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Masters of Management in Public Policy

Improving the Quality of Matric Learner Performance in Mathematics and Science in Gauteng

Constance Nompumelelo Ngobese

Student number: 420626

Supervisor: Koffi Kouakou

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Declaration

I declare that this research report is my own work and that all the sources that I used have been fully referenced. It is submitted in partial fulfilment of the requirements for the degree of Masters of Management in Public Policy at Witwatersrand University. It has not been submitted before for any degree in any other university.

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Constance Nompumelelo Ngobese

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Abstract

The foremost argument of this research is that the quality of matric learner performance in mathematics and science is poor. The objective of the research is to investigate the factors leading to poor performance in mathematics and science at matric level in Gauteng, South Africa. The research seeks to validate whether or not decision-making, policy and planning contribute to poor learner performance. Five documents addressing mathematics and science education matters were analyzed. Six candidates were interviewed to determine the causes of poor performance in mathematics and science at matric level in Gauteng and how the quality of learner performance could be improved.

The findings confirmed that the quality of passes in mathematics and science is indeed poor and showed that the National Policy on Promotion and Progression Requirements Grades R-12 in particular contributes to this poor quality of learner performance. They also confirmed that poor decision-making at strategic level and poor planning are also contributors towards poor learner performance. Scenario planning, as a strategizing foresight tool, was employed to create the Gauteng scenarios for mathematics and science education in 2022. A recommendation is made that the GDE should use these scenarios as learning tools when preparing for the future and to improve their planning and decision-making processes.

Keywords: matric learner performance quality, mathematics, science, scenario planning, educational planning

Acronyms

ACE – Advanced Certificate in Education

CAPS - Curriculum and Assessment Policy Statements

CDE – Centre for Development and Enterprise

COLTS – Culture of Learning, Teaching and Service

EMIS – Education Management Information Systems

FET – Further Education and Training

GCRA – Gauteng City Regional Academy

GDE - Gauteng Department of Education

HEI's – Higher Education Institutions

HSRC - Human Science Research Council

ICT – Information, Communication and Technology

LiEP – Language-in-Education Policy

MEC – Member of the Executive Council

MST Strategy - Mathematics, Science and Technology Strategy

MTSF – Medium Term Strategic Framework

NCS - National Curriculum Statement

NGOs – Non Governmental Organisations

NMST Strategy – National Mathematics, Science and Technology Strategy

OBE – Outcomes Based Education

PESTEL – Political, Economic, Social, Technological, Environmental and Legal factors

SACMEQ - Southern and Eastern African Consortium for Monitoring Educational Quality

SADTU – South African Democratic Teachers' Union

SGB – School Governing Bodies

SSIP - Senior Secondary Intervention Programme

TIMSS - Trends in Mathematics and Science Study

UJ – University of Johannesburg

UNICEF – United Nations Children's Fund

WITS – University of Witwatersrand

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Chapter 1: Introduction and Background

The state of mathematics and science education in South Africa is very poor throughout the school phases (Mahlong, 2011; Modisaotsile, 2012). This is despite the R70 million that the National Education Ministry set aside for the 2011/2012 financial year for interventions like the National Mathematics, Science and Technology Strategy, the Senior Secondary Improvement Programme, Curriculum Transformation and the 35,5 million for the Dinaledi Programme. It is also despite the NGOs, local and international donors' programmes that are directed at improving the quality of schooling. This confirms the argument of the Centre for Development Enterprise (2007) that the educational crisis in South Africa does not result from a lack of resources but a lack of planning efficiency.

The current curriculum policies such as the National Policy on Promotion and Progression Requirements Grades R-12 and Curriculum and Assessment Policy Statements have lowered the standard of education. Matriculants have to obtain a minimum of 30% in mathematics and at least 40% in science and yet universities require 50%. The 30% pass rate is too low, it does not only disadvantage learners but it contributes to poor quality tertiary students. It also creates a disjuncture between school and tertiary requirements (Radebe, 2013). Reddy (2005) asserts that this reflects the poor health status of the South African educational system. He further argues that the 30% pass rate represents a sub-standard level in comparison to international pass rates of 50%. The 2011 World Economic Forum's annual report attests to this. According to the report South Africa ranked last among 62 countries in the quality of mathematics and science education (Gernetzky, 2012).

The school curriculum does not adequately prepare learners for tertiary education and industry. International comparative studies such as the TIMSS and SACMEQ also revealed that the majority of South African children are performing at very low levels compared to their peers in Africa and the rest of the world. This clearly indicates a systemic problem linked to the consistent weak performance of South African learners (Horak and Friske, 2004; Reddy, 2005; Department of Education, 2010). In order to compete internationally and domestically, South Africa has to increase the number and the quality of mathematics and science passes in matric and the overall pass rates in all school phases (Kriek and Grayson, 2009).

The focus in South Africa has been to enforce universal school enrolment up to the age of 15 or up to the grade 9 level. The education ministry has done well in that regard. There are now more school-going age learners compared to before the enforcement of this policy. However, van der Berg (2007) states that there has been a noticeable dropout rate at the upper secondary level and that the high matric failure rates are a reflection of the weak educational quality.

This study takes an in-depth look at Gauteng's matric learner performance in mathematics and science. This is solely due to the fact that Gauteng is regarded as the hub of the South African economy since it contributes heavily in the manufacturing, transport, technology and telecommunication sectors. Therefore, there is more pressure on Gauteng, compared to other provinces, to produce individuals with mathematical and science related skills that will join these sectors and contribute to the economy of the province. Gauteng needs to ascertain that school leavers that enter HEIs and the world of work are thoroughly prepared in these subjects. To heed to this call, in 2011 the GDE announced that it was planning to spend R14, 5 million on Dinaledi schools, over the next three years. The aim was to improve matric mathematics and science passes in the province (Morokolo, 2011).

The Gauteng MEC for Education further announced the allocation of R106 million for the implementation of the MST strategy and R32, 5 million of which was allocated to MST resources for secondary schools across the province (Department of Education, 2010; Morokolo, 2011). This is mostly due to the fact that mathematics and science are critical gateway subjects that are required to support social and economic development. The National Development Plan envisages the creation of 11 million jobs by 2030 and most of these jobs need to be filled by graduates with science and mathematics related skills (National Planning Commission, 2011). It is therefore without a doubt that these are gateway subjects that provide opportunities for empowerment through understanding common technologies and through increasing access to tertiary education, highly skilled jobs and better livelihoods (Reddy, 2005).

After 1994, the ANC-led government emphasized mathematics and science as critical learning subjects because various sectors recognized their importance and also because they were seen as part of the human development strategy. This culminated in the development of government gazetted mathematics and science education intervention programmes and policies. All these policies and interventions were and are still aimed at building capacity at school level in order to re-balance educational participation in more equitable ways (Department of Education, 2010; Reddy, 2005). Unfortunately, these interventions fail to address issues of change, uncertainty, crisis and opportunities that face mathematics and science education in South Africa. The failure can be attributed to the inability of the interventions and policies to adapt to changes and mainly focusing on the present circumstances without taking into cognizance what might happen in the future. These interventions did not and still do not yield the desired results. They do not improve the quality of learner performance as they seem to focus mainly on short term solutions to address urgent and long standing educational problems, thus exposing long term decision-making to the uncertainties and whims of future planning.

Poor decision-making at strategic and operational level is the main cause of poor learner performance. In support of the researcher's argument Taylor (2009) postulates that the education system has weaknesses at every level from the classrooms, district offices and up to the administrative structure. It is also unclear how far reaching the use of strategic foresight tools has been integrated into the decision-making process towards educational planning in general and in particular to improving learner performance of mathematics and science at matric level. Havas, Schartinger and Weber (2007) contend that for the past two decades, foresight tools have emerged as decision-making tools that have helped organizations understand and anticipate risks, discover and exercise strategic future options with better appreciation of uncertainties. The education sector is very dynamic and curriculum changes occur rapidly and the high levels of uncertainties and complexities make scenario planning particularly suitable as a foresight tool. It has been highlighted that scenario planning, by virtue of its creative nature and through the stories about the long term future, can assist mathematics and science teachers and learners adapt to these changes.

Therefore scenario planning, among other foresight instruments, has emerged as a preferred instrument among decision-makers to address complex policies about taking a long view in times of great uncertainty (Schwartz, 1996; Illbury and Sunter, 2007). In this context it can assist the GDE to better prepare for the change and uncertainties that face mathematics and science education. It can also help the GDE identify risks and opportunities that are likely to be excluded by traditional planning processes. So, this study will look at the improvement of learner performance in mathematics and science at matric level through the use of scenario planning to inform policy.

Historically and in practice, there are two pieces of legislation that inform mathematics and science education in South Africa, namely the Bantu Education Act of 1953 and the Bill of Rights contained in the Constitution. The poor performance in mathematics and science can be traced back to the apartheid era whereby the government introduced an education policy that ensured racially-differentiated access to mathematics and science within the framework of Bantu education (Reddy, 2005; Wilcox, 2003). This is believed to have left a legacy of inequality, poor physical and human infrastructure and a racially divided and contested system (Bloch, 2009). Even though the Bantu Education Act was repealed it is still relevant because it explains where the problem addressed in this study stems from. The Act stipulated that mathematics and science would not be taught to black children. The purpose was to under educate black learners and the belief was that it was pointless to teach Africans mathematics and science as they would not use it in practice. The aim was to create uneducated individuals who would only be suitable for the unskilled labour market (Pennington, 2007). This explains why matric black learners particularly from township schools are still the worst underperformers in all provinces.

In his 2012 Helen Suzman memorial lecture Professor Jansen stated that the consequences of the current government's thinking about mathematics are not dissimilar to that of Verwoerd's government. He argued that neither Verwoerd nor the current Education Minister Angie Motshekga believes that black learners can or should do mathematics. The fact that learners who migrate from mathematics to mathematical literacy are mostly black is sufficient evidence. Jansen believes that by teaching learners mathematical literacy the current education system, just like in the apartheid era, is condemning them to the kinds of jobs they are fit to occupy (Jansen, 2012).

The second piece of legislation is the Constitution and according to its Section 29 all South African citizens have a right to basic, adult and further education and training. It is the state's responsibility to provide access to education. Therefore, the number of matric level mathematics and science learners and their pass rates are among the closely monitored performance areas (Department of Education, 2010; van Niekerk, 2012). It is clear that post 1994 legislation on mathematics and science education is still weak. Therefore, the legislation for effective performance management, administration, promotion and protection of the mathematics and science education and educators is urgently required.

1. 2. Definition of Terms

The following concepts will be used throughout this study: Educational planning, quality, learner performance, matric, scenario planning, scenarios, driving forces, critical uncertainties, scenario implications and networks.

1.2.1 Educational Planning

There are various definitions of educational planning. Coombs (1970:14) defines educational planning as, "the application of rational, systematic analysis to the process of educational developments with the aim of making education more effective and efficient in responding to the needs and goals of learners and society". Bray and Varghese (2011:22) regard educational planning as "an intervention by public authorities to direct and align educational development with the requirements of other sectors to ensure economic and social progress". Farrel (1997) cited in Bray and Varghese (2011:65) asserts that some authors refer to it as "policy analysis"; "policy-making"; "management"; "decision-making" or broadly as "politics". The common thread running through all these definitions is simply that educational planning involves determining what is to be taught and learned, how, when, where, by whom, at whose cost and for what purpose.

1.2.2 Quality Education

Quality is a complex and diverse term which is normally associated with effectiveness, efficiency and equity. In the education context quality encompasses processes that well-trained teachers use to facilitate learning and assessment in well managed classes and schools to lessen the inequalities. It also includes outcomes that cover knowledge, skills and attitudes which are connected to national goals and participation in society (UNICEF, 2000).

1.2.3 Learner Performance

Learner performance is simply what learners are able to do or how they demonstrate their competence. It is the ultimate indicator of success (Reddy, 2005). A seven level descriptor is used to grade learner performance. This ranges from a scale of 0 – 29% which is extremely poor performance to the highest scale of 80% to 100% which denotes outstanding performance.

1.2.4. Matric Level

"Matric" is a term generally used to refer to the final year of high school and the qualification received on completing the grade (Department of Education, 2003). It is also referred to as grade 12.

1.2.5 Mathematics

Mathematics is defined as a human activity that entails observing, representing and investigating patterns and quantitative relationships in physical and social phenomena and between mathematical objects themselves (Department of Education, 2003).

1.2.6 Science

Science is a subject that focuses on investigating physical and chemical phenomena through scientific inquiry. It involves applying scientific models, theories and laws in order to explain and predict events in the physical environment (Department of Education, 2003).

1.2.7 Scenario Planning Terms

Blyth (2005:1) defines scenario planning as “a strategic planning tool for improving decision-making against a background of possible future environments”. Scearce, Fulton and Global Business Network (2004:8) define it as “a process through which scenarios are developed and then used to inform strategy”. One element that stands out from both definitions is that scenario planning is a strategizing tool. The latter definition will be applied in this study. Scenarios are defined as “instruments for ordering people’s perceptions about alternative futures in which decisions made today may play out” (Blyth, 2005:1). van der Heijden (2005) defines them as stories about the future which are plausible and might unfold for organizations. In this study scenarios are simply seen as plausible stories of the future that help inform and guide decision-making. Driving forces are defined as “the major forces of change outside the organization that will shape the future” (Scearce et al, 2004; van der Heijden, 2005). Critical uncertainties are regarded as unpredictable driving forces that will have an important impact on the entity being studied (Scearce et al, 2004; van der Heijden, 2005). Wild cards are low probability events which, when they occur, have a significant impact on the future environment (Scearce et al, 2004).

1.2.8 Networks

The use of the term network differs greatly within and between disciplines. In social science, for instance, networks are regarded as new forms of social organization (Callon 1986, cited in Borzel, 1998). This study focuses on policy networks and Borzel (1998) defines policy networks as relatively stable set of interdependent and non-hierarchical relationships in which various actors share common interests with regards to a policy issue. This is the definition that will be adopted in this study.

