.

**Researcher**: Thanks. Suggest how learners could be actively involved in the teaching and learning of Mathematics?

**Focus Group 4**: [All shouting] Yes! Yes!

**D1**-Agreat deal sir! The fundamental issue is that, regardless of whether our teacher encourages us or not, l scarcely comprehends what he says, but he continues to give us tasks, which we fail to complete. The teaching methods and classroom set-up do not inspire us to appreciate mathematics. There is hardly any teacher-student interaction, which makes us fail to understand, since the teachers the one who talks on most occasions. Again, from the beginning, I found mathematics to be difficult and l have been struggling since then. It seems to be even more difficult now and the teacher has no patience with some of us who are struggling.

**D2-** Some of our friends laugh at us when we try to take an interest in mathematics, so we stay silent throughout each lesson. The teacher focuses on learners that are sharp and, once in a while, on a few of us who are struggling with mathematics. The vast majority of us neither ask nor answer questions in class for fear of being mocked by colleagues. The teacher needs to pay close attention to group activities as well as monitor individuals as they do activities in class. This will enable those of us who are hesitant to ask questions while the whole class is paying attention to ask the teacher confidentially so that he can help us with the concepts we are struggling with personally.

**D3-** One major issue we have is that we don't clearly understand what our mathematics teacher says. When he explains content, we are left confused and, at times, he doesn't focus on slow learners. The exercises that we are given are usually difficult, although there are a few units that are simple. The teacher does not teach us to reason in mathematics as most sums just need us to follow the method that he would have shown on the board. Some of the tasks that we do are not relevant or challenging enough for our level. So, the teacher must give us assignments and tests more frequently to help us to improve critical thinking through our mathematical abilities.

**D4-** Mathematics is interesting. However, it is hard to understand, and my concern is that I don't get sufficient chance to practice since l share a textbook with three other learners in my class. It is difficult to get the students in our class to effectively participate in group assignments. Also, all the groups are usually given identical tasks which are not challenging enough. The teacher needs to ensure that all group members participation carrying out tasks by contributing their thoughts and skills to find answers for the problem. Eish, sir, we need to help each other in class as we learn mathematics.

**D5-** My friends here have mentioned most of the issues we face. I likewise think that the teacher must mark our tasks, as most the times our work goes unmarked. Without feedback, we will not be certain whether we got the answers right or not. The teacher does not inspire us to do well in mathematics since he seldom gives us assignments that involve solving problems. Again, regarding technology, we are prohibited from bring in mobile phones to class, so games and other applications that can help us in mathematics are not offered space in our classes. Mathematics could be increasingly fun in the event that we use the games that increase our skills and understanding of content as we participate in group and class work.

**Researcher**: Thank you. How do you think Mathematics could be taught and learnt to give the best results?

**Focus Group 4:** [All at once] Yes! Yes!

**D1-** Eish, I trust this will work. If the end goal is to improve learners' performance in mathematics, our teachers must allow enough time for learning before individual tasks are given to the class. The teacher must invest more energy in helping us to understand the idea or content that is taught before drawing us into doing sums as a class or individually. The teacher should inspire students by showing them that it is possible to pass mathematics. The teacher is also expected to build a team or family spirit among the learners so that would be able to encourage each other and work together in solving the given mathematics problems. My other view is that our teacher should have more superior knowledge of mathematics in order to help us with solutions when we get stuck. This would give us the inspiration to continue attempting in spite of the difficulties we might experience.

**D2-** I likewise feel that as learners we should be allowed to help one another through sharing ideas and practicing in groups. Our teacher should maintain an inspirational spirit and not abandon struggling learners. I also figure that pressure must be put on understanding content compared to how sums are worked out. Spending additional time on content explanation is very pivotal. Mathematics should teach us to reason by distinguishing things and practicing our reasoning abilities.

**D3-** Sir, it's a huge expectation, but for mathematics to be improved, it starts with the teacher who ought to have enough content and understanding of what he teaches. Now and again, teachers neglect to answer questions because they lack knowledge of content. The teacher should enable us to be imaginative enough to work out problems individually. However, for that to happen we should be sure about what to do and how to do it with the assistance of the teacher. A few of us have been struggling in mathematics for a very long time due to lack of inspiration. So, our teachers must give us the confidence and encourage us to practice more. Sir, l doesn't know about this one, yet I think that our teachers must assist us by using innovation in class in order to improve our mathematics.

**D4-** Mathematics must be made simple and fun, and teachers must give examples and concepts that are straightforward. Again, much practice must be given in groups before we do individual work. Our teacher must give us problems that will assist us in using our mathematics skills to tackle problems in our communities, not simply the ***solve for X t***ype problems, a-ha [laughing resoundingly]. Use of different methods, for example, mental mathematics can help us since it will assist us with memorizing significant content and tasks. Learners also need to appreciate mathematics and figure using games can do wonders in that regard. The teacher must use mathematical games to shape our understanding of the subject.

**D5-**Our teacher must give us tasks in groups so we can practice a great deal. Again, homework must not be neglected since mathematics needs constant practice. Tasks and assignments where we apply diverse mathematical skills must be thoroughly taught beforehand. The teacher should constantly assist us by motivating us by demonstrating that mathematics is fun and simple. Teachers also need to sufficiently prepare students by giving a number of assessments such as tests to encourage practice and enhance understanding of ideas and content that is taught in class.

**Researcher**: Thank You. Suggest how the use of teaching and learning aids could improve the teaching and learning of Mathematics?

**Focus Group 2:**

**D1-** Learners understand mathematical concepts better when they actively participate in working out solutions/answers in groups and individually at school and home, respectively. One way of getting learners actively involved is to make the lessons fun and fascinating through incorporating games, tests and tasks that require learners to think critically and make meaningful contributions towards finding solutions.

**D2-** Learners can understand mathematics in two ways; by taking part in group work and practicing individually. Tasks could incorporate games and audio-visual recordings, culminating in assignments and tests. Learners need support to do mathematics and, all things considered, teachers must help us to like mathematics by making it exciting to learn. We should always be given encouragements that we can view mathematics as a simple subject, so teachers must continue motivating us to like the subject.

**D3-**The best way to motivate learners is giving them opportunities to “practice mathematics, eat mathematics and live mathematics”. Mathematics learning requires learners to be actively involved in class activities. Teachers must use familiar examples that we can easily relate to help us understand what we would be doing in class. More challenging assignments must be practiced in small groups to enable learners to share ideas and solutions before doing the tasks on their own. Encouragement from the teacher will help us to stay focused and motivated to like mathematics.

**D4-** Changing our thinking about mathematics is significant because the most of us believe that the subject is difficult and that influences how we learn and do it. Our teacher must make us more confident to study mathematics; that way we will develop a positive attitude towards it day by day. Teacher X [not real name] always says that we will never pass mathematics and I think that isn't good since it disheartens most of us who are not very good in mathematics but have a passion to learn it. Cooperating in our groups helps us to share ideas and I believe that it can assist a great deal with making mathematics learning bearable and exciting.

**D5-** I agree with those who say that all learners must have read material so that they can be able to practice and do homework on their own. Sir, [sounding miserable] we need textbooks for every single one of us and stop this sharing. We need to practice at home, so the school must supply us with textbooks. Again, teachers must give us the chance to try out with our very own techniques for finding answers and conduct lessons in different ways, rather than use one method throughout. I think that it would be good to make the classroom atmosphere suitable for teaching and learning of mathematics; teachers can do this by urging learners to be as open-minded as possible as they tackle mathematical problems.

**Researcher**: Thank you. Suggest how the use of teaching and learning aids could improve the teaching and learning of Mathematics?

**Focus Group 4:**

**D1-** Interestingly, our teacher does not carry any teaching aids to class. Teaching and learning aids must be taken to the classroom to assist the teacher in explaining the content. Teaching and learning aids must guide the teacher and us to understand what is taught, so the teacher must make use of aids that are clear enough to be seen from the back of the classroom. Teaching and learning aids must be motivating enough to inspire us to understand concepts.

**D2-** Teaching and learning aids help us to clearly understand ideas and the teacher must use them when presenting or explaining new concepts so we can easily see how the content is structured. The use of aids at each stage of the lesson aids students ‘understanding of the content. Teaching and learning aids certainly help to breakdown content into smaller and more manageable concepts or points.

**D3-** In all lessons, teachers must make use of teaching and learning aids in order to ensure that all learners effectively understand what is being taught. So, the aids must be suitable, clearly visible, and simple to follow and use so as to avoid confusing learners. Indeed, by using teaching and learning aids, teachers intend to help learners to understand an idea by visualizing it, even after the lessons done.

**D4-** Teaching and learning aids make the mathematical ideas taught in class appear real and fascinating. Learners will be able to touch, feel, smell, and use the teaching and learning aids, which helps them to easily relate to the subject content. Therefore, it is important for the teacher to make use of appropriate teaching aids because they compel the learners to think and understand better.

**D5-** My colleagues have said all I wanted to say, a-ha [giggling]. However, I think learning aids improve mathematics learning since they can be seen and touched, thus helping us to clearly understand what we are being taught. Teaching aids influence us to identify with mathematical ideas, thus making it easy for us to complete tasks. In any case, the teacher must make appropriate use of teaching aids to avoid confusing us, in the event that student find it difficult to relate the aids to the content.

**Researcher**: Thank you. How do you think small group learning could affect quality teaching of Mathematics?

**Focus Group 4**:

**D1-** Working in groups encourages us to share our thoughts on what would have been taught. Group learning provides students with a platform to discuss the different approaches to understanding mathematical concepts. Working in groups enables us to build self-confidence as we share ideas on what we would have learnt. Discussing with colleagues encourages us to cooperate in finding solutions to mathematical problems.

**D2-** Small groups help us to accomplish more and understand better than we could do in an entire class discussion. Being in groups makes us feel appreciated. It also makes mathematics learning a social action that we all can be allowed to participate in and learn from one another. So, sir, when we work in groups, we benefit from sharing thoughts. However, we have to first completely understand the assignment that will be done in groups.

**D3-** Group work encourages the teacher to screen class work or tasks viably as groups are smaller and simpler to deal with than entire classes. Working in groups results in classroom network in which mathematics problems and solution finding processes are mutually shared. Group work promotes learner interest and sharing of ideas as they seek for solutions to given tasks.

**D4-** Small groups help to bring discipline in class, especially when all learners are occupied with the given task. Small groups can be used to encourage learners to progress in the direction of finding math solutions. In most cases, group work helps learners to discover new ideas and methods on how to solve mathematics problems. In group setups, learners can identify and effectively than in whole class scenarios.

**D5-** When working in small groups, students are able to show initiative and leadership skills, and this may result in all students participating meaningfully and mathematics assignments being done on time. Be that as it may, in certain groups, some students do not participate at all, leaving only a few to do the greater part of the work. However, the main advantage of small groups is that the teacher can help more individuals in a short space of time, which helps students to understand content a lot quicker.

**Researcher**: Thank you. How do you think assessment in Mathematics could be improved to result in effective understanding of concepts?

**Focus group 4**:

**D1-** Assessment is the most significant aspect of teaching and learning and accordingly, it ought to be done accurately, fairly, and timeously. Learners must be allowed to get ready for assessments, with the goal that they demonstrate understanding of what they studied. Again, assessments must accommodate different learners 'levels of understanding. Assessment tasks must, therefore, reflect different levels of difficulty. Further, assessment must be continuous in order to help learners to perform better in mathematics and related subjects.

**D2-** The first step entails making assessment tasks applicable to what was taught. Assessors should provide clear guidelines of what learners are expected to do. Sir, I also think that through assessments, the teacher would be able to plan how to help learners who are struggling with schoolwork since each assessment tasks gives indication of individual students 'areas of strength and weakness. Different types of assessments, other than tests, should be used. It might also be helpful to display the marks of top performers in each task in the classroom.

**D3-** Assessments need to be completed within a reasonable timeframe. The assignments should be base discontent and concepts that the teacher presented and discussed in class. Assessment in mathematics must be pre-planned and students need to be given ample time to complete the tasks. Consistent practice is important as it helps to prepare learners for assessment. In addition, each assessment task helps to show the extent to which learners understood the content that was taught.

**D4-** Assessment must take different structures, for example, tests, tasks, assignments, and in-class practice, which all ought to be assessed after completion so as to give appropriate feedback to learners. Assessment feedback should encourage and guide learners to see where and how they need to improve. On the other hand, assessment is also used to assist the teacher to reflect on his teaching methods and how specific learners need to be assisted.

**D5-** [Expressing disappointment] Oh my goodness, all my points have been taken! However, one final point is that all assessments must be given on time, not in a rush. Again, they should be fairly spaced so we can get feedback on time. Mathematics assessments are essential as they help the teacher to plan remedial work and revision, based on students' performance. All assessments, like activities and tests, must have clear guidelines in order to assist us to use appropriate problem-solving methods and thinking abilities.

**Researcher**: Thank you, students that concludes our interview. I would like to thank you for the wealth of knowledge that you have contributed to this project.

**Focus Group 4**: Much thanks as well.

**APPENDIX 13. 5**

**Focus Group Interview Transcript for Grade 10 Mathematics Learners**

**Date**: 18 June 2016

**Interviewee**: Focus Group School E

**Place**: School E Guest lounge

**Researche**r: Right, we may begin. Good afternoon Grade 10 learners.

**Focus Group 5**: Good afternoon, Sir.

**Researcher**: My name is Vusani Ngwenya. I'm conducting a study for a Doctorate's degree at the University of South Africa. The topic of my project is "A Collaborative model for teaching and Learning Mathematics in secondary schools." I'm here to conduct interviews with mathematics learners. The interview will be divided into two sections with different types of questions. The first one will be biographical questions, where I will be asking questions of a personal nature and the second type will be research questions. The interview normally lasts for less than thirty minutes, for all the pilot studies that I have conducted, it has never exceeded thirty minutes and I would like to state on record that the study is conducted confidentially, the name of the school is kept confidentially- we use pseudo-names instead and the names of the participants are also kept confidential. Also, in response to all the questions, what the study seeks are just the experiences and views of mathematics learners regarding the teaching and learning of Mathematics in secondary schools and as such there are no correct or incorrect answers. I am going to start with biographical questions.

**Researcher**: **What are your names, Students**?

**Focus Group 5**: OK. We are Student E1, E2, E3, E4, and E5 (Pseudonym)

**Researcher**: How old are you?

**Focus Group 5**: We are 15, 18,16,15,19 years respectively.

**Researcher:** How long have been in this school?

**Focus Group 5**: We have been learning at this school since 2013, 2014, that is 4 years and 3 years.

**Researcher**: **Who do you stay with at home?**

**Focus Group 5: I** stay with **A1-** My stepmother.

**E2-** My grandmother because both my parents are now late,

**E3-** My mom,

**E4-** With my siblings our parents are no more,

**E5-** My mother. And my two other sisters.

**Researcher**: **What are the educational levels of your parents?**

**Focus Group 5:** Iesha Khuu, kkkk (all laughing)

**E1**-My parents went to school up to Grade 6, left school due to fail of their parents to pay fees during those years ago before democracy in 1994.

**E2**- My granny eish did not go to school and cannot even write her name, she says girls did not attend school in their days and schools were very few and far.

**E3**- My stepmom went up to matric but failed it, did not continue and just sits at home looking after us.

**E4**- We all are attending school and l am the oldest, so it's me with high level of education which is Grade 9.

**E5**- My mom dropped from school at Grade 7 kkkk(laughs)and opted to get married, she never went back to school after that level.

**Researcher**: **Do your parents monitor or help you in your Mathematics tasks or homeworks?**

**Focus Group 5**: Mmmmm yooo (in unison)

**E1**- No one in my home asks us about school work and what I learn is far above my parent's level of education, my mom only asks if teachers teach us well and see that we are on time to school and have uniforms and things needed in school. Ohhh (interjecting) My dad gets cross when a teacher beats me up or scolds at me

**E2**- oh my God granny granny, granny (excitedly repeating the word), my granny only encourages me to go to school, cannot read my work at all, she does not even look at our schoolwork since she cannot read nor write kkkkk (laughing at that). Yes yes, but always attends meetings and collects my report.

**E3**- My mom sometimes looks at my work; shouts if does not see a tick, but the sums we do are so difficult that she does not help me when l seek help, l struggle on my own but she says she used to be good in mathematics kkkkkk(laughs at the statement). I think if I had some help I could be better in mathematics than now.

**E4**- At my home we live by ourselves, I encourage myself; no one helps me, but I help my brother and sis with their mathematics. Eish eish (emotionally touched) I think could have been better if my parents were around schoolwork could be much easier I guess.

**E5**- Weeee bad bad bad (repeating d words), my mom has no idea what high school mathematics involves but encourages me to work hard. She always says she was good in mathematics at primary level and had she gone to high school she could have been of help. But shame she is supportive of schoolwork and gives me time to do school work.

**Researcher**: Thank you students. Now we proceed to research questions. The questions are intended to get your views and experiences on how Mathematics is taught in your classrooms and how you think you can improve in it. The first question. **As a Mathematics learner, how do you learn Mathematics in your class? /Describe how mathematics learning takes place in your class?**

**Focus Group 5**: mhhh eish kkkkk... (Laughing all at once)

**E1-** Our teacher teaches us well but most times he works out answers on the chalkboard and use textbook example to teach us after that he gives class work. Teacher puts more trying on how the sums or concepts are done even if we do not understand the actual sums or what is being taught. Teacher does not give us time to understand and practice in our own as group or pairs. Mineri (Afrikaans for Sir) does not give enough time to help us understand concepts in the lesson. I tell you sir had our teacher be patient to help us understand content woow we could be far.

**E2-** Our mathematics lessons are ok; teacher is always on time and teaches us but I hardly understand and am scared to ask questions because other learners will laugh at me. Once your hand is up everyone looks at u and you feel embarrassed. But again, our learning of mathematics lacks fun; I think games and talking about mathematics can help to make our learning interesting and fun. Group discussions on concepts and sums we do must be used we love mathematics sir kkkk (laughs)

**E3-**Sir I tell the truth, in our class our teacher does more talking and shows all working of examples on the chalkboard followed by group work and individual work.Eish sometimes I don't get anything on what is actually shown on the chalk board, our teacher must put more time in helping us to understand what is taught before showing how we must do it. Other plan could be to give us more practice on metal mathematics skills like we used to do at primary and that can help things we are taught to sink deep, and we understand better. My other problem eish this one (laughing) I make mistakes in using the calculator properly. Teacher must help us with such skills which are useful.

**E4-** Our teacher likes mathematics and is always on time, each day he introduces new things, explains to us, and gives us work to do on our own, he does not mark our work most times. This problem of not marking our work yooo (grinning) makes us not to know our levels of performance in work that is not marked. Teacher again always tell us how difficult mathematics is and that we will fail eish eish eish (changing facial looks) and that discourages us and make us not happy, teacher must motivates us who struggle in mathematics to like it and practice it most times.

**E5**- Teacher explains on chalkboard then we try in our groups, most times we do not understand but keep quiet until the teacher leaves class. Yoooooo (teasing). You can laugh if you visit our class during mathematics lessons; most learners heads down no one asks any questions or answers when the teacher teaches. Same way teacher teach makes mathematics boring wish games on our phones could be used to teach as well and make teaching and learning of mathematics fun and interesting.