1.3 Problem Statement

Learner performance in mathematics and science particularly at matric level continues to remain low. This is despite interventions like the SSIP, the Transformation of the curriculum, Mathematics, Science and Technology Strategy and the Dinaledi programme that have been employed to increase the mathematics and science pass rates and to improve the quality of passes. These interventions produce short term results, do not improve the education system and neither do they produce matriculants who obtain results that allow them entrance into universities. Reports from the GDE indicate that in 2012 Gauteng achieved an overall pass rate of 83.9%; in 2011 it was 81.1%; 78.6 % in 2010 and 71.8% in 2009. Even though these results show an improvement of over 10% the mathematics and science subject specific results have remained very low. Parker (2012) argues that the national matric discourse needs to change and center on the overall pass rates and the quality of the passes achieved.

1.4 Purpose Statement

The main purpose of the research is to investigate the factors leading to poor performance in mathematics and science at matric level in Gauteng. The researcher will present findings on the matric mathematics and science learner performance trends. The researcher will also interpret and analyze the findings and recommend scenarios for consideration to bring about improvement on the quality of mathematics and science at matric level.

1.5 Significance of the research

1.5.1 Better Planning

The researcher hopes that this study will achieve its objective if the application of scenario planning to address strategic and operational planning in relation to learner performance leads to better planning in mathematics and science at matric level in Gauteng. Poor planning has a negative impact on learner performance. One typical example is the situation where teaching and learning, particularly in public schools, does not occur during the first few weeks at the beginning of the year because there are no teachers for mathematics and science as most of them leave the department and join the private sector or private schools. Having an understanding of the plausible futures that are likely to play out will enable the GDE to plan better and execute those plans. However, as emphasized by Sayers (2010) scenario planning does not forecasts the future but raises awareness of the external environmental factors and expands the range of possible futures that are likely to unfold as well as policies and strategies for each of these futures.

1.5.2 Integration into Strategy

Scenario planning informs strategic decision-making. Once the scenarios have been created they will have a long-term influence on strategy and decision-making in the GDE. Scenarios will not only be used as a learning tool to deepen innovative thinking but will also inform and inspire action (Sayers, 2010). They will help the GDE test the robustness of their current MST strategy in light of the different possible futures. The GDE will use the scenarios to assess how each scenario would influence mathematics and science education and how the province can be more flexible. The scenarios will also help the GDE prepare for the future by taking action to bring about desirable scenarios and manage its way through the negative ones. Lastly, the GDE can look at what the scenarios suggest about the current interventions and policies and review them based on the scenario implications.

1.5.3 Visioning

Scenario planning will afford the GDE the opportunity to create a desired vision for the future. This means devising a desired vision from elements within the scenarios. It involves honing in on a specific future that the organization wants to make happen and focus on that without completely ignoring plausible multiple futures (Sayers, 2010). In this case the GDE will hone in on getting more learners choosing mathematics and science and getting bachelor passes at matric level with very high marks in these subjects. Scenario planning will not only shed light on potential changes which are out of the GDE’s control but will also highlight that there are a lot of choices facing the department as well as mathematics and science education going forward into the future.

1.6 Research Questions

Primary question:

- What are the factors leading to poor performance in mathematics and science at matric level in Gauteng?

Secondary questions:

- What are the Gauteng trends of learner performance in mathematics and science at matric level?

- What are the scenarios for consideration in relation to mathematics and science education?

1.7 Research Propositions

The two propositions that underpin this study are:

- Firstly, the constant poor performance in mathematics and science is due to poor decision-making both at strategic and operational level in relation to future direction. Using foresight tools during the educational decision-making process will result in better decisions.

- Secondly, if policy-making does not change for the better, the state of mathematics and science education will deteriorate even further. The number of learners choosing mathematics and science will significantly drop. It will be a classical case of a low road scenario where there is a confluence of downward spiral events of poor decision-making leadership and insufficient resources.

These propositions will be tested during the study to validate whether or not they are true.

1.8 Conclusion

Mathematics and science education in South Africa faces a myriad of challenges. These range from the efficacy of interventions, constant change of curriculum policies which create confusion amongst teachers to increased spending in education whereas academic achievement has remained stagnant. At the heart of these problems is poor decision-making at both strategic and operational level. It leads to failed systems, broken communication and low quality results. The constant poor quality of mathematics and science results at matric level has far reaching consequences. It perpetuates the gap between learners from the township schools and those from former model C schools and independent schools. This further widens the income inequalities gap in the society. This signals that the South African government is failing to use education as a tool to eradicate poverty and all forms of inequalities. Therefore, attention should be on ensuring that the schooling system provides quality mathematics and science education in order for education to achieve its objectives of economic development, growth and alleviation of poverty.

The next chapter reviews empirical debates around issues that have an effect on learner performance in mathematics and science particularly at matric level across all provinces in South Africa.

Chapter 2: Literature Review and Theoretical Framework

2.1 Introduction

This chapter reviews literature that addresses key aspects that impact on the quality of learner performance in mathematics and science at matric level. They, inter alia, include capacity building for teachers, laying a good foundation by focusing on primary schooling and addressing the language barrier that hinders effective teaching and learning of mathematics and science. It also reviews literature that looks at the application of scenario planning as a methodology to inform decision-making at strategic level. It explores ways in which scenario planning can be bring about the improvement of the quality of learner performance in mathematics and science in South Africa. The chapter ends with a critical review of the two theories that underpin this study and highlights how these theories interlink with the scenario planning methodology.

2.2 Strengthening Teachers

Teachers are fundamental in creating a supportive environment for learning mathematics and science. According to Kriek and Grayson (2009) and Mji and Makgato (2006), poor learner performance in mathematics and science at matric level can be attributed to mathematics and science teachers' limited content knowledge, ineffective teaching approaches and unprofessional attitudes. They further add parental role, language, non-completion of syllabus, laboratory usage, poverty and resources to the list. Taylor, Fleisch and Schindler (2007) concur and point out that most teachers still do not embrace the new curriculum discourses and practices. Therefore, rote learning and teacher talk continue to be the practice used in most classrooms. National and Provincial education departments have tried different interventions and mechanisms to ameliorate the state of mathematics and science education and yet compared to other countries South African learners' performance is far too low (Kriek and Grayson, 2009; Mji and Makgato, 2006). Therefore, they contend that long-term sustainable improvement of mathematics and science education must focus on strengthening teachers.

There are many professional development programmes that have been designed to empower and capacitate teachers but most of them have been ineffective because they are short-term. In response to this Kriek and Grayson (2009) designed a holistic professional development model. They assert that the model can address the problem of mathematics and science teachers' limited content knowledge, ineffective teaching approaches and unprofessional attitudes. This model focuses on a variety of skills and pedagogical content knowledge and is structured in such a way that it happens continuously and not only on weekends and during school holidays. Like Kriek and Grayson, Horak and Fricke (2004) contend that teacher training should be on-going. They advocate a teachers' mentorship programme which involves mentoring of mathematics and science teachers of disadvantaged schools during school time and by experienced mentor teachers. They maintain that on-site involvement ensures that teachers are empowered, capacitated to do their work properly and can implement what they have learnt with real support. What these scholars argue is that to make significant improvements, it will be necessary to set up regular, structured support until teachers are empowered and are able to work on their own.

Their arguments may be sound and their model good but they fail to consider other contextual factors that impact on having continuous professional development programmes. In Gauteng, for instance, the involvement of teacher unions serves as an impediment to the implementation of such programmes. Unions prohibit teachers from attending training that happens outside the seven hour working period that they are contracted for. This explains the CDE's (2007) suggestion for the education ministry to engage strongly with the unions about improving mathematics and science teaching so that there can be co-operation from their side. Secondly, professional programmes may be good but if the implementation thereof is not monitored the effectiveness levels will definitely be low. CDE (2007) supports the researchers' latter argument. It argues that after training has been conducted teacher's efficacy and performance should be closely monitored and provincial departments should negotiate with the unions to enable this. Even so, Carnoy and Chisholm (2008) caution against using the monitoring of teachers' performance in a judgmental way but argue that it should emphasize development and support of teachers through a formative rather than a summative evaluation process. They further state that it should contain elements of self-evaluation, peer review, consideration of contextual factors and mediation in the event of conflict. CDE (2007) recommends that the provincial department of education should have information about the effectiveness of mathematics and science teachers in high schools. It further states that the provincial department needs to have a diagnostic system so that it can offer support to teachers who need it.

Reddy (2006), on the other hand, questions the quality of professional development courses and asserts that it is crucial for investments in teacher development to be of high quality. Reddy's argument is that South African teachers attend a high number of professional development courses that are offered by the education department, universities and NGOs and yet there is no clear evidence of the impact these courses have on learner performance. This means that more attention must be given to the quality of these interventions so they need to be continually evaluated to ensure quality inputs and to measure the effect they have in the classrooms.

Apart from capacitating teachers, there is also a critical issue of shortage of mathematics and science teachers particularly in township schools. This shortage needs to be addressed because it also contributes to poor learner performance. Most mathematics and science teachers are not adequately qualified to teach these specialized subjects and they are allocated these subjects due to shortages. Mathematics and science teachers who have proper qualifications opt for private schools or other government departments (CDE, 2007). The 2005 education ministry report showed that the attrition rate was between 5 and 5, 5% nationally, which meant that between 17 000 and 20 000 teachers were lost to the system every year. Some of these teachers are mathematics and science teachers. The majority of teachers who leave the teaching profession are young teachers who test the system and then leave for lucrative jobs. The GDE'S 2006 EMIS data indicated that there is a small pool of teachers who have degrees in specialized subjects like mathematics and science. Furthermore, these qualified teachers are preferred in grades 7-9. This leaves a huge gap in grades 10-12 and has resulted in unqualified and inexperienced teachers teaching mathematics and science in grade 12. This misallocation of teachers contributes to poor quality of passes and low levels of learner performance in mathematics and science (Carnoy and Chisholm, 2008).

The new cohort of students in undergraduate teacher education courses is mainly white females who are undergoing primary education training. These are candidates who are unlikely to teach in township and rural schools where there is a need for qualified teachers (Reddy, 2005; CDE, 2007). Seemingly, the bursary schemes that have been introduced to attract undergraduate students to become mathematics and science teachers are ineffective. Consequently, Reddy suggests that innovative strategies are required to attract knowledgeable people to teach mathematics and science particularly in township schools. She strongly believes that ensuring that there is a full complement of mathematics and science teachers is a necessity if the quality of learner performance at matric level is to improve. The education ministry can pump millions of rands into the system but if teachers are the weakest link the financial resources will eventually become wasteful expenditure. Modisaotsile's (2012) recommendation is that teacher training colleges should be re-opened so that more teachers can be trained.

Taylor et al (2007) bring in a new element of the inefficiencies of the educational bureaucracies. They point out that there are serious capacity weaknesses in provincial education departments which affect the quality of policy development and the ability of departments to implement policy. They further argue that the national and provincial departments are understaffed, under-skilled and they are also inexperienced in critical areas which affect system development and delivery. Masehela's (2005) study also confirmed this. According to this study district officials are required to conduct regular classroom visits to support teachers in planning their lessons and teaching processes and yet they are understaffed, under-qualified or have no qualifications in subjects they are supposed to be specialists in. The challenge is that the same under-skilled and understaffed provincial offices are required to support district offices and this spills over to schools. Taylor et al's argument therefore, is that prior to debating about strengthening mathematics and science teachers the starting point should be capacitating district offices which are the only contact that schools have with outside agencies.

2.3 Primary School Focus

Most of the mathematics and science programmes and interventions that are aimed at improving the quality of learner performance are targeting grade 10-12 learners. Primary schooling is grossly neglected and lack of funding is always cited as a reason for this. Taylor et al (2007) are among the first scholars who applied scenario planning in addressing educational problems. They developed education scenarios for 2019 emphasizing long-term focus on primary school literacy and mathematics. Their argument is that inadequate mathematics and language teaching at secondary schools is due to the poor foundations that the vast majority of children receive at primary school level. This, they argue, has a direct impact on learners' achievement at secondary level. Howie (2002) cited in Horak and Fricke (2004) concurs and asserts that this results in South African teachers spending a lot of time re-teaching topics that should have been covered in the lower grades compared to their international counterparts.

The 2003 Systemic Evaluation of 54 000 grade 3 pupils revealed serious shortcomings in educational quality. The numeracy results were at 30% and most grade 6 learners performed at grade 3 level or worse in mathematics tests. CDE (2007) maintains that this is because 90% of mathematics and language lessons are conducted at lower than the correct grade level. These low levels of literacy and numeracy for South African grade 3 and 6 learners are a reflection of poor foundations. Some scholars believe that without the stable foundations South African learners will not be able to obtain the high level skills needed by the country to address poverty and inequality for growth and development (van der Berg, 2007; Modisaotsile, 2012). CDE (2007) attributes the poor foundations to the fact that teachers commonly fail to complete the curriculum of one grade before learners are promoted to the next grade and often times not even half the curriculum is covered because of slow pacing. This confirms that the problem requires intervention much earlier than in matric (van der Berg, 2007). It also indicates that the content knowledge of many primary mathematics and science teachers is limited (CDE, 2010). This means that if learners are to achieve at high levels at secondary school they need proper grooming at primary level. Therefore, instead of introducing numerous interventions aimed at ensuring that learners pass mathematics and science at matric level, efforts should be made to lay a proper solid foundation at lower levels particularly on mathematics and literacy. The main advantages of focusing on learners at a young age, according to CDE (2010), include identifying gifted learners earlier which provides organizations which run enrichment programmes greater opportunities to choose learners from a bigger pool. Focusing on primary schooling also enables schools to intervene and offer auxiliary services to learners with learning difficulties at an early stage rather than starting at grade 10.

Taylor et al (2007) argue that education authorities seem to be concerned with universal education access to primary schooling and extensive access to secondary schooling. Whilst they may be succeeding in addressing issues of access there is still a serious challenge with the quality aspect. Other scholars agree and argue that the vast majority of interventions have little existing impact on the quality of the mathematics and science schooling system (Parker, 2012; CDE, 2007). Taylor et al (2007) created three scenarios for primary schooling and they named the high road scenario “Improve the quality of basic education”. The main message that is put forward by this scenario is that improving the quality of primary schooling is essential to increasing the flow of science, engineering and technology skills into the economy and until that is done system-wide sustained improvement will not be possible.

2.4 Language Issues

The issue of language that should be used for teaching and learning mathematics and science in multilingual classrooms has been debated for years. Setati, Chitera and Essien (2009) ascribe this to the fact that learners in many of these multilingual classrooms are often not fully fluent in the language of learning and teaching which is English. This means that poor learner performance in mathematics and science is, inter alia, caused by the language barrier. The results of the international benchmarking tests like the TIMSS 2003 revealed factors which relate to the focus of language of tuition which impacts on mathematics and science learner performance. Firstly, learners who spoke either English or Afrikaans at home achieved much higher scores compared to those who spoke other languages. Secondly, the same learners’ average English score was very high. Thirdly, the language of learning in the classroom was found to be an important predictor of learner’s achievement in

South Africa. Lastly, second language learners from other countries performed much better than top performing South African learners (Mji and Makgato, 2006).

As a means of addressing this language problem the National Department of Education introduced the LIEP. This policy allows schools and learners to choose their language of learning and teaching as well as to use their language practices to make teaching and learning effective. Even though, this is a good policy initiative it does not change the fact that the English language is the language of power and status. The policy is also likely to create class divide in schooling especially in mathematics and science because learners who learn these subjects in their home languages are expected to switch to English at tertiary level which might create a challenge. Besides, learners who have a good command of English tend to do well in other subjects as well (Setati et al, 2009).

Setati (2008) views language and its use in the multilingual mathematics classrooms as having a political role. She argues that in South Africa language has always been mingled with the politics of domination, separation, resistance and affirmation. This can be traced back to the apartheid era whereby the language of learning became a dominating factor in opposition to the system of Bantu Education. Consequently, the decision about which language to use in multilingual classrooms is not only pedagogic but political as well and the political role is also linked to power relationships in the society.

Setati et al (2009) argue that mathematics and science teachers face a challenge of having to teach mathematics, science and English concurrently. Learners, on the other hand, have to cope with learning mathematics and science as disciplines of knowledge as well as communicating them in English. Infact, a study conducted by Mji and Makgato (2006) in Pretoria revealed that learners find it difficult to comprehend some of the concepts used in mathematics and science. This is exacerbated by the fact that mathematics and science use a language that is unfamiliar or strange. Sequentially this affects learners' understanding of these subjects and thus leads to alternative conceptions. A typical example cited by Mji and Makgato (2006) is the English definition of the concept "speed" and how it differs from the scientific definition.

There are two schools of thought with regard to the use of language when teaching mathematics and other content subjects like science. The one school of thought advocates the use of code-switching as the learning and teaching resource in multi-lingual mathematics classroom. The proponents of this school of thought argue that to aid multilingual learners' participation and success in mathematics, in particular, teachers have to acknowledge their home languages as accepted languages of mathematical communication. They contend that this can be done through code-switching whereby teachers use the learners' home language to explain concepts. They also posit that this way of code-switching becomes a linguistic resource from which teachers can draw on in a bid to encourage learner participation and also as a mechanism to allow learners to harness their languages as resources (Setati and Barwell, 2004 cited in Setati et al, 2009; Mathye and Setati, 2006 cited in Setati et al, 2009; Setati and Adler, 2006 cited in Setati et al, 2009).

The second school of thought focuses on the deliberate use of learners' home languages. Advocates of this school of thought such as Vorster (2005) and Molefe (2006) cited in Setati et al (2009), promote the deliberate, proactive and strategic use of learners' home languages in the teaching of mathematics. This, they contend, entails giving the learners tasks that are in English and in other languages present in the class. Learners can then choose the version that gives them greater access to mathematical knowledge. They further argue that this approach differs from code-switching in that the use of home languages in code-switching is reactive and learners' home languages are only used in oral communication and never in written text. Nevertheless, a study conducted by Mji and Makgato (2006) revealed that sometimes teachers find it difficult to explain things in the vernacular because it leads to misinterpretation and confusion particularly among the second language speakers. So, instead of mitigating the problem it aggravates it.

In critiquing this school of thought, Setati et al (2009) points out that focusing on home language only would disadvantage learners because English is a universal language, textbooks are written in English, examinations are also in English and higher institutions focus mainly on English. Furthermore, English is seen by teachers, parents and learners as a necessity for accessing social goods like employment and higher education. They recommend that teachers should use the learners' home language in such a way that learners gain access to English. The general consensus is that home languages can be used to teach and learn mathematics merely as a support needed while learners continue to develop proficiency in English whilst also learning mathematics (Setati, Adler, Reed and Bapoo, 2002, cited in Setati, 2008).

It is also important to note that the language problem is not unique to South Africa. Hornberger (1998) cited in Setati et al (2009) states that the same challenge exists in other countries like Percia whereby education has always meant learning Spanish which is regarded as the second language enabling wider communication. In South Africa English is seen as the channel of conforming and as a trait for maintaining privilege, whereas, African languages are regarded as an identifiable mark of lower status and disadvantage.

In conclusion, Setati et al (2009) remark that the issue of language in mathematics and science is important not only for equity and access but also because the majority of learners learn in a language that is not their home language. They caution that unless this issue is resolved South Africa will never be able to produce the number of scientists, technologists and engineers that are required. CDE (2007) affirms this by stating that achievement in mathematics and science is closely linked to proficiency in the language of learning and teaching. Hence, the importance of improving the proficiency of learners and teachers in English in order to improve the quality of teaching and the quality of passes in mathematics and science is emphasized. In conclusion, it is crucial that all mathematics and science education initiatives should include language components particularly English given the nature of global economic development.

2.5 Mathematical Anxiety

Many learners do not take mathematics and science simply because they do not see the relevance of these subjects to their future. This perceived lack of usefulness is contributing to the high dropout rate. By not taking mathematics and science a lot of learners screen themselves out of many potential careers. Secondly, a lot of learners do not take mathematics and science because of lack of confidence in their ability to be successful in doing mathematics in particular. They are also not motivated because they see the high failure rates which scare them off. Lastly, other schools discourage learners from taking mathematics and science and channel them towards mathematical literacy because they want to improve the overall pass rates. School principals do not want their schools to be classified as underperforming schools which would be the case if learners took mathematics and the schools' pass rates declined (Masehela, 2005; Reddy, 2005; Carnoy and Chisholm, 2008).

Even though this study looks at learner performance in both mathematics and science at matric level, mathematics is viewed as more problematic than science. When mathematical literacy was introduced, a great number of learners did not choose mathematics anymore instead they opted for mathematical literacy. Horak and Friske (2004) and Hlalele (2012) maintain that the massive decline in the number of learners taking mathematics appears to be still persisting and this is a worrying trend. According to Hlalele 300 000 learners wrote the matric mathematics paper in 2008 and the number declined to 225 000 in 2011. Scholars refer to this fear of mathematics as mathematical anxiety. Perry (2004) and Newstead (2006) cited in Hlalele (2012:268) define mathematical anxiety as "a person's feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary and academic settings". They further argue that this sense of discomfort which is observed while working on mathematical problems is associated with fear and apprehension to specific mathematics related settings.

McAnnalen (2010) cited in Hlalele (2012:269) defines mathematical anxiety as "an effective response that includes avoidance of mathematics, subsequent failure to learn mathematical skills and thus negative career and school-related decisions". The three common types of mathematical anxiety listed by Hlalele (2012) are mathematical test anxiety, numerical anxiety and abstraction anxiety. The former anxiety is associated with anticipating, taking and receiving mathematics tests. The latter is associated with the fear of abstract mathematical content. Numerical anxiety, on the other hand, is associated with number manipulation (Hlalele, 2012). Judging from this, it is clear that mathematical anxiety is far more than a mere dislike for mathematics and that it does hinder learners' positive thinking about mathematics.

Hlalele (2002) further points out that, mathematical anxiety is not only experienced by learners, but that teachers also go through this experience and this negatively impacts on learners in many ways. The most common effects include limited classroom interaction which culminates in learners not asking questions, not getting answers and knowledge being presented in a limited and confusing manner. Subsequently teachers emphasize rule-based strategies and they treat mathematics as random collection of facts to promote an illusion of their expertise and disciplinary power over learners (Levine, 2008 cited in Hlalele, 2012). Ultimately this anxiety gets to be passed on to learners. Learners with higher levels of mathematical anxiety are inclined to have lower levels of performance in mathematics therefore; lowering the levels of mathematical anxiety is in accordance with improving mathematics achievement (Hembree, 1990 cited in Hlalele, 2012).

Various scholars attribute mathematical anxiety to lack of confidence which they argue leads to decreased motivation (Edelmuth, 2006; Zakaria & Nordin, 2008 cited in Hlalele, 2012). They contend that learners who suffer from mathematical anxiety tend to perceive their skills in mathematics as less than those in other subjects. This results in them not enjoying mathematics and ultimately not having the desire to master it. Horak and Fricke (2004) agree with these scholars; they argue that learners' perceptions and self concepts impact on their performance and are significant predictors. They further state that learners who perceive mathematics as important achieve much better than those who do not. On the contrary, learners with a positive self-concept regarding mathematics achieve very good scores in mathematics tests.

As a solution, Furner and Berman (2003) suggest that learners need to view mathematics as a human endeavor initiative so they can learn to value and realise the application for learning mathematics in and outside the classroom. They posit that this will help learners realize that it is a practical subject. They also suggest that academic settings should create an atmosphere that encourages strengths and weaknesses in order to reduce mathematical anxiety. Furthermore, mathematics and science teaching and learning should also focus or cover a variety of learning styles.

2.6. Private and Public Partnership

High level of performance in mathematics and science is important for the country's economy. The construction and engineering industries are currently experiencing shortages in the managerial, professional and technological fields and the production of skills in these fields needs to drastically increase in order to address the needs of the advancing economy (Taylor et al, 2007; CDE, 2007). Poor learner performance in mathematics and science in high schools poses a problem not only for the education department but for all government departments and the private sector. It is against this backdrop that CDE (2007) maintains that the private sector has a close interest in improving mathematics and science education because in a modern technology-based economy many of the high level skills are based on mathematics and science.

The demand for high level skills in mathematics and science indicates that there is a need to strengthen strategic public and private partnerships. This is based on CDE's (2007) argument that business and donor funding of mathematics and science education that are currently existing have not had a significant impact on the education system as whole. The reasons cited include poor school management, the quality of teachers or selecting the right schools. The centre's recommendation is that the private sector should now focus on improving the entire system rather than engaging in small scale and low impact interventions. Improving the school system could according to CDE (2007), inter alia, include the creation of the mathematics and science forum and improving and analyzing the quantitative database of all developments in mathematics and science education at high school level.

In support of this argument, Modisaotsile (2012) posits that building relationships of mutualism among stakeholders in education will improve the quality of education. Howie (2002) cited in Horak and Fricke (2004) further confirms this by arguing that addressing the issue of mathematics and science education at schools is a matter of national priority and the extent of the problem requires all stakeholders to be involved. He cites the shortages of engineering professionals as an example and emphasizes that the poor state of mathematics and science education is a problem that affects all sectors.

Howie further argues that tertiary education institutions can also no longer do nothing and wait for the problems in the school system to sort themselves out. They have a crucial role of creating awareness and providing additional support to learners not doing well in mathematics and science. It is, however, important to note that there are tertiary institutions that are doing something in this regard. One such institution is the Engineering School of the University of Pretoria. This school is involved in activities that range from national competitions to awareness initiatives in science, engineering and technology (Horak and Fricke, 2004). There is an urgent need for other tertiary institutions, NGOs and corporate to follow suit so that more mathematics and science learners can be reached. These institutions and other stakeholders should review the kind of support they have given to mathematics and science education at all levels of the education system. This support should be geared towards individual schools that are performing well or are improving, assessments of grade 9 learners for mathematics and science aptitude, financial incentives for best performing teachers and learners as well as bursary schemes for learners who are performing well in mathematics and science (Modisaotsile, 2012).

2.7 Mathematics and Science Teaching and Learning Resources

The general belief is that for effective teaching and learning of mathematics and science to take place teachers of these subjects must have proper resources. These resources include science laboratory equipments and materials, computer software for science instruction, library materials relevant to mathematics and science instruction and audio-visual resources. Research, however, seems to reveal differing opinions regarding the availability or lack of resources and the impact this has on learners' performance in mathematics and science. Some scholars are of the opinion that where resources are available learner performance will be good, whereas, others believe non-availability has no bearing on how learners perform in mathematics and science. These scholars further believe that providing more resources to poor schools has so far little improved educational performance.

The latter scholars use the 2000 SACMEQ results to indicate that lack of resources does not influence learner performance in subjects like mathematics and science. The SACMEQ report unveiled that South Africa was outperformed by countries like

Mozambique, Kenya, Uganda and Tanzania which are much poorer than South Africa (van der Berg, 2007; Taylor, 2009). This indicates that there are education systems that achieve higher education quality with far fewer resources. In support of this argument Bloch (2009) asserts that enhancing resource inputs seems to have little effect on outcomes in poorer schools. Bloch's main contention is that it is not only money or physical infrastructure that is important but the way the education process is ordered, managed and translated into the classroom practice is extremely crucial. He argues that South Africa spends more money on education compared to other developing countries and yet South African learners perform far worse than those of other developing countries. This signals that the public education system is inefficient and ineffective in its use of resources. It is on this basis that Taylor (2007) maintains that South African schools can do far more with the resources at their disposal than they currently do.

van der Berg (2007) believes that post 1994 transition learner performance in matric mathematics and science passes has not been good notwithstanding more resources pumped into historically black schools. As a matter of fact, mathematics and science matric performance is extremely poor in the poorest provinces which are the ones who mostly benefitted from resource shifts. Modisaotsile (2012) confirms this by stating that over the past five years South Africa has doubled its education budget to more than R1 billion and yet the system has failed to reverse low exam mathematics and science results in matric and to improve the standard of teaching. Modisaotsile further states that the quality of education remains very poor, the output rates have not improved, classrooms are still overcrowded, dropout rates are very high, literacy and numeracy levels are very low despite the huge budgetary commitments by government.