**Researcher:** Thank you. **How do learners participate in the teaching and learning process?**

**Focus Group 5**: Participation Participation wooow Eerr (sounding surprised)

**E1**- Sir its bad, Very few only two or three out of a class of 40 participate actively in mathematics lessons, most of us we only do group tasks and individual work. Our mathematics class is always quiet during mathematics as no learner is able to ask or answer questions. Thinks is because we understand little of what our teacher says but fear our friends will laugh if we expose ourselves. Only one learner called X (not real name) is good and was not learning here until this year yoo he is good but does not get chance to help us, teacher should give him the chance. If our fellow learner explains mathematics, we could see maybe that it is easy and doable.

**E2**- Eish eish Sir, our class is disaster, most learners only do group tasks and class work and do not ask the teacher any questions during lessons. Mathematics learning in our class to say truth is boring and not interesting at all, same style of teaching daily, teacher must try games we see on cell phones and TV and internet to help us to understand mathematics content. Other big, big problem is that teacher does not make us understand the content taught but rushes to show us how answers are worked out which makes it difficult to do sums on our own and in groups.

**E3**- Most learners in my class find mathematics difficult and do not freely participate in lessons for fear of being laughed at by other learners.Weee wee(expressing sadness) mathematics learning in our class is bad just disaster because most of us do not understand the content even when the teacher shows us on the board. I think more time must be put on explaining content before shown how to work out the sums. I also think teacher must encourage us and increase our expectations in mathematics. More problem solving and project tasks can make us work together is groups as we do tasks.

**E4**- Our mathematics teacher spends most time talking and explaining and there is little time for us learners to do practice tasks and we fail in most of our work. Much time in class should be for us learners to show what the teacher was teaching us so teacher must give us clear steps of how we should do sums. It’s all writing and calculating and most sums are just difficult yoo yoo (exclaiming) wish games could also be used to help us understand mathematics.

**E5-** Learners in mathematics class most times are quiet and do not answer teachers’ questions. Mathematics is too difficult and confusing us. Only child X and Y (not real names) are the ones who answer and ask questions in our mathematics class, most of us we honestly do not follow and me is got low expectations of myself in mathematics, but l love the subject.

**Researcher**: Thank You guys. **How do methods used in teaching Mathematics affect your understanding of concepts? Explain your answer?**

**Focus Group 5:** Oh, yes yes yes (expressing relief)

**E1-** The way mathematics is taught in my class has impact on my understanding of concepts, my teacher uses textbook worked examples and I rarely understand him but scare to ask because class will laugh at me. Same methods that the teacher uses to teach and are boring to say the least, teacher talk and shows on chalkboard how one sum is done and gives us more difficult ones is not enough for us, we want more explanation on understanding content before calculations on it, games are not used yet they are fun and can help us to understand.

**E2-** Quick and everyday use of individual tasks before we understand what the teacher would have taught is discouraging as we fail to do the task which is given. Our teacher rushes us to do give us task before we understand what was taught, I need to understand content before calculations on sums from it. Again, our teacher eish eish eish all the time (showing hopelessness) does not encourage us but always say mathematics is difficult and we will fail it. That discourages us a lot.

**E3-** Me sir its bad, I fail to understand the teacher’s explanations during the lesson period and as such most times I do not get the sums correctly. Teacher takes little time to explain content that he wants us to learn and gives us an example that is worked out from the textbook then after that yooo hard sums come which are difficult, we try them but get stuck on way, Teacher frightens us that mathematics will teach us hard lessons because it is difficult so we have low motivation. Teacher must give us hope in mathematics and support us as we learn it.

**E4-** Mathematics lessons in my class are mostly teacher act where the teacher does most talking and showing us on the chalkboard how the concepts are explained. Teacher gives same sums type and makes our assessment boring we can maybe just think is we get other types of assessment such as projects or task where we can find solution to a problem or work in group and be creative using our things and books. My other complaint is that our class must be busy with things to do things that we can use to learn mathematics and again chance to help each other on our own can help us. We love mathematics and want to enjoy it.

**Researcher**: Thank you. As Mathematics learners, **what challenges do you face in the learning of Mathematics?**

**Focus Group 5**: OK. Yah yah yah (same time chanting)

**E1-**Eish eish quite a lot sir, Main problem is that even if our teacher teaches us well l hardly understands him and he proceeds to give us tasks as individuals where we again fail to work out the sums. Our class does not offer support and create room for us learners to do and enjoy mathematics. There is little dialogue in our class and that makes us not to understand it as only the teacher talks most times in our class. Again this mathematics was difficult from primary and l never understood it so now worse and teacher has no time to walk with us who are struggling. All our teachers from primary made us look fools in mathematics we always fail it.

**E2-** In our class. some of our friends laugh at us when we try to participate in mathematics lessons and we choose to keep quiet during lessons. Teacher pays attention to learners that are clever and rarely pay attention to some of us who are struggling with mathematics. Most of us fear to ask or raise hands in class because some will laugh at us. Teacher must give us attention say in groups or on our own come to us as we do the work so we ask him questions where we are not clear. Little time is put on helping us to understand the content I see the teacher putting more time and emphasis on how the sum is worked out than on its content.

**E3-** One big challenge this is the key yooo (sad expression) we have is that we don't understand our Mathematics teacher and when he explains we are left behind and sometimes he does not pay attention to slow learners. Sums that are given are always difficult may be some sums must be easier to do so that we can try difficult ones. Teacher does not teach us to reason in mathematics as most sums only want us to follow the steps that the teacher will have shown us on the board. Tasks we do some must be like problems to some situations and we work out solutions to them that can make us happy. So teacher must give us projects and investigations more often so that we improve our problem solving skills through mathematical skills.

**E4-** Mr., to me, Mathematics is enjoyable but difficult to understand, my problem is that I don't get enough time to practice since l share a textbook with three other learners in the class. Our class does not support working in groups on tasks that are given and our tasks are the same not interesting or involving all of us to help find solutions. Teacher must support us in working together on tasks like projects and investigations where we will share ideas and our abilities in finding solutions to a problem. Eish sir we want to help each other in class as we learn mathematics.

**E5-** My friends have said most problems we face but I also think that teacher must marks our books after a task is given because most of the work in our books is not marked and we not sure is we got the answers correct. Teacher does not make us participate in mathematics lessons through giving us tasks that will involve us in solving problems that we are given and give back our solutions to the class. Again how about using technology, teacher insults you if you carry a cell phone to class so games and other applications that can help work mathematics are not given space to be tried in our classes. Mathematics could be more fun if we use the games and share skills and understanding in our groups and class.

**Researcher**: Thank you.**How do you think Mathematics could be taught and learnt in order to give best results?**

**Focus Group 5:** Jah yes, yes yes, yes (all at once)

**E1-** Eish, eish hope this works, in order for mathematics to be improved our teacher must give enough time for practice before individual tasks are given to the class. Teacher must spend more time on helping us to understand the concept or content that is taught before engaging us into doing sums as a class or individuals.Teacher must also create an environment in class that promotes investigation and make our class a family that helps each other in finding solutions to mathematics problems given. Another of my view is that our teacher must have more knowledge of mathematics and give us answers where we are unclear and give us motivation to keep trying despite being difficult.

**E2** Yes, sir, I also think that as learners we must be given a chance to explain to each other the concepts and practice in groups and share ideas of what has been taught. Our teacher must always maintain a positive attitude about mathematics and not give up on us struggling learners. Again I think stress must be put on understanding content compared to how sums are worked out, more time on content explanation is crucial. Mathematics must also teach us learners to reason through identifying things and exercising out thinking skills. More mathematics must be games so we enjoy it and participate.

**E3-** Sir it’s a huge hope, For mathematics to be improved I think it begins with the teacher who should have enough content and understanding of what is taught, sometimes teacher fail to answer us. Teacher must also allow us to be creative, to work out problems on our own but for that to happen we need to be clear on what to do and how to do it with the help of the teacher. Some of us have been failing mathematics for ages and have little motivation so our teacher must give us hope and encourage us to do more more practice and more thinking and engaging in mathematics tasks. Sir l am not sure on this one, but I think our teacher must help us to use technology in class to improve our mathematics.

**E4-** Mathematics must be made easy and fun, teachers must give examples and illustrations that are easy to understand and again much practice must be given in groups before we do individual work. Again our teacher must give us problems that will help us to use our mathematics skills to solve problems in our communities not always doing solve for x problems kkkkkkk (laughing aloud).Use of other approaches such as mental mathematics can help us because it will help us to memorise important content and steps by head. We as learners also want to enjoy mathematics and I think using games can do wonders; teacher must bring mathematics games to increase our attention and make us focused.

**E5**-In our class, teacher must gives us tasks in groups so we practice a lot and again homework must be there as mathematics needs practice a lot. Various tasks such as projects and assignments where we apply mathematics skills must be explained before given to us. Our teacher must always help us to grow positive attitudes towards mathematics to make us believe that mathematics is fun and easy. Our teacher must also make assessment varied and interesting include more tests and quizzes to foster practice and understanding of concepts and content that is taught in class.

**Researcher**: Thanks. **Suggest how learners could be actively involved in the teaching and learning of Mathematics?**

**Focus Group 5**: Yes, Yes, change change change (All of the students exclaiming)

**E1-** Starting point it that learners must be made to understand Mathematics concepts, be involved in the practice of the concepts as groups and individually at home and school. One condition for involvement of learners is to create activities that are varied and interesting, these could include games quizzes, tests and projects that will involve all of us to think and contribute ideas that are useful to find solutions.

**E2-** Learners can effectively do mathematics through doing it in groups and pairs as well as individually. Tasks could be made into games, projects, assignments, investigations, videos and tests. Learners need encouragement to do mathematics and as such teacher must motivate us to like mathematics by making it enjoyable and helping us to do tasks that are set. We as learners need to be given high hopes that mathematics is doable and easy so teachers must keep on motivating us to like the subject.

**E3**- Solution only way is to give learners chances to practice mathematics concepts, eat mathematics and live it in their lives. Mathematics must be lived experience in that activities we do in class must be related to our life experiences and help us understand what we learn in school. Problem solving tasks must be designed and given to us and the teacher helps us to work them out in our groups as we share our ideas.

**E4-** Changing beliefs, what we think Sir about mathematics is also very important, most of us think that mathematics is difficult and that affects how we learn and do it. Our teacher must make us gain confidence in learning and doing mathematics, make us love it and like to do it daily.Minneri (Sir) our teacher sometimes say we will never pass mathematics and I think that is not good because it discourages us who struggle and love mathematics. So working together in our class understanding ourselves and sharing ideas can help lot to make mathematics nice and interesting.

**E5-** I can add on what others have said that all learners must have own textbook for practice on his or her own and home works as well must be given and marked by our teacher. Sir, sad on this one, we need textbooks each one of us and stop this sharing, we want to practice at home and on our own so school must supply us with textbooks. Another one... what is it (pausing) teacher must give us chance to come out with our own methods of coming out with answers and opine the lesson to various approaches to a problem instead of one only. One relevant idea is to make mathematics classrooms very friendly for teaching and learning of mathematics by encouraging learners to be active as they do and discuss mathematics in the classroom.

**Researcher**: Thank You learners. **Suggest how use of teaching and learning aids could improve the teaching and learning of Mathematics**?

**Focus Group 5:**

**E1-** Interesting, teacher does not bring any teaching aids to class. Teaching and learning aids must be brought to the classroom to help teacher to explain the things we learn. Teaching and learning aids must aid the teacher and us to understand what is taught so the teacher must make them big enough to be seen from the back of the classroom and must be motivating to us to use to help our understanding. Sir I also think teacher must ask us to help in making the teaching and learning aids for use in our lessons.

**E2-** Teaching aids help us to understand concepts and teacher must use them at the concept introduction and explanation stage effectively so we see easily how the concepts unfolds. These are pointers of what the lesson parts are about and should increase our understanding of what the teacher is teaching in a topic. Teaching aids simplify what is taught into smaller easier to understand parts of the topic. Use of things we are familiar with from home could also help to make mathematics easy and interesting.

**E3-** All our lessons must have teaching and learning aids so that the help us to understand easily the concepts taught. So aids must be relevant, big enough and easy to understand and use so that they help explain what we learn. Yes with teaching and learning aids learners can easily understand a concept as they sink deeper even after the lesson has been finished.

**E4-** Teaching and learning aids help to make real the mathematical concepts taught in class and make mathematics real and interesting. Through using teaching and learning aids learners will touch, smell and use the aids to aid understanding of the learnt concepts. So teacher must bring enough of the teaching aids and helps the learners to muse the aids for better understanding. Teacher must put thought in making aids to help in teaching and learning mathematics.

**E5-** My ideas taken kkkk (laughing), but I think learning aids simplify mathematics in that they can be seen and touched and as a result we understand better what is taught. Teaching aids make us relate to mathematical concepts that are taught and easier to follow through the use of teaching aids. But eeee(pausing) the teacher must be clear how they fit or are used in class lest they confuse us if he is not clear on how they relate to what us taught.

**Researcher**: Thank you. **How do you think small group learning could affect quality teaching of Mathematics?**

**Focus Group 5**: Yes yes that is the way (Exclaiming all at once)

**E1-** I think working in groups helps us to share ideas on what is taught, the challenges and wins of getting answer right. Groups sir are also good to increase our confidence and make us enjoy learning as a team and encouraging dialogue and sharing views on what is learnt in class. Through a mathematics talk that encourages working together to find mathematics solutions. We can also freely express ourselves in group set up as compared to class.

**E2-** Sir in small groups we get motivated to do more, to express ourselves in a way we cannot do especially in a whole class. Being in groups make us to feel wanted and makes mathematics a social activity that all of us can be free to engage in and learn from each other. So Sir when we work in groups we enjoy sharing ideas but we need to first fully understand the task that is to be done in groups. Groups motivate and make us act and keep trying.

**E3-** Mineri, the truth is that group work helps teacher to monitor class work or task effectively as groups are small and easier to manage that whole class. Working in groups is making a classroom a community where mathematics problems are everyone’s challenge and as such everyone is actively involved in finding a solution. Group work encourages participation and giving out ideas towards a solution.

**E4-** Small groups help to manage discipline in class as everyone gets engaged in the task that is given. Small groups' sir can also be used in class to encourage learners to work towards finding solutions and live mathematics in real life situations and come out with new ideas on how to solve mathematics problems .In group setups learners can create and solve their problems easily.

**E5-** Small groups teach leadership as in them one has to lead, that helps to have mathematics tasks done on time and with everyone participating. But in some groups only few participate while others do most of the work. Again in small groups teacher can help more people at the same time and that makes understanding of the concept much faster within a given space of time.

**Researcher**: Thank you. **How do you think assessment in Mathematics could be improved to result in the effect of understanding of concepts?**

**Focus group 5**:

**E1-** Yes that is the key, assessment is the most important result of teaching and learning and as such it should be done correctly and on time after a concept has been covered. Learners must be given a chance to prepare for assessments so that they revise. Again assessments must vary and cater for different learner levels of understanding. Assessment task must not all be difficult, some should be simple while others difficult. Further assessment must be ongoing and related to expectations per grade and help learners to be better in mathematics and related concepts.

**E2-** Sir our starting point is to make assessment tasks relevant to what was taught and have clear instructions and what learners are expected to do. Sir I also think that through assessments the teacher can plan how to help learners who are struggling with school work because their performance is informing the teacher on how many understood and how many are struggling in a concept. Other forms of assessments must be used that are not tests but could be games, quizzes or projects. Group leaders could present the outcomes to the class as well.More practice and more assessments can help us to improve and teacher must mark our work.

**E3-** True, assessment should be done within adequate time, quality tasks that are related to covered concepts and done after a revision by the class and the teacher. Assessment in mathematics must be well planned and done not in a hurry but on time this means teacher must teach and give practice time after which learners get themselves ready for assessment which will show how they understood the content that was taught and is being tested.

**E4-** Assessment must take various forms such as tests, projects, assignments and informal practice and all should be marked after done so that learners get feedback. Assessment mark must be given back to learners as feedback or what they got from a given topic and using the feedback teachers can plan how to help a learner who is struggling. So assessment must not be used for the sake of it but to let the teacher know of how the lesson was taught and how the learners understood what was taught to them.

**E5-** Oh my God my points taken, but one last point is that all assessments must be given on time not in a hurry and marked on time so we get our marks and feedback on time. Mathematics assessments are important to help plan remedial work and may be re-teaching of a topic by the teacher if most learners did not do well in it. Some assessments like projects and investigations must have clear instructions as they are designed to help learners to think of ways of solving problems and thinking skills that may help us in life.

**Researcher**: Thank you students that concludes our interview. I would like to thank you for such a pool of knowledge that you have contributed to this project and hope it will be of much use to the study.

**Focus Group 5**: Thank you very much too Sir.

## APPENDIX 14: INFORMATION AND CONSENT FORMS FOR TEACHERS AND PRINCIPALS

| THESIS TITLE: A COLLABORATIVE MODEL FOR TEACHING AND LEARNING MATHEMATICS IN SECONDARY SCHOOLS |
|---|

| RESEACHER CONTACTS |
|---|
| Mr Vusani Ngwenya<br>Doctor of Education (Curriculum Studies) Degree (student)<br>0719425356<br>ngwenyavee@yahoo.ca |

Description

This project is being undertaken as part of Doctor of Education (Curriculum Studies) Degree for Vusani Ngwenya.The project is unfunded. The purpose of this thesis is to develop **a Collaborative model for teaching and learning Mathematics in secondary schools.**

The researcher requests your assistance to contribute to information about the attitude of practicing Mathematics teachers and their views on how collaboration can play a key role in improving the teaching of Mathematics in a social context as opposed to individualised classrooms. The opinions and personal experiences of practising educators are considered to be extremely valuable. The data collected will help the research understand the beliefs and attitudes of Mathematics educators and how they can work together as teams in collaboration with each other and the learners they teach in Mathematics classrooms.

Participation

Your participation in this project is voluntary. If you do agree to participate, you can withdraw from participation at any time during the project without comment or penalty. If you choose to withdraw, any data collected from you will be removed from the data set and destroyed immediate. Your decision to participate will in no way impact upon your current or future relationship with the researcher or the University of South Africa. Your participation will involve:

Completing an attitude toward mathematics survey. This will take approximately 15 minutes and can be completed at a time convenient to you.

Receiving confidential follow up feedback about your attitude (as measured in the survey) at a time and place convenient to you

Considering an offer to participate in the open ended interview to further

Explore how your attitudes toward mathematics were formed. As part of this research, I am interested in using the views of educators and the learners they teach to craft a model that will be used in teaching and learning Mathematics in secondary schools and improve the Mathematics outcomes.

Expected benefits.

The research may not benefit you immediately, however, it may prompt greater understanding of your attitude towards mathematics and it may help inform future provision of professional support to teacher. Provision of a model will usher in a new teaching approach that does not isolate educators but unites them in improving the teaching and learning of Mathematics.

Risks

This is a low risk project meaning that the only identified risk for you is likely to be one of discomfort during or following the survey or interview process. Should you experience anything more than discomfort, for example if you become distressed, please let me know so that I can offer support?

Confidentiality

Your survey responses will be identifiable until the point at which feedback is provided to each individual respondent and then removed. Identifying details on the surveys will be replaced by codes so that participant identities are known only by Vusani Ngwenya and his supervisors. Pseudonyms for both the school and participant will be used in all reporting to ensure anonymity.