Other scholars like Reddy (2005) and Masehela (2005) maintain that the availability of resources impacts on learner performance in mathematics and science. Reddy's argument, for instance, is that better learning opportunities are determined by access to economic resources. This means that learners who have finances to access the ex-model C schools stand a better chance for improved learning opportunities, improved performance and ultimately life prospects. Learners from poor backgrounds, on the contrary, receive fewer educational experiences and insufficient inputs because they rely solely on their township-based or rural schools to improve their life chances. A study conducted by Masehela (2005) indicated that school environments particularly in township schools are not conducive to increasing the participation rates. Schools are required to produce good results and yet there is lack of media centres, laboratories and currently relevant textbooks. CDE (2007) recommends that the education department, with the help of private sector and NGO's should bring infrastructure and equipment up to the standards required for effective mathematics and science teaching.

UNICEF (2000) also supports the argument that the quality of school facilities has a direct effect on learning. The centre's contention is that the quality of school buildings may be related to other school quality issues like the presence of adequate instructional material and textbooks, working conditions for learners and teachers as well as the teachers' ability to offer lessons. Shortage of classes may as an example lead to overcrowding which eventually impacts on the quality of education, the teacher-pupil ratios which make it impossible for teachers to address the learning needs of each individual child. Working conditions like these affect the teachers' ability to provide quality education (UNICEF, 2000).

It is important to note that the availability of teaching and learning resources cannot be separated from the overall socio-economic situation of learners. This is due to the fact that the socio-economic status has a significant effect on mathematics and science achievement. A number of international benchmarking studies like TIMSS have consistently proclaimed that in more than two-thirds of the homes of learners there are few or no books (Horak and Fricke, 2004). This is disturbing considering the fact that textbooks are an important resource for teaching and learning of mathematics and science. This shortage of textbooks culminates in limited teaching and learning in the classrooms.

2.8 Curriculum Policies

There is dissension regarding the impact of constant change in mathematics and science curriculum policies on learner performance Reddy (2005) asserts that curriculum practices and policies in schools in the post-apartheid dispensation are still replicating inequalities. Reddy believes these social class inequalities are replicated through mathematics pedagogic in South African primary schools. Reddy's concern is that learners from the working class school context are taught context-dependent meanings and everyday knowledge through localizing discourse while learners from affluent areas are taught context independent meanings and conceptual mathematics through specializing discourses. Learners who have access to economic resources receive better learning compared to those who do not. So, given that the department of education does not have norms and standards that ensure equitable access to education, schools in the public sector are not serving learners in an equitable manner in South Africa.

The introduction of Curriculum 2005 policy in 1997 brought a lot of confusion in the education system as it had a number of flaws. The two main shortfalls included the fact that the policy failed to estimate the extent to which resources would be a constraining factor. Secondly, it was the impracticality of providing in-service training to all teachers in all phases of schooling (Masehela, 2005; Bloch, 2009). This resulted in it being reviewed and before its impact could be assessed a new curriculum policy called Curriculum Assessment Policy Statement was introduced in 2012 in grade 10 and in the foundation phase. It is currently being implemented in grade 11 and in the intermediate phase and will be introduced in grade 12 in 2014. The main challenge is that just as teachers become familiar and comfortable with the policy a new one is introduced and this creates further confusion which ultimately impacts on learner performance. District officials have to constantly deal with new developments including the implementation of new curriculum policies. Masehela (2005) argues that this results in them not being able to deal with professional demands at hand.

Nonetheless, there are scholars such as (Carnoy and Chisholm, 2008) who commend the new curriculum policies because they believe that the mathematics curriculum, in particular, foregrounds the development of subject knowledge to a greater extent than before and that it expresses the skills, concepts and the content that learners are expected to acquire at each grade. Moreover, they argue that the mathematics curriculum is more structured and knowledge-based and focuses more on attaining core skills and knowledge competencies. Carnoy and Chisholm posit that the learner-centered pedagogy is the most effective approach to improving educational quality in classrooms and achieving greater equality in learning outcomes for socio-economically disadvantaged learners.

Reddy (2005) does not dispute the fact that South Africa has good policies for quality mathematics and science education but points out that the challenge is the implementation part. She argues that there is a need to develop human resources to manage the education system and ascertain the implementation of these mathematics and science curriculum policies at schools. Masehela (2005) agrees with Reddy and affirms that these policies aim to bring equity and redress in education, he questions the extent to which these policies are implemented. He also questions whether or not the policies are producing the desired results and the extent to which they have increased participation and learner performance rates in mathematics and science.

One of the policies promoting mathematics and science education is the Education White Paper 2 of 1995. This policy recommends that girl learners take mathematics and science since they are crucial for further growth and development of the nation. Increasing girl participation will also help address gender inequalities in South Africa. This is because participation and good performance in mathematics and science leads to increased access to economic power hence it's mostly males who occupy senior positions and have benefits that come with knowledge gained from these subjects (Masehela, 2005). In conclusion, Masehela argues that while a lot has been done in terms of policy designs and implementation a lot more remains unachieved. Therefore, these policies should be given more time to produce the desired results.

2.9 School Management and Leadership

School leadership and management have a significant role to play in improving learner performance. In support of the researcher's argument Taylor et al (2007) argue that school management is a key factor in determining the quality of education. UNICEF (2000) also maintains that well-managed schools and classrooms contribute a lot to education quality. They recommend that teachers, administrators and learners should agree upon schools and classroom rules as well as policies and that these rules and policies should be clear and understandable.

If school management is to improve learner performance particularly in mathematics and science it has to play dual roles (Taylor, 2009). Firstly, there needs to be distributed leadership where functions are shared by school managers and teachers. Principals need to direct schools towards effective teaching and learning and they need to be agents of change. They need to create conditions under which teachers can work effectively and an environment conducive for teaching and learning is essential for good school performance. Two issues that school leadership needs to focus on in order to improve teaching and learning are time management and curriculum leadership (Taylor, 2009).

Studies conducted by various scholars indicated that most South African teachers in township schools spend less time at school teaching and this is due to poor management (Chisholm, Hoadkey, Kivilu, Brookes, Narse and Rule, 2005 cited in Taylor, 2009). They assert that the situation is completely different at successful schools where school management ensures that punctuality is observed during the schools days and additional teaching time is created outside the normal hours so this explains the good learner performance particularly in critical subjects like mathematics and science.

Another study conducted by the HSRC showed that about 20% of teachers are absent from school on Mondays and Fridays and this tends to be worse at month ends. Township school teachers, for instance, tend to teach an average of 3.5 hours compared to the 6, 5 hours a day in former model C schools (Modisaotsile, 2012). The reason is that most principals fail to apply a strong time management administration in their school which leads to failure to take responsibility and exercise control of their work environment. The majority of school principals lack the ability to make sure that their school environments are conducive to teaching and learning (Taylor et al, 2007; Taylor, 2009).

A typical example is the school management's failure to control teacher attendance and the time table as well. The time spent by teachers in total at school is highly significant in predicting South African learners' achievement. The more time teachers spend preparing lessons after school the better the South African learners' score in mathematics. Evidently, in schools where teachers offer extra lessons in the morning and afternoon, learners tend to perform much better in mathematics and science (Horak and Fricke, 2004). Gustafson (2005) cited in Taylor et al (2007) confirms this by indicating that teacher late coming is a factor in 85% of the South African schools. He asserts that if all schools were brought up to the level of the best schools then the overall scores on the SACMEQ tests would definitely improve around 15% across the system and by 20% in the poorest schools.

In order to improve learner performance in mathematics and science school management and leadership needs to ensure that the school environment and the climate improve. They also need to ensure that there is good class and school attendance. Establishing a good climate will make it possible to focus on issues directly related to mathematics and science (Reddy, 2006). Professor Jansen of the Free State University also supports the notion that leadership matters and has a huge impact on how learners perform. After engaging with principals from disadvantaged backgrounds who managed to produce 100% passes in mathematics and science he made the following discoveries.

Firstly, he discovered that leaders from such schools do simple things well and these are things like good teaching and structured learning, every learner has textbooks in every subject. Secondly, leaders from such schools establish non-negotiable rhythms and routines. This includes the school starting on time, pupils arriving on time; compulsory uniform; learners receiving quick feedback on the tests and homeworks and discipline being enforced on both learners and teachers. However, they also recognize and reward success and all the above-mentioned activities result in the optimal use of instructional time. Thirdly, good school leaders create motivational cultures within their schools. These manifest in the way learners are encouraged to be ambitious and to dream big. Good leaders also plan in advance. They plan the teaching schedules and timetables for the following year and this is not done for deadline purposes but for reaching the schools' goals. Lastly, he contends that good school leaders organize and value team work and this creates a sense of buy-in from both learners and teachers (Jansen, 2012).

In conclusion, it is important to note that unless management problems are addressed at all levels from the provincial office to school level all the programmes that are aimed at resourcing poor schools or to improve the quality of education will not produce the desired results. Modisaotsile (2012) confirms this by remarking that there are poorly resourced schools that do not have laboratories and textbooks and yet they produce good results in mathematics and science because of strong leadership given by principals who insist that teachers come to schools punctually, teach and assess learners properly. It is such disciplined environments that are conducive for effective teaching and learning.

2.10 Interventions

The education ministry has a number of intervention programmes that are aimed at improving the quality of mathematics and science learner performance. The first one was the COLTS and the objective was to deal with the erosion of time and disruption of teaching and learning which had become the culture in many schools since the late 80s and early 90s. During this era mathematics and science were offered at two levels which was higher and lower grade. Thereafter, a new campaign to deal with failure rate in schools was introduced in 2001. This campaign set national targets for pass rates and it targeted schools achieving under 20% pass rates and the focus was on time management and teaching and learning (Crouch and Vinjevold, 2006; Taylor, 2009).

The NMST strategy was introduced in 2001 and its objective was to increase the participation and the success rates in mathematics and science. Initially a total of 102 schools were selected nationwide to drive the goals of the strategy. Arguably, the campaign has paid some dividends and there is improved efficiency in secondary schooling and the numbers of learners who are performing at lower than 20% in mathematics and science are gradually declining. However, there are also indications that the quality of the passes is not expanding (Crouch and Vinjevold, 2006). A new curriculum was introduced in 2006 as an intervention to address poor learner performance amongst other things. According to this new curriculum, all subjects were converted to higher grade level making the curriculum more demanding cognitively.

Another initiative that was introduced to improve the quality of mathematics and science is the National Learner Attainment Strategy (Crouch and Vinjevold, 2006).

According to this strategy all the provincial departments have to develop interventions to support increased pass rates in schools with a lot of African learners. This has been in the form of pace setters for teachers, common exams in grades 10 to 12 for standardization purposes and extra classes as well as the intensive training of teachers.

Another intervention is the Dinaledi Programme which was introduced by the Department of Education in 2006 and has been running in historically disadvantaged schools since then. The aim of this intervention is to improve the performance of African learners on mathematics and science and to ultimately increase the number of learners pursuing careers in the field of Engineering and ICT. It is still early to assess in great depths the impact of this intervention. However, the 2011 national report indicated that the number of learners taking mathematics in Dinaledi schools declined by 5 667 and the greatest declines were in Gauteng, Western Cape and Limpopo (Rasool, 2012; Crouch and Vinjevold, 2006).

This reverts to Jansen's (2012) argument that most learners migrate from mathematics to mathematical literacy. The total number of learners who wrote and passed mathematics in Dinaledi Schools in 2011 was 54% and only 1 174 out of 42 083 passed with over 80% and 9 412 obtained 50% and again there was a huge decline compared to the previous year. Science followed more or else the same trend and the highest declines were in Gauteng, Limpopo and North West. In 2011 20 884 learners from Dinaledi schools wrote science and only 1 191 passed with 80% and above and those who passed with 50% to 70% were 8 554 (Rasool, 2012). As argued earlier on, this shows the poor quality of passes and that even with the Dinaledi intervention, the results have continued to decline. The overall pass percentages may be high but the majority of learners' marks range within the thirties. Radebe (2013) concurs by pointing out that even though the percentages look good learners are not getting good results in critical subjects like mathematics and science. Radebe further states that the total number of learners who wrote mathematics nationally has decreased from about 300 000 in 2011 to 225 000 in 2012.

The Gauteng Province's target that was set by the education minister is 80% and to reach that target the GDE introduced the SSIP in 2010. It is a supplementary tuition programme which targets schools that are not achieving the 80% pass rate. Since its implementation the programme has grown and expanded to 431 underperforming schools. This intervention seeks to improve learner performance in problematic subjects like Mathematics, Science, Accounting and Life Sciences. However, other subjects like History, Geography and Mathematical Literacy were later introduced (GDE, 2012). Even though it is still early to assess the impact of this intervention, the Gauteng's 80.1% pass rate in 2011 and the 83.9 % in 2012 can to a certain extent, be attributed to this programme.

Most of these interventions are targeted at grades 10 to 12. According to CDE (2010) and Reddy (2005) and as argued earlier on, these interventions should be introduced at the primary school level where they will have more impact because at secondary level it is already too late. This will help build mathematics and science concepts from the early stages. The challenge is that most of these interventions are not implemented properly and some of them are abandoned after a few years of implementation on the basis that they do not produce the desired results. Morokolo (2011) cites the Dinaledi Programme which is an intervention which was established with the purpose of increasing the number of learners taking mathematics and science.

Morokolo believes that though millions are pumped into this programme it is failing in achieving its objective. The number of enrolments in both mathematics and science are decreasing and pass rates, not only in Gauteng but across all provinces, are an indication of government's failure to achieve its goals with this programme. In Gauteng, for instance, the number of learners enrolling for mathematics in Dinaledi schools decreased from 53 469 in 2008 to 50 921 in 2009 and there was a further decrease in 2010. The physical science enrolments followed the same trend, there was a drop from 40 379 in 2008 to 39 445 in 209 and in 2010 only 36 861 learners wrote physical science in Gauteng. The Dinaledi programme and other interventions like the SSIP are not adequately evaluated (Masehela, 2005; Reddy, 2005). Reddy's recommendation is that when interventions are introduced they should be accompanied by clear implementation plans, realistic timetables regarding time frames for assessing their impact and identification of lessons learnt from the interventions.