Interviews will be audio recorded and then transcribed by Vusani Ngwenya for data analysis. Audio recording will be destroyed once they have been transcribed. The researcher and his supervisor will have access to the transcribed data. Prior to analysis, Interview participants will have access to the transcript of their interview and given an opportunity to verify the data collected ensuring that a true and accurate portrayal of their responses has been recorded.

Consent to participate.

We would like to ask you to sign a written consent form (enclosed) to confirm your agreement to participate.

Question / further information about the project

Please contact the researcher or his supervisor, named above, to have any question answered or if you require further information about project.

Concern / complaint regarding the conduct of the project

The researcher and the University of South Africa are committed to research with integrity and the ethical conduct of research project.

However, if you do have any concerns or complaint about the ethical conduct of the project you may contact the thesis supervisor Professor Nkopodi Nkopodi on 0828554384.

Statement of consent

By signing below, you are indicating that you:

Have read and understood the information document regarding this research project.

Have had any questions answered to your satisfaction.

Understand that you have any additional question you can content the research.

Understand that you are free to withdraw from the sample at any time without penalty.

Understand that you can contact the University of SOUTH AFRICA (UNISA) research Ethical coordinator on CEDU REC Chairperson: Dr Madaleen Claassensat mcdtc@netactive.co.za.

If you have concerns about the ethical conduct of the research project.

Understand that participation in the project involves.

Completing a survey/questionnaire

Participating in pre-tests and post test

Classroom observation while teaching Mathematics.

Understand that the interview in this project will include audio recording and give me permission for this audio recording

Agree to the publication of excerpts of all classified interviews transcripts.

Agree to participate in the research project.

Name:

Signature :…………………………………. Date:……………………………………..

HOW IS IT BEST TO COUNT YOU FOR FOLLOW UP?…………………

**APPENDIX 15**

**LETTER TO CENTOCOW WARD MANAGER**

Ginyane high school

P.O. Box 168

Creighton

3263

1 February 2016

The Ward Manager

Centocow Ward

Department of Education

Pholela

Dear Sir/ Madam

**REF: REQUEST FOR PERMISSION TO CONDUCT RESEACH IN CENTCOW WARD: V NGWENYA STUDENT NUMBER 47288902: THESIS TITLE: A Collaborative model for teaching and learning Mathematics in secondary schools.**

I hereby write to request for permission to conduct research in Centocow for a Doctor of Education (Curriculum Studies)Degree which I am studying at the University of SOUTH AFRICA (UNISA) The research topic is:

A COLLABORATIVE MODEL FOR TEACHING AND LEARNING MATHEMATICS IN SECONDARY SCHOOLS.

Data collection for the study is scheduled to commence from 1 April to 30 May 2016. It is my hope that if granted permission the findings of the study shall capacitate educators in improving the performance of Mathematics not only in the Sisonke District but nationally and internationally.

In line with research ethics I shall make the findings and recommendations available to the schools that participated in the study. I would greatly appreciate if permission will be granted without delay so as to keep pace with the research plan.

Thank you in advance.

Yours Sincerely

Mr V NGWENYA (DED student - UNISA)

CONTACT : 0719425356

Email : ngwenyavee@yahoo.ca

**NAME**:……………….

DESIGNATION: …………………………………………………

**DATE**: ……………………………………………………………

**APPENDIX 16**

**BASELINE/ DIAGNOSTIC TEST FOR EDUCATORS AND LEARNERS IN GRADE 10**

INSTRUCTIONS: 1

Answer all questions.

2 Show all your calculations.

**NB:** Your steps towards an answer are far more important than the answer itself.

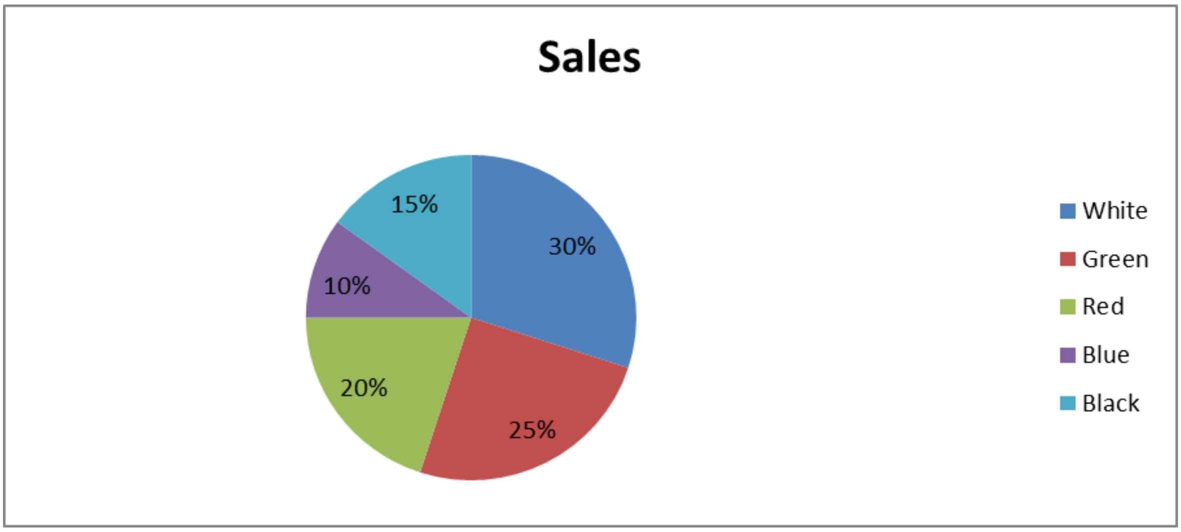
Question 1

Ann and Jenny divide 560 zeds between them. If Jenny gets $\frac{3}{8}$ of the money, how many zeds will Ann get?

$$\frac{4}{100} + \frac{3}{1000}$$

Which of these is the BEST estimate of $\frac{7.21 \times 3.86}{10.09}$?

The pie chart shows the percentage of caps for sale at a sporting goods store. If there are 200 caps, what is the total number of caps that either white or green?




Which of these shows 36 can be expressed as a product of prime factors?

Write $3\frac{5}{6}$ in decimal form, rounded to 2 decimal places.

Place the four digits 3, 5, 7, and 9 into the boxes below in the positions that would give the greatest result when the two numbers are multiplied.

Look at this table:

| $4^1$ | $4^2$ | $4^3$ | $4^4$ | $4^5$ | $4^6$ |
|---|---|---|---|---|---|
| 4 | 16 | 64 | 256 | 1,024 | 4,096 |

Use the table to express the value of 256 × 4,096 as a power of 4.


Which number does *K* represent on this number line?

The fractions $\frac{4}{14}$ and $\frac{\quad}{21}$ are equivalent.

Which fraction is equivalent to 0.125?

A workman cut off $\frac{1}{5}$ of a pipe. The piece he cut off was 3 metres long. How many metres long was the original pipe?

Here is a pattern.

3 – 3 = 0

3 – 2 = 1

3 – 1 = 2

3 – 0 = 3

What will the next line in the pattern be?

Kim is packing eggs into boxes. Each box holds 6 eggs. She has 94 eggs. What is the smallest number of boxes she needs to pack all the eggs?

Which number is equal to $\frac{3}{5}$ ?

What is the sum of the three consecutive whole numbers with $2n$ as the middle number?

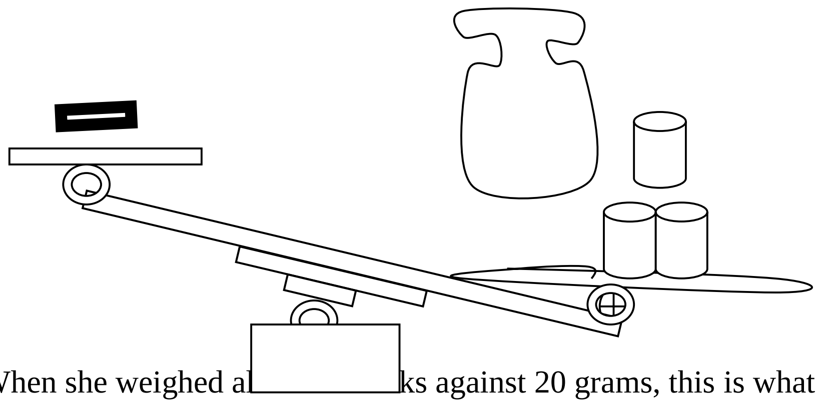
There were *m* boys and *n* girls in a parade. Each person carried 2 balloons. Which of these expressions represents the total number of balloons that were carried in the parade?

The shadow length of four bushes

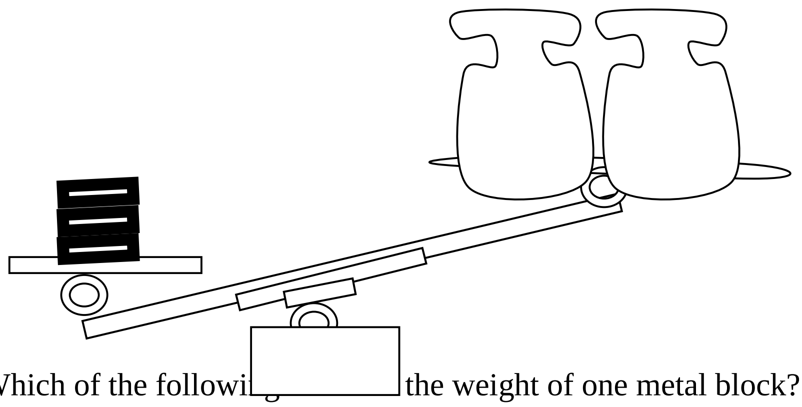
| Bush height (cm) | Shadow length (cm) |
|---|---|
| 20 | 16 |
| 40 | 32 |
| 60 | 48 |
| 80 | 64 |

The table above shows the shadow lengths of four bushes of different heights at 10 a.m. What is the shadow length at 10 a.m. of a bush that has a height of 50 centimetres?

Jo has three metal blocks. The weight of each block is the same. When she weighed one block against 8 grams, this is what happened.



When she weighed al ks against 20 grams, this is what happened?



Which of the followi the weight of one metal block?

Section B: Answer all questions.

1) If $x$ =1 and $x$ is greater than 1, than 0, which of the following statement is true

When $x$ is greater than I, $y$ is negative.

When $x$ is greater than 1, $y$ is greater than 1.

When $x$less than 1 is, $y$ is less than 1.

As $x$ increases, decreases.

2) The vertices of the triangle POQ are the p (1, 2), Q (4, 6) and R (-4, 12). Which one of the following statements about triangle POQ is true?

A) POQ is right triangle with the right angle, P.

B) POQ is a right triangle with the right angle, Q

C) POQ is a right with the right angle, R.

D) POQ is not a right triangle.

3) Which one of the following conics is represented by the question $(x - 3y)(x + 3y)$ =36?

A) Circle

B) Ellipse

C) Parabola

D) Hyperbola

4) Determine the distance between the $x -$ intercept and the $z$ - intercept of the place whose equation is $3x + 2y - 4z = 12$.

A) 9

B) 1

C) 5

D) 7

5)

AB is the diameter of semicircle k, arbitrary point on the semicircle (other than A or B), and Sis the centre of the inscribed into triangle ABC.

Then the measure of

A) Angle ASB changes as C moves on k.

B) Angle ASB is the same for all position of C, but it cannot be determined without knowing the radius.

C)Angle ASB =130°for all ℃

D) Angle ASB =150° for all℃.

6) A set of 24 cards is numbered with the positive integers from 1 to 24. If the cards are shuffled and if only one is selected at random, what is the probability that the number on the card is divisible by 4 or 6?

A) 1/6

B)5/24

C) ¼

D)1/3

E) 5/12

7) A translation maps A (2, -3) under the same translation, find the coordinates of B; (1, 4).

A) (-5, -2)

B) (6,6)

C) (-2, -4)

D) (-4,2)

8) The number of the bacteria in colony was growing exponentially. At 1 pm yesterday the number in the colony at 6 pm yesterday?

9) Determine all complex number $z$ that satisfy the equation

Where denotes the conjugate of $z$

A) (-1/3+5/3i)

B) (-3-i)

C) (1-i)

D) Answer not given

10) The graph of the function g passed through the point (1, 2). The slope of the tangent to the graph at any point $(x, y)$ is given by g '$(x)$ =6$x - 12$ . What is g $(x)$?

A) $6x^2$- 12$x + 11$

B) 6$x^2$ -2$x - 11$

C) 3$x^2$ -2$x$ $+ 11$

D) 3$x$-$12x$

11) What is the value of $x$ for which inequality?

Is true.

A) $x$ is less than or equal to 7/9

B) $x$ is less than or equal to -1/3

C) $x$ is greater than or equal to 0

D) $x$ is greater than or equal to 7/3

E) $x$ is greater than or equal to 9/3

12) The sum of the infinite series 1-(1/2) + (1/4) – (1/8) + …. Is

A) 2

B) 5

C) -3/5

D) 5/3

E) 3/232

13) The velocity $v$ of a body moving in a straight line $t$ seconds after starting from rest is $v = 4t^3$ - $12t^2$ metre /second

How many seconds after starting does its acceleration becomes zero?

Seconds

14) A warning system installation consists of two independent alarms probabilities of operating in an emergency of 0, 95 and 0, 90 respectively. Find the probability that at least one alarm operates in an emergency.

A) 0,995

B) 0,975

C) 0, 95

D) 0, 90

E) 0,855

15). an examination consists of 13 questions. A student must answer only one of the first two questions and only nine of the remaining ones. How many choices of questions does the student have?

A) 13 C 10= 286

B) 11 C8 =165

C) $2x11C9 = 110$

D) $2x11p2$= 220

E) Some other number

16) For what real value of k will the equation below describe of circle of radius equal to 3?

$x^2$ $+y^2$ - $4y$ + k =0

A)K=2

B)K=8

C)K=-4

D)K=-9

E)K=4

17) Find all real values of $x$ which satisfy the equation

A) $x = 1$

B) $x = 4, x = 1$

C) $x = 2, x = -1$

D) $x = 2$

18) Use algebraic problem solving to find the value of $x$: $40x + 12 = 24x - 20$

a) Show all of your work

b) Explain the steps in your solution.

19) Solve the equation for $x$: $3x + 12 = -15$

a) Show all of your work

b) Describe the steps taken in your solution

20) Students at Central High School voted on whether to have pizza dogs at their school carnival. A total of 280 student voted. If the number who voted for hot dogs was 40 less than the number who voted for pizza, how many students voted for each type of food?

a) Write an equation to represent the situation. BE SURE TO IDENTIFY ANY VARIABLE S.

b) Solve the equation showing your work.

c) State your answer clearly.

21) Experts say that 25% of all serious bicycle accident involve head injuries and that, of all head injuries, 80% are fatal.

16%

20%

55%

105%

If the population increases by the same rate from the year 1990 to the year 2000 as in the years from 1980 to1990, approximately what is the expected population by the year 2000?

A) 47 million

B) 50 million

C) 53 million

D) 58 million

A 45 000 –litre water tank is to be filled at the rate of 220 litres per minute.

Estimate, to the nearest half an hour how long it will take to fill the tank.

A) 4 hours B) ½ hours C) 3 hours D) 2 ½ hours

24) If there are 300 calories in 100 grams of a certain food, how many calories are the in a 30-gram portion of that food

A) 90

B)100

C) 900

D)1000

E) 9000

25) In a vanes yard there are 210 rows of vines. Each row is 192 m long, and plants are planted 4m apart. On average, each plant produces 9 kg of grapes each season.

The total amount of grapes produced by the vineyard each season is nearest to

10 000 kg

100 000kg

400 000 kg

600 000 kg

26) A store is having a 20% off sale. The normal price of is $1250.

What is the price after the 20% discount is applied?

$1000

$1050

$1230

$1500

27) Brighton soap power is packed in a cube–shaped carton. A carton measures 10 cm on each side. The company decided to increase the length of each edge of the carton by 10 per cent.

How much does the volume increase?

A) 10 cu.cm.

B) 21 cu.cm

C) 100 cu.cm

D) 331 cu.cm

28) In a school election with three candidates, Joe received 120 votes, Mary received 50 votes, and George received 30 votes

A) 60%

B) 66 20/3%

C) 80%

D) 120%

29) From a batch of light bulbs, 100 were selected at random and tested. If 5 of the light bulbs in the samples were found to be defective, how many defective light bulbs would be expected in the entire batch?

A)15

B) 60

c)150

D) 300

30) Theresa wants to record 5 songs on tape. The length of time each song plays for is shown in table.

Estimate to the nearest minute the total time taken for all five songs to play and explain how this estimate was made.

A) 13 minutes

B) 14 minutes

C) 15 minutes

D) 17 minutes

D) Destroy the layer.

SECTION C

Answer all question and show working.

1. Last year there were 800 students in the preserves programme. This year there are 1000. what percentage increase of student is that?

2. Jesse was planning the amount of time he would devote to each stand in his 120 hours mathematics course. He planned to spend 0.4 of time on measurement and data management 15 % of the time on algebra, 3/8 of the time on numeracy, and the reminder of the time on geometry. How many hours were spent on each of the four stands?

3. Jerusha has two bowls of fruit on her kitchen table. In one below she has a ratio of 1 apple to every 2 bananas. In the second bowl she has a ratio of 2 plums to every 3 oranges. Both bowls have same total number of fruits. How many are there of each fruit? (Give one possible assortment)

4. A group of 150 tourists were visiting Thunder Bay. Two tenths of this group went to the Terry for look out. Two third of 150 went to Historical for William. All the rest went out to the sleeping Giant. How many tourists went to the sleeping giant?

5. Luis exercises by running 5 km each day. The course he runs is ¼ km long. How many times does he run the course each day?

Measurement

6. How many 750 ml bottle can be filled from 600 l water?

7. A farm water tank (with a capacity of 615 cubic metres) has sprung a leak. It loses water. At the rate of 1 cubic metre an hour. If no one fixes it, when would the tower be empty? (Answer in weeks, days, and hours for examples 2 weeks 2 days and 5hours)

8. You purchase $ 14.70 worth of cd cases, each case costs 35 cents and is 5.2 mm thick. How many cm tall is your stack of CD cases?

9. A rectangular box with no lid has base of 4cm by 7 cm and height of 2cm. What is the exterior surface area of the box?

10. Workers are laying large rectangular tiles measuring 4x 6 metres. If they want to fit them into a square, what is the minimum number of these tiles they would need.

PATTERNING ALGEBRA

Dave gave Charlotte half of his hockey cards. Charlotte gave Johnnie half of the cards she received from Dave. Johnnie kept 8 of those cards and gave the remaining 10 to Dune. How many hockey cards did Dave have to start with?

DATA MANAGEMENT AND PROBABILITY

12. Vanessa set te school record for the most points in a single basketball game when her team scored 48 points in total. The five other players on her team who scored, averaged 5 point each. How many points did Vanessa score to set her record?

13. Each of the six faces of cube is painted either red or blue. When the cube is tossed the theoretical probability of the cube landing with the red face up is 2/3. How many faces are red?

PROFIT

14. A retailer buys a 40-meter bolt of cloths for $ 184 00. What price should be charged per metre to make profit of 25.

THANK YOU:

RESEACHER CONTACT:

NAME: VUSANI NGWENYA

EMAIL: ngwenyavee@yahoo.ca cell number: 0719425356

**APPENDIX 17**

**ATTITUDES SURVEY FOR MATHEMATICSLEARNERS IN GRADE 10 AT CENTO COW CLUSTER TO MEASURE BELIEFS ABOUT MATHEMATICS AND HOW IT IS TAUGHT IN CLASSROOMS IN SECONDARY SCHOOLS**

INTRODUCTION

My name is Vusani Ngwenya a Doctor of Education (Curriculum studies) degree student at the University of South Africa (UNISA). I am conducting a research study on developing **a Collaborative model for teaching and learning Mathematics in secondary schools.** You are thus kindly asked to complete this survey truthfully. Thank you in advance for your co- operation and valuable assistance.