CDE (2010) postulates that the private sector and NGO mathematics and science education interventions have led to measurable success and that aptitude tests played an important role in these interventions. These are interventions like the Star School and Student Support Programme which are enrichment programmes for learners from disadvantaged backgrounds and programmes for placement scholarships from grade 7 upwards. Prior to being placed in these programmes learners are subjected to aptitude tests and these aptitudes tests produce very reliable results and can provide standardized, consistent and valid predictions of a learner's future success in a specific area (CDE, 2010).

However, as argued by Masehela (2005) earlier on, there's no empirical evidence of these interventions' success since they have not been independently evaluated so their impact and efficacy are not actually known. He further points out that the key thing now is not the introduction of other interventions but what is urgently required is the impact evaluation study of these interventions. He asserts that there is a mismatch between these interventions and the cognitive level of learners attending the programme. Secondly, there are no remedial programmes that are aimed at supporting learners in need of individual attention particularly in overcrowded classes. It is thus clear that the education department does not necessarily need more interventions but needs to improve on the ones that currently exist.

2.11 Quality of Schooling

Since 1994 the focus has been on promoting access to education and this has led to putting emphasis on quantity in the form of increasing the number of learners that get to grade 12. Despite this effort, Horak and Friske (2004) assert that the number of matric learners in South Africa has declined steadily over the past five to eight years. They also argue that the proportion of learners taking mathematics and science has been kept at even lower levels. The declining numbers of mathematics and science learners who are part of the Dinaledi Programme in Gauteng which was mentioned earlier on validates this argument. van der Berg (2007) and Modisaotsile (2012) argue that there needs to be a shift and concentration should be on the quality of education. This, they argue, is confirmed by the high enrolment rate each year and the progressively poor grade 12 outputs and the high dropout rate.

In his June 2011 ministry's diagnostic overview the National Planning Minister discovered that the quality of schooling is substandard particularly in the township schools. This means that there are differences especially in mathematics and science learner performance between learners who attend township schools and those who attend ex-model C schools. This, according to Taylor (2009), is similar to the 2003 TIMSS report which revealed that children who attend in former black schools had an average mathematics score of 227 whilst learners from ex-model C schools had an average score of 456 which was closer to an international average of 467. A study conducted by Horak and Friske (2004) also indicated that mathematics and science learners who pass with acceptable symbols and meet the requirements for university enrolments in fields like engineering or science based are even less and the demographic distribution is greatly biased towards white learners .

Furthermore, a study conducted by Reddy (2005) in Gauteng showed that approximately 42% of learners writing mathematics were blacks, 26% were from former white schools, 24% were from independent schools, 4% coloureds and 3% Indians. Evidently, a higher percentage of mathematics and science learners are from township schools which do not have adequate resources like laboratories and well-qualified mathematics and science teachers. As a result, the gap between the quality of schooling provided for and the achievements of white and African students is quite big. Whilst there is a difference in the quality of passes in mathematics and science between township and ex-model C schools, there are also differences between independent and ex-model C schools in respect of performance in mathematics and science. The high number of quality mathematics and science passes is heavily concentrated in independent schools (Taylor, 2009).

Hlalele (2012) brings in a third category which is mathematics and science learner performance of matric learners from the rural school settings. Hlalele argues that rural education is marginalized in South Africa and that it continues to face a set of challenges because of the diverse geographic location of the schools, diverse learners' backgrounds and diverse learning styles. van der Berg (2007) posits that this differential quality of school education is a major cause of unequal labour market earnings. Bloch (2009) concurs and further contends that township and rural schools definitely form a second system of education which ultimately results in learners from these schools only becoming part of the second economy.

A good indicator of the quality of passes of mathematics and science education, according to Crouch and Vinjevold (2006), is the number of "exemptions" which refers to the total number of learners who pass matric and meet the university entrance requirements to pursue studies in the science field. They argue that this number is constantly declining which means that the passes are of poor quality. Results announcements seem to indicate that the pass rates are good but Jansen (2012) warns that such improvements should not be equated with advancement in education equity or quality of education. Jansen asserts that such results only provide information about how candidates did in the context of the examination. There is no indication of whether there has been a significant redistribution in the exam success rate of learners who attended schools in previously disadvantaged areas. Neither do they mention learners who dropped out before they reached grade 12, the failure rates or the circumstances that led to learners dropping out of the education system.

Jansen (2004) argues that the education department opts for short term measures which merely serve as substitutes for the changes the education system really needs. One of these short cuts is the norm referencing assessment system whereby marks are adjusted in specific examinations. Jansen's contention is that the mechanisms and applications of moderation and the degree to which marks are adjusted should be made known to the public. Unless this is done, Jansen believes there will always be a perception that the process is vulnerable to political pressure and manipulation.

The second short cut is the one applied by schools whereby they hold back grade 11 learners when they suspect that they might fail matric and lower the school average. In some instances they refer them to public FET Colleges or encourage them to take mathematics literacy instead of pure mathematics. Due to this, Jansen concludes by stating that international tests like the TIMSS are a more authentic reflection of the state of South African education rather than matric results. It can be argued therefore that the South African education will be deemed to be of good quality once it reaches a point where every matric learner passes well enough to meet university entrance requirements and complete their degree or when they finish matric being knowledgeable enough to access the labour market.

2.12 Scenario Planning as a Strategic Planning Tool

There is little academic material that looks at the application of scenario planning as a methodology to inform decision-making at strategic level in the field of education in South Africa. Nevertheless, there is a lot of academic material on how scenario planning, as a foresight tool, provides a framework for developing resilient policies and as a systemic methodology that leads to better decisions. Chermack and van der Merwe (2003) for instance, believe that scenario planning was developed as a strategic planning tool because it plays a crucial role of improving the quality of executive decision-making and critical thinking. It provides managers with an opportunity of acting with more confidence in the face of uncertainty and ambiguity because it allows them to reperceive reality. It also helps executives make better and more resilient strategic decisions thereby avoiding the common errors of over-prediction and under-prediction of change. Shoemaker (1995) regards scenario planning as relevant to strategic planning in the sense that it helps managers broaden their imaginations to perceive a large spectrum of possible futures. It also helps them exploit the unexpected opportunities that might arise.

The research problem addressed in this study is a policy issue and policy making is about making decisions. The challenge that policy-makers face is making those decisions without knowing the future outcomes so they end up making decisions based on a number of uncertainties (Volkery and Ribeiro, 2009). They further argue that scenario planning serves a critical role of describing a range of possible consequences for candidate policies. It also helps discover policy options and surface some blindspots of an organisation’s policy or strategy functions.

There are various other reasons why scenario planning is relevant to policy making and should be applied in educational contexts. Firstly, it enables policy makers to make better sense of changes in their external environment. Secondly, it enables policy makers to identify early warning signals. Thirdly, it helps refine perceptions of existing or emerging problems as well as corresponding problem solving strategies. Fourthly, it helps surface and manage conflicts between differing societal values and interests which results in reaching a common ground for future action and this is what policy making is about. Furthermore, the policy-making process is complex and diverse so this diversity requires sound governance of scenario planning .This is because different formats might be necessary to conform to diverging information needs and context conditions. Lastly, scenario planning offers a policy risk-free space to visualise, rehearse and test the opportunity of different strategies without being implicated by the actual constraints (Volkery and Ribeiro, 2009; Sayers, 2010).

In this study scenario planning will help identify the uncertainties that are critical in improving the quality of learner performance in mathematics and science at matric level in South Africa. The scenario implications will then be utilized to prepare for those uncertainties.

2.13. Theoretical Framework

The research problem addressed in this study is informed by educational planning as the main theory with network theory as a complementary theory.

2.13.1 Educational Planning Theory

Educational planning theory looks at future decisions and actions by drawing insight from the past. Educational planning is an on-going process that does not only focus on mapping out how to reach goals but also considers implementation whilst noting unforeseen obstacles that develop and how they can be handled (Coombs, 1970). Coombs further asserts that this theory is anchored in five propositions which form a general educational planning framework. Firstly, educational planning takes a longer range view. It has a short, middle-range and long range perspective. Secondly, it is comprehensive. One vision is adopted and it must be linked to the goals of the society. It is incorporated with plans of the broader economic and social development. Bray and Varghese (2011) concur and they emphasize that educational planning is critical because it assists government and other sectors set priorities and to achieve economic and social objectives.

For education to effectively contribute to individual and national development and make use of scarce resources it has to take into cognisance the realities of the world around it. In relation to scenario planning this entails looking at the driving forces. Fourthly, it should be part of educational management so this involves being attached to processes of decision-making and operations. Lastly, it must be concerned with the qualitative aspects of educational development and not only focus on quantitative expansion. This is the only way the education system can be more relevant, effective and efficient (Coombs, 1970).

In relation to mathematics and science education, these propositions, inter alia, address issues of quality of passes in mathematics and science at matric level rather than focusing on the throughput of mathematics and science learners that go through the system per year. Taking a longer range view in this context would, for instance, include doing projections of the number of learners that would choose mathematics and science at grade ten and ensuring that there will be a full complement of mathematics and science teachers in their schools at the beginning of the year.

Bray and Varghese (2011) argue that current and future educational planning should display what is to be done in the sector and how government agencies, other stakeholders and government can share responsibilities. This will result in plans becoming conciliated agreements among all actors involved in implementing educational programmes. In conclusion, Bray and Varghese (2011) argue that educational planning can provide an opportunity to inform policy with regard to uncertainty, controllability and locus of control.

2.13.2 Network Theory

The network theory is simply about a range of stakeholders who work together to ensure that a mutual goal is achieved and these stakeholders form policy networks. This theory is applied in this study based on the fact that scenario planning requires collective participation of various actors like strategists, managers and experts who have formed networks with an intention of creating alternative future representations (Roubelat, 2000). This means that scenarios cannot be developed by one individual or sector but rather by many experts in the field. Strategists and managers come together and create various plausible futures. Lesourne (1996) cited in Roubelat (2000) and Peterson, Cumming and Carpenter (2003) concur by arguing that by forming networks made up of different people, stakeholders and constituencies, scenario planning attempts to make various dimensions interact through large networks of information and expertise. For instance, the GDE cannot single handedly identify the driving forces and key factors influencing performance in mathematics and science and then come up with mechanisms to react to possible developments. Rather, a range of stakeholders need to be involved to sketch out the plausible future of mathematics and science because of their interdisciplinary and interdependent natures.

The researcher's second reason for applying the network theory is based on Scearce et al's (2004) argument that scenarios can be utilized with multi-stakeholder affiliations to formulate a joint vision and enhance coordination around a preferred future or strategic direction. They further argue that the application of scenario planning often produces a better understanding of the complexities of public problem-solving. In this case, it means that when officials from Sci-Bono Discovery Centre and the GDE apply scenario planning to inform policy around improving the quality of passes in mathematics and science they will have to identify the driving forces, potential opportunities, barriers and pitfalls and then plan for all of them. Working together with other interested stakeholders will help establish common ground and joint solutions for the future. Networks tend to succeed when there is integration and actors have a shared understanding of policy problems faced and how they should be solved within a governance framework (Gains, 2003).

Application of network theory in this study can also be seen as what Gains (2003) and deLeon and Varda (2009) call intersectoral collaboration. Improving the quality of mathematics and science passes is not a goal that can be achieved by the GDE and the Sci-Bono Discovery Centre only. There are other institutions such as the Mathematics Centre for Professional Teachers, the Gordon Institute of Business Science in collaboration with Investec and Organization for Resources and

Technological Training South Africa that are working towards improving matric results. The challenge currently is that there is no collaboration between these intersectoral networks, they operate in silos and end up being ineffective. They would be more effective if there was an exchange of tangible and intangible resources through reciprocal, trusting and mutually supportive relationships (deLeon and Varda, 2009).

2.14 Conclusion

The literature reviewed in this chapter affirms that the problem of poor learner performance in mathematics and science at matric level is multifold and thus require a multifaceted approach and solution. It also highlights that education is a societal responsibility so all stakeholders need to be involved in order for the quality of matric learner performance in mathematics and science to improve. Therefore, the initiatives of all stakeholders need to be well coordinated and communicated and the impact thereof monitored. The review has also indicated how, when applied properly, scenario planning can be a useful policy tool.

The next chapter explains the research design and methods the researcher used in a bid to empirically answer the research questions.

Chapter 3: Research Methodology

3.1 Introduction

The literature review covered in the previous chapter formed a framework on which to base this study. It also contextualized the phenomena under study which is learner performance in mathematics and science at matric level in Gauteng. This chapter elucidates the research methodology that was employed to answer the research question. It begins by locating the field within which this study is situated. It also unravels the mixed-method approach that was used, the role played by each approach as well as the explanation of how these approaches complement each other in this study. The chapter also outlines the data collection methods that were used and they include in-depth interviews, documentary analysis and analysis of learners' pass rates in mathematics and science at matric level in Gauteng. Issues of ethics, reliability and validity of the study are also explored. The chapter ends by highlighting the limitations of this study.

3.2 Fields of Study

This is a descriptive study that deals with the quality of learner performance in mathematics and science at matric level in Gauteng. There are different definitions of a descriptive study. Neuman (2011) regards a descriptive research as the type of research in which the basic intention is to "paint a picture" using words or numbers. He further states that a descriptive study presents a profile, a classification of types or an outline of steps to answer questions like when, how and who. He points out that this research type lays out a picture of the specific details of a situation, social setting or relationship. Teddlie and Tashakkori (2009) refer to descriptive research as the type of research which is conducted with the goal of exploring the attributes of a phenomena or possible relationship between variables. Both these definitions emphasise the fact that a descriptive study explains in detail the data and the characteristics of what is being studied.

Advantages of a descriptive research study include the fact that it provides a detailed and highly accurate picture. A descriptive research also creates a set of categories or classifies types and documents a causal process or mechanism. Lastly, it reports on the background or context of a situation (Neuman, 2011). This study is descriptive in nature in that it aims to paint a picture and tell stories of what Gauteng matric mathematics and science learner performance is likely to look like in 2022. This is in line with Neuman's (2011) argument that the descriptive study's outcome is a detailed picture of the issue or answer to the research questions. After conducting the research and analysing the data the researcher will be able to list factors leading to poor performance in mathematics and science at matric level in Gauteng. This data will then be used to create scenarios for consideration in relation to mathematics and science education.

This research type was determined by the nature of the research question which will be addressed through the filters of educational planning and scenario planning. The educational planning aspect looks at how better educational planning and improved decision-making can enhance mathematics and science results. The issue of educational planning is closely tied to policy matters because the overarching goal of the study is to inform policy around improving the quality of mathematics and science performance at matric level. The scenario planning methodology is meant to support future and foresight of mathematics and science education.

3.3 Research Design

The research design employed to answer the research questions is the mixed method approach. Even though both qualitative and quantitative approaches are critical in addressing the research question, the study leaned more on the qualitative approach.

3.3.1 Qualitative Approach

The qualitative research approach is defined as "any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification" (Straus and Corbin 1990 cited in Golafshani, 2003:600). Rather, it produces findings arrived from the real-world settings where the phenomena that is being studied unfolds naturally (Paton, 2001 cited in Golafshani, 2003). Teddlie and Tashakkori (2009) view it as a technique that is associated with the gathering, analysis, interpretation and presentation of narrative information. One element that stands out from these definitions is that the qualitative research approach tries to understand people's interpretations under their natural conditions. The researcher studies the real world as it unfolds because it is a naturalistic and interpretative approach to the world. Patton (2002) confirms this by pointing out that in qualitative research observations occur in real world settings whereby people are interviewed in places and under conditions that are comfortable and familiar to them.

There are numerous advantages of conducting the qualitative approach and they include the fact that it provides an opportunity to build a complex and holistic picture of the phenomena of interest. Secondly, it enables the researcher to develop a level of detail about the individual or place and to be involved in real experiences of the participants (Creswell, 2003).

The qualitative research approach enabled the researcher to thoroughly explore the type and quality of responses because it acknowledges the social and behavioral context in which the phenomena occurs (Babbie and Mouton, 2001; Creswell, 2003). In this study the researcher used this approach to gather data that will help decision-makers at the GDE gain a deeper understanding of the world in which the improvement of the quality of mathematics and science education takes place. The GDE can then use this data to inform their strategy and then enhance the ability to make better decisions in the present and in the future (Scearce et al, 2004).

3.3.2 Quantitative Approach

The nature of the research questions also required the use of the quantitative research approach. Teddlie and Tashakkori (2009) regard the quantitative research approach as a technique associated with the gathering, analysis, interpretation and presentation of numerical information. This approach differs from the qualitative approach in that it emphasises the measurement and analysis of causal relationships between variables and not on the processes. It is based on the idea that social phenomena can be quantified, measured and expressed numerically. It involves exploring how often and how much something happens. The focus is more on measurement and proof. It is based on the premise that something is meaningful only if it can be observed and counted. Its key characteristic is numerical data that permit a range of statistical analysis (Golafshani, 2003; Hancock, Windridge and Ockleford, 2009)

Generally, the quantitative research approach is used to test hypothesis and in this study it was not used to test any hypothesis but to validate the research propositions mentioned in the first chapter of this report. The focus was on the information in the form of numbers that can be quantified and summarized. In this context the numbers are the grade 12 pass rates in mathematics and science at matric level in Gauteng. The quantitative approach was used to investigate matric learner performance in mathematics and science in Gauteng from 2010 up to 2012 using a trend analysis technique. The researcher collected and analysed Gauteng's numerical data of the past three years' pass rates in mathematics and science. The purpose was to observe the overall patterns of change and trends in mathematics and science learner performance from one year to another. Secondly, the goal was to develop generalisations that contribute to theory that enabled the researcher to predict, explain and understand social phenomena. In this case the social phenomenon is learner performance which is expressed in numeric terms. This numerical data was used to complement data collected through documentary analysis and through interviews.

3.3.3 Mixed-Method Approach

The qualitative research approach is different from the quantitative research approach in that researchers have an opportunity to get close to the actors' perspectives through interviews and observation which is not necessarily possible to do with quantitative research. This is because the quantitative approach relies more on remote, inferential empirical words and materials. Quantitative researchers, on the contrary, find data collected through the qualitative approach unreliable, impressionistic and not objective. It is indisputable therefore that each of the research approaches discussed above has advantages and disadvantages. The disadvantages of these approaches may serve as hindrances to collecting valid and authentic data. It is against this background that this study focused on analyzing, collecting and mixing qualitative and quantitative data in a single study. This was done based on the premise that combining the quantitative and qualitative approaches provides a crystal clear comprehension of the research problems than when using one approach. Upretty (2009) concurs and asserts that the mixed method approach gives a better integrated and comprehensive picture of the phenomena being studied. The mixed approach was also used because the study involved the collection of both soft and hard data. Thirdly, the mixed approach was deemed appropriate for this study in order to expand an understanding from one method to another and to converge or confirm findings from different data sources (Bryman, 2006). The challenge however, as pointed out by Creswell (2003) was that the mixed method required the researcher to be familiar with both quantitative and qualitative research approaches.

The researcher used a system which Teddlie and Tashakkori (2009) refer to as the sequential mixed design. In this design, phases of the study occur in a chronological order whereby one strand follows the other. In the first phase the researcher collected data sequentially starting with qualitative data and the intention was to explore the topic with the identified respondents at their sites. As part of the second phase the researcher collected hard data from the EMIS unit at the GDE. This is the unit that is responsible for developing and maintaining an integrated education information system for management of education. This integrated information system is accomplished through acquisition, processing, dissemination and reporting of quality education data.

The researcher's priority was, however, skewed towards the qualitative data and the reason was that the researcher needed this data to identify the key driving forces and the critical uncertainties that are likely to affect learner performance in mathematics and science at matric level in future. Nevertheless, the hard data from the quantitative approach was also valuable as it helped the researcher identify learner performance trends. In the end both approaches were used to describe social reality which in this case is learner performance in mathematics and science at matric level in Gauteng. Once all the data had been collected the researcher integrated it and it is presented in the next chapter in a form of tables, figures and the narrative.

3.4 Research Methods

The qualitative data collection methods that were used in this study are documentary analysis and in-depth interviews. The quantitative data collection method was the analysis of 2010 – 2012 Gauteng mathematics and science results.

3.4.1 Documentary analysis

Bailey (1994) cited in Mogalakwe (2006) refers to documentary analysis as the analysis of documents that contain information about the phenomenon that is being studied. It entails the systematic identification and analysis of underlying themes in materials and then providing an interpretation that increases the effectiveness of the theoretical argument (Fitzgerald, 2012). Fitzgerald further contends that documents provide valuable information about the context and the culture of institutions. Documents also enable the researcher to read between the lines of official discourse and thereafter triangulate information through interviews, observations and questionnaires. A wide range of written material can produce qualitative information which can be useful in trying to understand the philosophy of an organization. Therefore, on the basis of these arguments the researcher conducted documentary analysis first which helped formulate the questions that were asked during the interviews.

There are numerous reasons for using this data collection method. Firstly, documentary analysis was used because documents could be easily accessed at a time convenient for the researcher. They had critical facts like names, dates and specific event details. Documents also provided access to information that the researcher would not have been able to get through interviews and also because they were unobtrusive. Documentary analysis was also used because documents reveal what people do or did because the behavior occurred in its natural setting and because data has a strong validity. They also enabled the researcher to obtain the language and the words of the participants. Lastly, they served as written evidence and thus saved the researcher a lot of time and the expense of transcribing data (Creswell, 2003; Hancock et al, 2009; Fitzgerald, 2012).

Documents can either be public, private and personal. Public documents include government’s publications like acts, policy statements, ministerial or departmental annual reports and others. Private documents can come from civil society organizations like trade unions, NGOs and other institutions. They can include things like minutes of meetings, interdepartmental memos and annual reports (Mogalakwe, 2006).

A total of five documents were analyzed and these include the Gauteng Mathematics Science Technology Strategy, Medium Term Strategic Framework, Gauteng Teacher Development Professional Strategy, Curriculum Policies and the ANC Education Road Map. These documents were selected because they contain information relevant to the research topic. A documentary analysis template (Annexure A) was used a guide for analysing these documents.

The researcher also looked at documents containing statistics of learner performance for the past five years and these statistics gave face value meaning from which its real significance needed to be reconstructed. Therefore, the raw figures were interrogated and their real meaning was reconstructed. Mogalakwe (2006) argues that one can only make sense of such information by situating it within a theoretical context and it is that theory that will re-order the data and the inferences come as a matter of interpretation of the raw material informed by theory.

3.4.2 Interviews

Interviews were also conducted to supplement the data gathered from the documentary analysis. Neuman (2011:342) defines an interview as a "short-term secondary social interaction between two strangers with the explicit purpose of one person obtaining specific information from the other". Interviews differ from normal conversation in that in an interview the interviewer asks pre-arranged questions and then the respondents give answers that might be recorded. Unlike a conversation, an interview has specific goals that should be attached at the end of the interview process. They are regarded as a powerful data collection strategy because they use one on one interaction between the researcher and the interviewees (Turner, 2010; Curtis and Curtis, 2011; Neuman, 2011).

In this study the researcher conducted standardized open-ended interviews. These interviews according to Patton (2002) cited in Teddlie and Tashakkori (2009) and Turner (2010) are done in such a way that the exact wording and sequencing of questions are determined in advance. This means that all the candidates were asked the same basic questions in the same order and these questions were worded in a totally open-ended manner. This allowed the respondents to express their own understanding in a way that was suitable and comfortable for them. The open-ended nature of the questions posed defined the topic under investigation but it also provided opportunities for both the researcher and the interviewees to discuss the topic in detail.

Interviews were used as a data collection method because they provide comprehensive information about the experiences and viewpoints, perceptions and experiences of participants on a particular topic. They also afford the researcher the opportunity to ask for explanations of vague answers or produce clarification if a question is not clear. They are also good for measuring people’s attitudes and interests. They are easier to manage because the researcher focuses on one person and does not have to deal with group dynamics. They allow the researcher to build a rapport with the participants which ultimately makes the participants more willing to discuss personal material. Eventually this enables the researcher to gather rich information. The other advantage includes the fact that respondents answer the same questions which increases the comparability of responses (Turner, 2010; Curtis and Curtis, 2011).

An interview questionnaire (Annexure B) was prepared prior to the interviews. The researcher then requested permission to collect data from the sample and all candidates that were interviewed were sent the Wits Research student letter beforehand. The aim was to assure the candidates that data was collected purely for academic purposes. Notes were taken during the interviews and the researcher also took note of non-verbal expressions of the participants during the interview sessions. In instances where interviewees gave brief responses probing was done to encourage them to elaborate or provide specific information. Data was captured on the computer immediately after each and every interview. To maintain confidentiality, the candidates' names were not mentioned when transcribing the data.

3.4.3 Analysis of mathematics and science results

From the quantitative side, the researcher studied the annual matric results reports from 2010 to 2012 that were generated after the results had been published. The process started off with examining the overall mathematics and science pass rates in Gauteng. The researcher looked at the different degrees of passing, the failure rate and the comparison of district performances was also made. The pass rates were also compared with the total number of learners that enrolled for matric each year with those who actually sat for exams. The systems and techniques for acquiring and processing education information are subjected to audits therefore the data that the researcher scrutinized was accurate. The aim of this exercise was to identify trends and patterns of learner performance in mathematics and science in Gauteng and then draw conclusions based on the available figures. The challenge was that the number of schools with matric varies from one year to another because new high schools are built every year and that impacts on the overall percentage pass rates.

3.5 Sampling

The units of analysis in this study were managers and senior managers from the GDE and Sci-Bono Discovery Centre, which is an agency of the education provincial department. The qualitative section of the study had a sample of six candidates which were interviewed. These included the Chief Education Specialist, Director FET Curriculum, Teacher Development Director at Sci-Bono Discovery Centre, the Sci-Bono's Chief Executive Officer and the Provincial Mathematics and Science Coordinators. This is a multi-disciplinary team whose role is to make short and long-term strategic decisions in the Gauteng province regarding improving learner performance particularly in mathematics and science. The researcher used what McMillan and Schumacher (2006:319) refer to as purposive sampling which is defined as "a sampling method that chooses a small group of individuals who are knowledgeable and informative about the phenomena the researcher is investigating without needing or desiring to generalize the findings". The participants were not randomly selected but were chosen based on the fact that they are a manageable sample size, are knowledgeable and relevant to the research topic and not on their representativeness (Flick 1998 cited in Neuman, 2011; Teddlie and Tashakkori, 2006). Generalisability of the findings to a wide more diverse population was not the aim. The findings and the plausible future scenarios for the matric mathematics and science education that will be mapped out, will only apply to the Gauteng Province.

Additionally, the quantitative part of the research looked at all public Gauteng schools that have grade 12 mathematics and science learners. There were 749 high schools in Gauteng at the end of 2012. The number has gone up in 2013 because new schools are opened every year.

3.6 Deductive Approach (Scenario Planning)

This study applies the scenario-driven approach to address the quality of matric mathematics and science passes in Gauteng. Scenario planning arose as a way of dealing with increasing complexity and uncertainty (Scearce et al, 2004). In this study scenario planning was used to deal with the uncertainty and complexity that face mathematics and science education. Annexure D explains the steps the researcher followed when creating the four scenarios. The three main benefits of scenario planning include gaining a broader vision by introducing alternative views and identifying risks and opportunities that could be excluded by traditional planning processes. Secondly, it offers a more impactful understanding of the world gained through living the future in scenario-based explorations. Lastly, it offers a more robust planning process that provides better strategic options (Peterson and Laudicina, 2007). Scenarios were developed using the qualitative data that was collected during the interview and the documentary analysis process.