Respondent are guaranteed that:

All the information supplied will be stretchy treated with confidentiality.

When completed responding to the questions return the questionnaire to the person administering the survey.

School: Learner code:

| MATHEMATICS ATTITUDES SURVEY |
|---|

| DIRECTION: please read each statement carefully and decide whether it describes the way you feel about mathematics right now. For each item. Select one of the four responses to choose is show how much you agree or disagree with the statement |
|---|

Maths is useful in everyday life.

Strongly Agree Disagree Strongly Agree

Maths is something I enjoy.

Strongly Agree Agree Disagree Strongly Agree

I am not very good at maths.

Strongly Agree Agree Disagree Strongly Agree

My maths teacher present material in a clear way

Strongly Agree Agree Disagree Strongly Agree

There is little need for maths in most jobs.

Strongly Agree Agree Disagree Strongly Agree

Having to take a maths class makes me unhappy.

Strongly Agree Agree Disagree Strongly Agree

Maths is easy for me.

Strongly Agree Agree Disagree Strongly Agree

Maths is helpful in understanding today ‘s world.

Strongly Agree Agree Disagree Strongly Agree

I usually understand what we are talking about in maths class.

Strongly Agree Agree Disagree Strongly Agree

My teacher makes it interesting.

Strongly Agree Agree Disagree Strongly Agree

I don’t like anything about maths.

Strongly Agree Disagree Strongly Agree

No matter hard I try, I cannot understand maths

Strongly Agree Agree Disagree Strongly Agree

My maths teacher is willing to provide students with individual maths

Strongly Agree Agree Disagree Strongly Agree

I would really like to learn maths

Strongly Agree Agree Disagree Strongly Agree

It is important to know maths in order to get a good job

Strongly Agree Agree Disagree Strongly Agree

Sometimes I “freeze up” and forget what to do in a maths test

Strongly Agree Agree Disagree Strongly Agree

I would like a job that doesn’t use any maths

Strongly Agree Agree Disagree Strongly Agree

I am good doing maths` problem

Strongly Agree Agree Disagree Strongly Agree

You can get long perfectly well in life without learning maths

Strongly Agree Agree Disagree Strongly Agree

My maths teacher likes students to asked questions

| | | | |
|---|---|---|---|
| Strongly Agree | Agree | Disagree | Strongly Agree |

It makes me nervous to even think about doing maths

| | | | |
|---|---|---|---|
| Strongly Agree | Agree | Disagree | Strongly Agree |

I have a good feeling about maths

| | | | |
|---|---|---|---|
| Strongly Agree | Agree | Disagree | Strongly Agree |

The only reason I ‘m taking maths is because I have to

| | | | |
|---|---|---|---|
| Strongly Agree | Agree | Disagree | Strongly Agree |

I would rather do maths problems on my own than in a group activity.

| | | | |
|---|---|---|---|
| Strongly Agree | Agree | Disagree | Strongly Agree |

THANK YOU:

RESEACHER CONTACT:

NAME: VUSANI NGWENYA

EMAIL:ngwenyavee@yahoo.ca cell number: 0719425356

**APPENDIX 18**

**QUESTIONNAIRE FOR SUBJECT ADVISORS IN MATHEMATICS ON TEACHING APPROACHES, LEARNERS ACTIVITIES AND MOTIVATION TECHNIQUES IN MATHEMATICS IN SECONDARY SCHOOLS**

INTRODUCTION

My name is Vusani Ngwenya a Doctor of Education (Curriculum studies) degree student at the University of South Africa (UNISA). I am conducting a research study on developing **A Collaborative model for teaching and learning Mathematics in secondary schools.** You are thus kindly asked to complete this survey truthfully. Thank you in advance for your co- operation and valuable assistance.

Respondents are guaranteed that:

All the information supplied will be strictly treated with confidentiality.

When completed responding to the questions return the questionnaire to person administering it

PLEASE CIRCLE THE RESPONSE THAT INDICATES HOW YOU FEEL ABOUT THE STATEMENT IN THE FOLLOWING QUESTIONNAIRE.

STRONGLY DISAGREE 2- DISAGREE 3- UNDECIDED 4- AGREE 5- STRONGLY AGREE

| | | | | | |
|---|---|---|---|---|---|
| 1.A vital task of teacher is motivating children to solve their own mathematical problem | 1 | 2 | 3 | 4 | 5 |
| 2. Ignoring the mathematical ideas that that children generate themselves can seriously limits their learning | 1 | 2 | 3 | 4 | 5 |
| 3. It is important for children to be given opportunities to reflect on and evaluate their own mathematical understanding | 1 | 2 | 3 | 4 | 5 |
| 4. It is important for a teacher to understand the structured way in which mathematical concepts and skills relate to each other | 1 | 2 | 3 | 4 | 5 |
| 5. Effective mathematical teachers enjoy learning and doing mathematics themselves | 1 | 2 | 3 | 4 | 5 |
| 6. Knowing how to solve mathematical problems is as important as getting the correct solution | 1 | 2 | 3 | 4 | 5 |

| | | | | | |
|---|---|---|---|---|---|
| 7. Teachers of mathematical should be fascinated with how children think and intrigued by alternative ideas | 1 | 2 | 3 | 4 | 5 |
| 8. Providing children with Interesting problems to investigate in a small group is an effective way to teach mathematics | 1 | 2 | 3 | 4 | 5 |
| 9. Mathematics is a beautiful, creative and useful human endeavour that is the both a way of knowledge and way of thinking | 1 | 2 | 3 | 4 | 5 |
| 10. Allowing the child to struggle with mathematical problems, even a little tension can be necessary for learning to occur | 1 | 2 | 3 | 4 | 5 |
| 11. Children always benefit by discussing their solution to a mathematical problem with each other | 1 | 2 | 3 | 4 | 5 |
| 12. Persistent questioning has a significant effect on children's mathematical learning | 1 | 2 | 3 | 4 | 5 |
| 13. Justifying the mathematical statement that a person makes is an extremely important part of mathematics | 1 | 2 | 3 | 4 | 5 |
| 14. As a result of much experience in mathematics classes, aIl have developed an attitude of inquiry | 1 | 2 | 3 | 4 | 5 |
| 15. Teachers can create for all children a non–treatment environment for learning mathematics | 1 | 2 | 3 | 4 | 5 |
| 17. There is an established amount of mathematical content that should be covered at each grade level. | 1 | 2 | 3 | 4 | 5 |
| 18. It is important that mathematics content be presented to children in the correct sequence. | 1 | 2 | 3 | 4 | 5 |
| 19. Mathematical materials are the best presented in an expository style, demonstrating. explaining and describing concept and skills | 1 | 2 | 3 | 4 | 5 |
| 20. Mathematics is computation | 1 | 2 | 3 | 4 | 5 |
| 21. Telling the children the answer is an efficient way of facilitating their mathematics learning | 1 | 2 | 3 | 4 | 5 |

| | | | | | |
|---|---|---|---|---|---|
| 22. I would feeL uncomfortable if a child suggested solution to mathematical problems that I hadn't thought of previously. | 1 | 2 | 3 | 4 | 5 |
| 23. It is not necessary for teachers to understand the source of children`s errors, follow-up instruction will correct their difficulties | 1 | 2 | 3 | 4 | 5 |
| 24.Listening carefully to you the teacher explain mathematics lesson is the most effective way to learn mathematics | 1 | 2 | 3 | 4 | 5 |
| 25. It is important to cover the entire topic in the mathematics curriculum in the textbook sequence. | 1 | 2 | 3 | 4 | 5 |
| 26. If a child's explanation of a mathematical solution doesn't make sense to the teacher it is best to ignore it. | 1 | 2 | 3 | 4 | 5 |
| | 1 | 2 | 3 | 4 | 5 |

SECTION B: ANSWER ALL QUESTIONS

Suggest how mathematics could be taught through involving educators and learners in a learning environment?

.............................................................................................................................................

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How can educators work together to improve learning mathematics in secondary schools?

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What advice could you offer mathematics educators to make teaching and learning of mathematics enjoyable and effective?

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..........................................................................................................................................
..........................................................................................................................................
..........................................................................................................................................
....................

THANK YOU:

RESEACHER CONTACT:

NAME: VUSANI NGWENYA

EMAIL:ngwenyavee@yahoo.ca cell number: 0719425356

## APPENDIX 19: PROFESSIONAL DEVELOPMENT STANDARDS A, B, C AND D OF THE NATIONAL RESEARCH COUNCIL OF NEW YORK.

Professional Development Standard A

Professional development for teachers of science requires learning essential science content through the perspectives and methods of inquiry.

Science learning experiences for teachers must

Involve teachers in actively investigating phenomena that can be studied scientifically, interpreting result, and making sense of findings consistent with currently accepted scientific understanding.

Address issues, events, problems, or topics significant in science and of interest to participants.

Introduce teachers to scientific literature, media, and technological resources that expand their science knowledge and their ability to access further knowledge.

Build on the teacher's current science understanding, ability, and attitudes.

Incorporate ongoing reflection on the process and outcomes of understanding science through inquiry.

Encourage and support teachers in efforts to collaborate.

Professional Development Standard B

Professional development for teachers of science requires integrating knowledge of science, learning, pedagogy, and students; it also requires applying that knowledge to science teaching.

Learning experiences for teachers of science must

Connect and integrate all pertinent aspects of science and science education.