There are three approaches that can be used to develop and frame scenarios and they are the deductive, inductive and the incremental approaches. The approach suitable for this study is the deductive approach which is a simple technique of prioritization to construct a 2 x 2 matrix based on the two most critical uncertainties that are likely to affect the future. This approach was chosen because it uses a simple technique and can be executed more quickly with fewer resources (Blyth, 2005; Volkery and Ribeiro, 2009; van Heijden, 2005). The following eight steps were followed:

Step 1: Identifying the focal issue.

This step began with the identification of a central issue or problem. The identified problem was then used as a focusing devise for assessment of the system. The identifed problem in this context is the poor quality of mathematics and science results at a matric level (Blyth, 2005; Dawson, 2010). The process of developing scenarios should according to Schwartz (1996) start from the inside out. This means that scenario planners should begin with a specific decision or issue and then build out to the environment. In practice this translated to learning more about the challenges facing mathematics and science education in Gauteng and the underlying assumptions about the nature of those challenges.

Step 2: Identifying key forces in the local environment

This step encompassed identifying key factors which affect the quality of learner performance in mathematics and science at matric level in Gauteng. These key factors influencing the quality of learner performance in mathematics and science were then listed. According to Schwartz (1996) these can range from facts about customers, to suppliers and competitors and others. In this case the key factors ranged from poor quality of teaching and learning to lack of resources for teaching mathematics and science among other things.

Step 3: Listing of driving forces

Schwartz (1996) asserts that this step involves listing the driving forces in the macro-environment that influence the key factors that were identifed in the previous step. This is done by applying the PESTEL technique which includes political, economical, social, technological, environmental and legal factors. In this study political factors included things like better relations between government and teacher unions and the economical factors included the constant budget cuts in districts for instance. All these findings are presented in the next chapter. Schwartz further maintains that these factors should be relevant to the focal issue therefore, a lot of research was done so that driving forces could be adequately defined.

Step 4: Rank by importance and uncertainty

This step is mainly about deciding which driving forces and key factors are most important in addressing the identified problem and which ones are the most uncertain (Blyth, 2005; Schwartz, 1996). They further contend that these are the primary focus of the scenario building process. Key factors and driving forces were ranked based on the degree of importance and uncertainty and this resulted in the critical uncertainities and predetermined elements emerging. The researcher then identified two factors or trends that are most important and most uncertain. These forces were used to create the Gauteng matric mathematics and science scenarios that are sketched out in chapter 5.

Step 5: Select scenario logics

The researcher then created scenario frameworks and these frameworks were constructed from the resulting trends of the previous step. Schwartz (1996) argues that these trends are important because they determine the story's outcome. Schwartz further cautions against having many scenario drivers and emphasises the importance of refining the axes until crucial uncertainties are identified. Therefore great care was taken when identifying the fundamental axes of crucial uncertainties and they were presented as a two by two matrix. This data was gathered during the interview process whereby interviewees were asked to list what they thought were the most critical uncertainties that would impact on learner performance in mathematics and science in Gauteng. The matrix served as a solid platform on which to explore the future possible outcomes of matric mathematics and science education in Gauteng.

Step 6: Flesh out scenarios

Using the two by two matrix constructed in the previous step, four scenarios were created. Initially they were defined in broad terms and later fleshed out in more detailed story lines. This was done in line with Schwartz's (1996) and Blyth's (2005) assertion that scenarios should be presented in a narrative form, should be simple, dramatic, simple and bold.

Step 7: Explore scenario implications

Schwartz (1996) asserts that this step involves imagining living and working in each scenario. It entails learning from the scenarios, adapting and taking effective action. He further points out that patterns and insights emerging from these implications form the building blocks of an organisation's strategic agenda. As indicated earlier on, the researcher hopes that the GDE will look at the four scenarios and assess what each scenario suggests about the current mathematics and science curriculum policies, mathematics and science interventions and the MST strategy. Based on scenario implications decision-makers at provincial level will then review them so that they can improve the quality of learner performance in mathematics and science at matric level in the future.

Step 8: Selection of leading indicators and signposts

The last step involves finding indicators or signposts that tell if particular scenarios are beginning to unfold. These indicators are signs of potentially significant change and when selected carefully and imaginatively they serve as powerful signals that organisations need to adapt (Ogilvy and Schwartz, 1998). Therefore, once mathematics and science scenarios have been developed they can be used to test, analyse and create policies. They can also be used to judge how the existing policies would turn out in different scenarios because the benefit of scenarios is that they are critical in identifying weak policies and those that are more vigorous to uncertainty about the future (Peterson et al, 2003).

The whole point of this exercise was to enhance the GDE decision-makers' ability to cope with and take advantage of future change. It was also meant to help them make better decisions and implement management plans that would drive the mathematics and science education system towards a more preferred future.

3.7 Reliability and Validity of the Study

Reliability and validity are the two ideas that help establish the truthfulness, credibility or believability of the findings. Joppe (2000) cited in Golafshani (2003:598) defines reliability as "the extent to which results are consistent over time and an accurate representation of the total population under study and if the result of the study can be reproduced." Neuman (2011:208), on the other hand, defines it as "dependability or consistency". He further states that it measures the extent to which the analysis of data yields reliable results that can be repeated or reproduced at different times or by different researchers. The common thread in these definitions is that reliability has to do with the same thing being repeated or recurring under identical or very similar conditions and producing the same results.

It was a challenge to attain perfect reliability in this research because it is a social study whereby the interviewees gave responses based on their perceptions, thoughts and feelings which are likely to change over time. This is confirmed by Golafshani (2003) who states that the use of reliability and validity to judge accuracy of a research is common in quantitative research but is questionable in qualitative studies. As indicated earlier on, this study was more skewed towards the qualitative approach. Nevertheless, the researcher conducted interviews in a professional and impartial way. Employing quantitative and qualitative research designs and triangulating data gathered from different sources also enhanced the reliability and validity of the findings.

Joppe (2000) cited in Golafshani (2003) posits that validity determines whether the research truly measures that which it was intended to measure and how truthful the research results are. Neuman (2011:208) simply defines it as “truthfulness”. This means that validity looks at whether the study measures what it was intended. In this study the researcher was more concerned with achieving the authenticity of the study rather than a single version of the truth. Authenticity, according to Neuman (2011) provides a fair, balanced and trustworthy account of social life from the viewpoints of the people who live it every day.

When conducting documentary analysis the researcher ensured that the documents that were analyzed were authentic and accurate. The fact that most of them were obtained from the Education Department’s website made it easy to validate their authenticity and the accuracy (Creswell, 2003). According to Mogalakwe (2006) there are mainly four quality control criteria for handling documentary sources and these include authenticity, credibility, representativeness and meaning. Authenticity looks at whether the information is genuine and is from reliable sources. Credibility assesses whether the evidence on the documents is free from error and distortion. Representativeness deals with whether the documents that are consulted are representative of the totality of the relevant documents. Meaning, on the contrary, refers to whether the evidence is clear and comprehensible. To ascertain authenticity when conducting documentary analysis the researcher ensured that the documents that were analyzed were genuine and had integrity. After establishing the authenticity of the documents the researcher also verified that the names inscribed on the documents were real names of authors. To ascertain credibility the researcher analyzed documents that were prepared independently and beforehand. None of the documents were produced for the researcher's benefits. Therefore, they were sincere and could have not been altered to mislead the researcher.

3.8 Ethical Considerations

When collecting data the researcher adhered to the code of ethics. This entailed obtaining informed consent from the participants and avoiding deception during the data collection process. Voluntary informed consent is the most crucial aspect of ethically appropriate research because it minimizes the risk of harming the respondents (Curtis and Curtis, 2011). Denzin and Lincoln (2011) concur and they point out that in research subjects have the right to be informed about the nature and consequences of experiments in which they are involved. They further assert that subjects must not be psychologically or physically coerced but should voluntarily participate in the research. Secondly, their agreement should be based on open and full information. Deception is also an important aspect of ethically appropriate research. According to Curtis and Curtis (2011) deception in research often applies to pretending that a study is about something different from what appears to be the case and the use thereof is condemned in research. To uphold this ethical conduct all the interviewees were briefed on the purpose of the study and participation was completely voluntary and based on full understanding of what was involved.

Following the code of ethics also entailed maintaining the respondents' privacy and confidentiality and ensuring accuracy of data. Only the research participants' positions were mentioned in the research and this was done in order to protect participants from inappropriate exposure. A good research study guarantees confidentiality when the researcher can identify a given person's responsibility but not make it public (Denzin and Lincoln, 2011; Babbie, 2013). The researcher pursued scientific knowledge without violating the rights of the people being studied; their names and responses were kept confidential. All the data that was collected was verified to ascertain accuracy. The researcher is a staff member of the Sci-Bono Discovery Centre and could exhibit undue biases towards the way decision-making is made to improve the quality of learner performance in mathematics and science in Gauteng. To mitigate this, the researcher exercised fairness in her thinking, personal morality and actions.

3.9 Study Limitations

Scenario planning is a specialized methodology that is not well-known and applied in the field of education in South Africa. Therefore, the lack of knowledge by interviewees about its practical applications served as a hindrance to getting comprehensive data from the interviewees. Some interviewees wanted the researcher to explain the methodology and how it applies to the study. Furthermore, in an attempt to explain the concepts and clarify the questions the researcher, to an extent, influenced the interviewee's responses.

The second limitation regarding interviews was keeping them on track. Some interviewees had a tendency to reveal or discuss things that were not relevant to the topic or even revealed sensitive information. Even though this was desirable it created extra burden of ensuring that the participants remained comfortable during and after the interviews.

Thirdly, the researcher interviewed participants from the GDE and analyzed results from the Gauteng schools only so the findings of this study will be confined to the Gauteng province and may not be generalized to other provinces. As a result, the study may lend itself to the criticism of not being broadly applicable. Therefore, the study lacks what Neuman (2011) calls external validity. This refers to an extent to which the findings of a study can be generalized to a wider range of settings and other people. It should be noted though that, as pointed out earlier, generalisability was not the aim of this study.

3.10 Conclusion

An overview of the mixed-method research approach and data collection methods was given. An explanation regarding the appropriateness of these methods in addressing the quality of learner performance in mathematics and science at matric level in Gauteng was also given. These tools enabled the researcher to collect both qualitative and quantitative data. The chapter further described the measures taken to ensure that the data that was collected was valid and reliable.

The next chapter will present the findings of this research study.

Chapter 4 –Findings

4.1 Introduction

This chapter is divided into two sections. The first section presents the findings of the documentary analysis and in-depth interviews. A total of five documents were analysed and these include the Gauteng MST Strategy; Medium Term Strategic Framework; Gauteng Teacher Development Professional Strategy; Mathematics and Science Curriculum Policies and the ANC's Education Roadmap. When analysing these documents the researcher looked at the content of the documents, the topic and the themes each document covers. The researcher further looked at how these documents relate to improving the quality of learner performance in mathematics and science at matric level. Regarding interviews, the researcher interviewed six candidates and the interview findings are presented as themes extracted from the interview questions. Section 2 presents the quantitative findings and this information is depicted in tabular and graphical format. The researcher looked at Gauteng's mathematics and science results from all 15 districts from 2010 to 2012.

4.2 Documentary Analysis

4.2.1 Gauteng MST Strategy

The MST Strategy is meant to be implemented from 2009 to 2014 by mathematics, science and technology teachers. It is an authentic document with the GDE logo however; the author, designation and the recipients or the audience are not indicated on the document. The strategy is written in a simple language that can be understood even by the general public. It has a list of references which is an indication that thorough research was done and a lot effort was put into compiling it.

The document was developed to address the challenges and improve the poor state of MST education in Gauteng. All the initiatives stated in this document are aimed at improving the quality of learner performance in mathematics, science and technology. It is clearly stated in the document that Gauteng is the economic hub of South Africa so it needs to produce school leavers that have MST related skills in order to improve the province's economy.

The strategy covers a number of issues, which were raised in the first two chapters of this research report, such as the language, training of teachers as well as teaching and learning resources. It starts off by reiterating what was stated in the first chapter regarding the standard of MST education which is of poor quality and how this creates a challenge because MST related skills are required for the development of the economy. It explains the four objectives that the GDE hopes to achieve by 2014.

The first objective deals with strengthening MST teachers in all Gauteng schools and this confirms the argument pointed out in the literature review chapter that the training of MST teachers is critical in improving learner performance in these subjects. The strategy emphasises the need to increase the quantity of MST teachers. The relief teacher programme is cited as one of the initiatives and it involves releasing MST teachers from schools for intensive training and substituting them with other teachers who will teach during that period. The programme anticipates that a pool of 200 teachers will exist by 2014. It requires a lot of funding and yet budgets are constantly reduced. As a result the programme does not run consistently and when it is suspended relief teachers end up seeking employment elsewhere which makes it difficult for the GDE to keep a database of these relief teachers. They end up having to constantly recruit more teachers and train them which ends up being a costly exercise.

The second objective looks at improving the provision of MST resources in Gauteng schools which was also alluded to in the literature review chapter of this report. The strategy however, aims at greater distribution and use of ICT in schools. An oversight of this document is that it fails to recognize that a lot of township schools do not have basic facilities like electricity and computers that would enable the usage of ICT. The third objective looks at providing programmes of learner support in MST. The strategy outlines a number of initiatives aimed at improving learner achievement both in the short and long term. Some of these initiatives were discussed in the literature review chapter and based on evidence it was argued that they have not or do not produce the desired results. Nonetheless, the strength of this document is that it also includes initiatives designed to improve knowledge, skills and attitudes at school level which will influence learners to consider post-school careers in science, engineering and technology through career education. The last objective focuses on improving the management of MST teaching and learning in Gauteng. This according to the strategy entails ensuring that the teaching and learning environment is conducive for learning. It also promotes and encourages the sharing of good practices among schools and managers. This appears to be the strength of this document.