Occur in a variety of places where effective science teaching can be illustrated and modelled, permitting teachers to struggle with real situations and expand their knowledge and skills in appropriate contexts.

Address teachers 'needs as learners and build on their current knowledge of science content, teaching, and leaning.

Use inquiry, reflection, interpretation of research, modelling, and guided practice to build understanding and skill in science teaching.

Professional Development Standard C

Professional development for teachers of science requires building understanding and ability for lifelong learning. Professional development activities must

Provide regular, frequent opportunities for individuals and collegial examination and reflection on classroom and institutional practice.

Provide opportunities for teachers to receive feedback about their teaching and to understand, analyse, and apply that feedback to improve their practice.

Provide opportunities for teachers to learn and use various tools and techniques for self-reflection, and collegial reflection, such as peer coaching, portfolios, and journals.

Support the sharing of teachers' expertise by preparing and using mentors, teachers' advisers, coaches, lead teachers, and resource teachers to provide professional development opportunities.

Provide opportunities to know and have access to existing research and experiential knowledge.

Provide opportunities to learn and use the skills of research to generate new knowledge about science and the teaching and learning of science.

Professional Development Standard D

Professional development for teachers of Science must be coherent and integrated. Quality preservice programs are characterized by

Clear, shared goals based on a vision of Science learning, teaching, and teacher development congruent with the National Science Education Standards.

Integration and coordination of the programme components so that understanding and ability can be built over time, reinforced continuously, and practiced in a variety of situations.

Options that recognize the developmental nature of teacher professional growth and individual and group interests, as well as the needs of teachers who have varying degrees of experience, professional expertise, and proficiency.

Collaboration among the people involved in programmes, including teachers, teacher educator, teacher unions, scientists, administrators, policy makers, members of professional and scientific organisations, parents, and business people, with clear respect for the perspectives and expertise of each.

Recognition of the history, culture, and organization of the school environment.

Continuous programme assessment that captures the perspectives of all those involved, uses a variety of strategies, focuses on the process and effects of the program, and feeds directly into programme, and feeds directly into programme improvement and evaluation.

## APPENDIX 20: UNIVERSITY OF SOUTH AFRICA RESEARCH ETHICS CLEARANCE CERTIFICATE

UNISA | university of south africa

**COLLEGE OF EDUCATION RESEARCH ETHICS REVIEW COMMITTEE**

17 February 2016

Ref : **2016/02/17/47289902/09/MC**
Student : Mr V Ngwenya
Student Number : 47289902

Dear Mr Ngwenya

**Decision: Ethics Approval**

---

**Researcher**
Mr V Ngwenya
Tel: 074 739 5454
Email: vusaningwenya998@gmail.com

**Supervisor**
Prof N Nkopodi
College of Education
Department of Science and Technology Education
Tel: 012 429 4731
Email: nkopon@unisa.ac.za

**Proposal:** A collaborative model of teaching and learning mathematics in secondary schools

**Qualification:** D Ed in Curriculum and Instructional Studies

---

Thank you for the application for research ethics clearance by the College of Education Research Ethics Review Committee for the above mentioned research. Final approval is granted for the duration of the research.

*The application was reviewed in compliance with the Unisa Policy on Research Ethics by the College of Education Research Ethics Review Committee on 17 February 2016.*
*The proposed research may now commence with the proviso that:*

1) *The researcher/s will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.*
2) *Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study, as well as changes in the methodology, should be communicated in writing to the College of Education Ethics Review Committee. An amended application could be requested if there are substantial changes from the existing proposal, especially if those changes affect any of the study-related risks for*

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*the research participants.*

3) *The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study.*

*Note:*

*The reference number* **2016/02/17/47289902/09/MC** *should be clearly indicated on all forms of communication [e.g. Webmail, E-mail messages, letters] with the intended research participants, as well as with the College of Education RERC.*

Kind regards,

**Dr M Claassens**

**CHAIRPERSON: CEDU RERC**

mcdtc@netactive.co.za

**Prof VI McKay**

**EXECUTIVE DEAN**

**APPENDIX 21: KWAZULU- NATAL DEPARTMENT OF EDUCATION PERMISSION CERTIFICATE TO CONDUCT RESEARCH IN KWAZULU-NATAL DEPARTMENT OF EDUCATION INSTITUTIONS**

education

Department:
Education
**PROVINCE OF KWAZULU-NATAL**

Enquiries: Phindile Duma Tel: 033 392 1004 Ref.:2/4/8/743

Mr V Ngwenya
Ginyane High School
P.O. Box 168
Creighton
3263

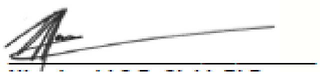
Dear Mr Ngwenya

PERMISSION TO CONDUCT RESEARCH IN THE KZN DoE INSTITUTIONS

Your application to conduct research entitled: **"A COLLABORATIVE MODEL FOR TEACHING AND LEARNING MATHEMATICS IN SECONDARY SCHOOLS",** in the KwaZulu-Natal Department of Education Institutions has been approved. The conditions of the approval are as follows:

1. The researcher will make all the arrangements concerning the research and interviews.
2. The researcher must ensure that Educator and learning programmes are not interrupted.
3. Interviews are not conducted during the time of writing examinations in schools.
4. Learners, Educators, Schools and Institutions are not identifiable in any way from the results of the research.
5. A copy of this letter is submitted to District Managers, Principals and Heads of Institutions where the
Intended research and interviews are to be conducted.

6. The period of investigation is limited to the period from 15 March 2016 to 30 June 2017.
7. Your research and interviews will be limited to the schools you have proposed and approved by the Head of Department. Please note that Principals, Educators, Departmental Officials and Learners are under no obligation to participate or assist you in your investigation.
8. Should you wish to extend the period of your survey at the school(s), please contact Miss Connie Kehologile at the contact numbers below
9. Upon completion of the research, a brief summary of the findings, recommendations or a full report / dissertation / thesis must be submitted to the research office of the Department. Please address it to The Office of the HOD, Private Bag X9137, Pietermaritzburg, 3200.
10. Please note that your research and interviews will be limited to schools and institutions in KwaZulu- Natal Department of Education.
Harry Gwala District



Nkosinathi S.P. Sishi, PhD
Head of Department: Education
Date: 15 March 2016
KWAZULU-NATAL DEPARTMENT OF EDUCATION
POSTAL: Private Bag X 9137, Pietermaritzburg, 3200, KwaZulu-Natal, Republic of South Africa PHYSICAL: 247 Burger Street, Anton Lembede House, Pietermaritzburg, 3201. Tel. 033 392 1004 EMAIL ADDRESS: kehologile.connie@kzndoe.gov.za / Phindile.Duma@kzndoe.gov.za CALL CENTRE: 0860 596 363; Fax: 033 392 1203 WEBSITE: WWW.kzneducation.gov.za

## APPENDIX 22: LANGUAGE EDITTING CERTIFICATE

CERTIFICATE FOR

ENGLISH LANGUAGE EDITING

This is to certify that the THESIS written by

MR. V. NGWENYA

Has been English Language edited by PROF LA GREYVENSTEIN

Lesley Greyvenstein

PROF LESLEY ANN GREYVENSTEIN

018 468 7335

082 974 4505

**APPENDIX 23**

**Table 6.12 Demographic Analysis Calculation of Standard Deviation of Scores of Learners in the Baseline Test.**

| Case # | Scores $x_1$ | $x_1 - \bar{x}$ | $x_1 - \overline{x^2}$ |
|---|---|---|---|
| A | 10 | 0 – 4,15 | 17,22 |
| B | 15 | 0,85 | 0,72 |
| C | 19 | 4,85 | 23,52 |
| Ď | 20 | 5,85 | 34,22 |
| E | 21 | 6,85 | 46,92 |
| F | 16 | 1,85 | 3,42 |
| G | 11 | – 3,85 | 14,82 |
| H | 13 | – 1,85 | 3,42 |
| I | 15 | 0,15 | 0,02 |
| J | 10 | – 4,15 | 17,22 |
| K | 13 | – 1,85 | 3,42 |
| L | 15 | 0,85 | 0,72 |
| M | 19 | 4,85 | 23,52 |
| N | 09 | – 8,85 | 34,22 |
| O | 05 | – 9,85 | 97,02 |
| P | 41 | 26,15 | 684,61 |
| Q | 08 | – 6,85 | 46,92 |
| R | 14 | – 0,85 | 0,72 |
| S | 07 | – 7,85 | 61,62 |
| T | 02 | – 12,85 | 165,12 |

**APPENDIX 24**

**Table 6.13 Comparison of Baseline Test Results-Schools and Educators**

| Schools /case | Scores (64) | Teachers score | $\bar{X}$ Mean | $\bar{X}$ Schools |
|---|---|---|---|---|
| 1 | | 25 | $\frac{64}{4} =$ 16 | $\frac{283}{20} =$ 14,15 |
| A | 10 | | | |
| B | 15 | | | |
| C | 19 | | | |
| D | 20 | | | |
| 2 | 21 | 20 | $\frac{61}{4} =$ 15 | $\frac{283}{20} =$ 14,15 |
| F | 16 | | | |
| G | 11 | | | |
| H | 13 | | | |
| 3 | | 18 | $\frac{53}{4} =$ 13 | $\frac{283}{20} =$ 14,15 |
| I | 15 | | | |
| J | 10 | | | |
| K | 13 | | | |
| L | 15 | | | |
| 4 | | 38 | $\frac{74}{4} =$ 19 | $\frac{283}{20} =$ 14,15 |
| M | 19 | | | |
| N | 09 | | | |
| O | 05 | | | |
| P | 41 | | | |
| 5 | | 29 | $\frac{31}{4} =$ 08 | $\frac{283}{20} =$ 14,15 |
| Q | 08 | | | |
| R | 14 | | | |
| S | 07 | | | |
| T | 02 | | | |