One of the arguments debated in the literature review is that improving the quality of learner performance in mathematics and science education requires the involvement of all stakeholders including the private sector, higher education institutions and NGOs. The document addresses this issue through the formation of an advisory committee of skilled and experienced MST educators from schools, universities and NGOs who are tasked with helping to plan and monitor the implementation of the strategy. This way, improving the quality of learner performance in mathematics, science and technology becomes the responsibility of all who have an interest in education. One other strength is that it addresses the needs of special schools and learners with special needs in respect of MST education which is often overlooked.

The strategy also addresses the longitudinal continuity between early child-hood, primary, secondary and higher education. This provides a solution to the problem of poor foundation laid at primary level. The strategy also complements the GDE’s strategic goals; it is guided by local and international research in respects of improving mathematics, science and technology education. The strategy also addresses the issue of language and its impact on achievement in MST education. It makes mention of the fact that there are a number of models that may provide solutions to this challenge but does not explain these models and how they can resolve this problem.

Even though the document covers a number of issues, there are questions that are left unanswered. Firstly, the strategy hopes to increase the number of MST teachers to at least 5000 by 2014. It is now 2013 and yet there is no indication of progress by the GDE is in terms of achieving this objective. There is still a huge shortage of MST teachers and there is no indication whether or not there is a tracking and monitoring system that is put in place to assess progress. Secondly, although the strategy is for

2009 to 2014 and there is no clear signal of what will happen beyond this period and how the impact of this strategy will be assessed.

4.2.2 Medium Term Strategic Framework

The document was released by the National Planning and Commission ministry in July 2009. It was written in order to guide planning and resource allocation across all spheres of government. It also defines the objectives and targets of government for the period 2009 – 2014. In relation to education, the main indicator theme of the strategy is centred on having more matriculants with mathematics passes and more students graduating in science, engineering and technology fields. Out of the ten strategic priorities outlined in this document the only one relevant to this study's topic is strategic priority four which encompasses strengthening skills and human resource base. This strategic priority is based on the premise that when learners have good skills and education they will be able to participate in social and economic life and will ultimately contribute to the reduction of inequalities.

One of the elements of this strategic priority entails creating a culture of achievement and improving learner outcomes with a target of an overall 20% improvement in the key education indicators by 2014 and improving South Africa's position in cross-country tests. The strategy asserts that this can be achieved by increasing support to schools and ensuring effective utilization of resources in order to improve the quality of education. The strategy further states that the quality of education can be improved by ensuring accountability through the implementation of performance measurement systems throughout the educational system.

Another element of this strategic priority is the one that looks at developing a teaching profession that is devoted to providing education of high quality, in which the levels of learner performance are high and teachers uphold ethical and professional standards of conduct. It further postulates that this can be attained by providing financial assistance to individual interested in pursuing the teaching career. It can also be accomplished by improving teachers' content knowledge through training in targeted subject areas like mathematics and science as well as by establishing teacher performance appraisal systems and monitoring performance targets for accountability purposes. The final element relevant to this research study is the one regarding creating conditions for effective school management. The strategy asserts that this can be achieved through actions such as training and administrative support for principals to enable them to manage their schools and thereafter monitor and evaluate their performance.

Evidently, there is synergy between this strategy and the Gauteng MST Strategy discussed above. Whilst this strategy explains the education outcomes in broad terms the MST strategy refines these outcomes into definitive desirable goals. These include goals such as increasing the number of grade 12 passes so that 250 000 learners are able to enter university; increasing grade 12 passes in mathematics, science and computer science to 50% for those who register for university entrance and conducting exiting proficiency tests among a sample of those that pass grade 12 with a university entrance.

4.2.3 Gauteng Teacher Development Professional Strategy

The Gauteng Teacher Professional Development Strategy was developed by the provincial teacher directorate at the GDE. It is meant to be implemented from 2010 to 2014 and the purpose is to translate the GDE's vision and mission into a simple plan for improved delivery of quality education in the classroom daily. The target audience includes all teachers in the Gauteng Province, teacher development officials in the districts, all the GDE agencies such as Matthew Goniwe School of Leadership, GCRA and Sci-Bono Discovery Centre, HEI's, NGO's, public and private sectors that offer funding, services and products in support of teacher development in Gauteng.

The subject of teacher quality and how it impacts on learner outcomes was debated in chapter two of this report. It was emphasised that teachers lack subject content knowledge which is required for them to teach effectively. The strategy was therefore written in order to respond to the challenges that negatively impact on effective teaching and learning in order to ensure the delivery of quality education in all classrooms daily. It outlines a number of actions that should be taken to make certain that plans are carried through.

The strategy hopes to enhance continuing teacher professional development and this will be achieved through actions such as improving the quality of teaching and learning through content training, assessment and pedagogical knowledge. It will also be attained by continuously enhancing the educators' competence and performance. This concurs with Kriek and Grayson's (2009) assertion that teacher development initiatives will be successful only if they are done on a continuous basis. It also aims to increase the capacity of the system to provide teacher education and development. This is envisaged to be achieved by strengthening support at different levels, encouraging all HEI's to provide training and development and other institutions such as Sci-Bono Discovery Centre to provide education and development for special needs teachers and schools particularly in mathematics and science.

The strategy acknowledges that there are models that have been used before that have not produced the desired results such as the cascading model. The reason for the failure of this model is that information tends to get lost when it is passed from one person to the other. The strategy thus makes provision for all teachers to be trained so they can derive maximum benefits from direct training and development interventions. The strength of this strategy lies in its alignment to other national initiatives and other provincial department strategies that are aimed at strengthening MST teaching in all Gauteng schools. This also include strategies for provisioning of learner support in MST, provisioning of resources and the management of MST teaching and learning.

Most teacher development initiatives focus on equipping teachers with the relevant skills ensuring that they master the content and they ignore soft issues like teacher morale and attitudes which also play a key role in how teaching and learning happen in schools. This strategy's advantage is that it makes provision to include the boosting of morale, development of aspirations, enjoyment and commitment of teaching by teachers which are critical. Therefore, it has a holistic approach because it addresses knowledge, skills and attitudes in developing teacher confidence and competence. The document stresses the importance of monitoring this strategy and all its interventions in order to respond quickly to emerging issues. However, it fails to clearly spell out how these issues will be dealt with. It also vaguely states that monitoring tools for measuring outcomes will be determined by relevant structures. Such lack of specific details can result in lack of monitoring.

4.2.4 Mathematics and Science Curriculum Policies

The literature review chapter explained how the constant change and review of curriculum policies has created confusion amongst teachers and to a certain extent learners. In 2012 the National Curriculum Statement for Grades R-9 and Grades 10-12 were combined into a single document now known as the National Curriculum Statement Grades R–12. So, it is not entirely new but is an improved version of the previous curriculum and it provides a clearer specification of what teachers should teach per term. It consists of three documents namely: CAPS for all subjects, National Policy pertaining to the progression and promotion requirements of NCS Grades R-12 and National Protocol for Assessment Grades R-12. CAPS was first implemented in grade 10 for the first time in 2012 and in grade 11 in 2013 and will be implemented in grade 12 in 2014.

These are national policies and not only meant for the Gauteng Province. They explain what each subject is about, subject aims and the time that should be allocated for teaching each subject. They also give a detailed overview of the science and mathematics topics that should be covered for the entire year but breaking it into terms. They also cover the weighting that should be given to each topic and an overview of formal assessment and practical work teachers should give to learners. They further specify the skills, knowledge and values learners should acquire per grade at the end of the academic year.

The strength of these policies is that they set standards across all provinces and clarify confusions regarding the content that should be taught and assessed. However, they fail to accommodate differences in schools for instance, teachers in some schools are unable to do practical work in science due to lack of resources such as laboratories. In most instances, where there is a shortage of classes they are used as classes. Therefore, these policies seem to focus on what should be taught, basic skills and knowledge that learners should acquire and do not address the quality aspect of learner performance.

4.2.5 ANC's Education Roadmap

Bloch (2009) describes this document as a multi-layered policy intervention which is meant to stimulate educational policy makers and practitioners into action and get schools the support they need, get teachers teaching and learners learning and ultimately produce a good quality system of education that is functional. The document is written in a simple language, is dated and the author who is an educational specialist is identified. It was a collective effort since various institutions, unions, government officials, academics and NGO's were involved in the development and adoption of this document.

It came into existence as a way of responding to the problematic state of the South African public education system which is poor in terms of skills production, outcomes like numeracy and the inequalities that are reproduced in schools and society. These problems impact on social and economic development. The purpose of this document is to open up new room for policy deliberations in South Africa.

The document identifies five key issues for educational development in South Africa that need urgent attention because they negatively impact on education. These include social disadvantage which looks at the fact that many parents are either under educated or are uneducated so they cannot actively participate in their children's education. They also include teachers' lack of content knowledge, weak pedagogical practices, insufficient number of mathematics and science teachers in particular and performance evaluation systems that are inadequate. Dysfunctional schools, shortage of resources like science laboratories and computers in schools and lack of accountability and responsibility on the side of the provincial departments are amongst the key issues. It is evident therefore, that the issues raised in this document are not necessarily new; other scholars and researchers have debated them before but the shortfall was in the lack of implementation.

The strength of this document is that it does not only list problems facing the education ministry but it also highlights a 10 point programme which is meant to address these problems. This programme is categorised into three levels namely in school; support to schools and societal. The in-school aspect addresses what happens between teachers and learners in the classroom. The support to school category is concerned with principals and district officials who ensure that schools are well managed and resourced. The last category looks at how the community can be involved and actively participate in education issues. This can, for instance, be in a form of starting up nutrition programmes and social support for children to improve the environment for teaching and learning.

Another advantage of this document lies in its ability to provide good guidance on how to reform the education system and on offering a range of potential policy responses. It also covers all the levels of schooling system from early childhood to primary and secondary schooling. In conclusion, although the document emphasises that these ideas will be implemented, it fails to clearly articulate how they will be implemented and who will enforce the implementation.

4.3. Profile of interviewees

Respondent 1 is the Gauteng Science Provincial Coordinator. He has two main key responsibilities and the first one is to manage the implementation and monitoring of science curriculum policy in the Gauteng province. This he achieves by supporting the development of science curriculum learning programmes and their integrated implementation in the FET schools. This task is also achieved through monitoring and evaluation of integrated grade 10-12 NCS curriculum policy implementation in line with National and Provincial policy. He also maintains a curriculum implementation information system for FET schools and facilitates the development of district school support plans for science. His second task is to support science facilitators or curriculum advisors at district level. This task entails holding meetings with science facilitators to discuss feedbacks from school visits and identifying professional development needs of science facilitators and addressing them.

Respondent 2 is the Teacher Development Director at Sci-Bono Discovery Centre. This is the department that focuses on building teacher mastery of curriculum content, developing teacher's professional skills and developing ICT competencies. He is responsible for mathematics, science and technology teacher training programmes including ICT youth development programmes. Respondent 3 is the Chief Executive Officer at Sci-Bono Discovery Centre. He is the coordinator of the Gauteng MST Strategy and his role is to provide strategic advice on this strategy. He serves on the Executive Management Team of the Gauteng Member of Executive Council for Education.

Respondent 4 is the Gauteng Mathematics Provincial Coordinator. His role is exactly similar to that of the provincial science coordinator, the only difference is that he focuses on mathematics and therefore works with mathematics district facilitators or curriculum advisors.

Respondent 5 is the Provincial Curriculum Director. He is responsible for the implementation of the new curriculum in FET schools. His focus and emphasis is on education support to enhance learner performance.

Respondent 6 is the Provincial Curriculum Chief Education Specialist. His role is to plan, manage, coordinate and monitor the implementation for compliance of the curriculum and assessment policies in the Gauteng province. He also oversees the implementation of the examinations and assessment framework for FET schools. He also manages the human, material, physical and financial resources to provide efficient and effective curriculum support to FET schools. Furthermore, he engages and interacts with all stakeholders to ensure policy compliance and enhance learner performance. Lastly, his task is to enhance the capacity of school management and educators to ensure effective and efficient service delivery.

4.4 Perceptions and experiences of interviewees

4.4.1. Causes of poor performance in mathematics and science

The respondents identified a number of factors that they believe lead to poor performance in mathematics and science at matric level in Gauteng. They unanimously cited the poor quality of teaching as one of the leading causes of poor performance in mathematics and science at matric level. This links to Mji and Makgato (2006) argument that poor learner performance in mathematics and science at matric level is attributed to teachers' limited content knowledge.

"The constant poor learner performance in mathematics and science is the end result of poor teaching from lower grade up to matric level" (Respondent 2).

This is because most teachers, particularly at primary level, were trained as generalist and not as subject specialists. They skip topics that they find challenging and learners end up not being taught the entire curriculum. This spills over to assessment practices at school level because teachers tend to ask learners recall and comprehension questions only and never give them tasks that require analysis and evaluation. Unfortunately, they are expected to answer such questions in the matric exam. This lack of content competence affects methodology and learners accumulate curriculum deficit which eventually creates content gap. Mathematical and scientific concepts are not properly formed as learners go through the grades so learners get to grade 12 having a huge curriculum gap that grade 12 teachers can not close in a period of ten months.

The provincial mathematics coordinator stated that: “Methodology is affected in a sense that mathematics teachers do not use the process driven approach which helps learners find solutions on their own instead they use the product driven approach which merely gives them solutions” (Respondent 4).

The science provincial coordinator stated that there are few qualified teachers in science and the qualified ones are poached by private industry. In the same breath he pointed out that there are science teachers who are highly qualified but unfortunately fail to impart knowledge to learners and some lack commitment to teaching.

Closely tied to content mastery is teachers’ failure to use resources provided to them by the provincial department, failure to motivate learners and give them sufficient mathematics exercises including the ones that are in their textbooks. Respondents 4, 5 and 6 identified learners themselves as contributors towards their own poor performance. This, they maintained, is through lack of commitment and daily practice, lack of discipline, failure to use technology when it can help them and not partaking in initiatives aimed at helping them to master mathematics like Mathematics Week.

Lack of parental support was also pinpointed as the cause of poor performance. Parents are perceived as not playing the part of encouraging learners to study and practice mathematics and disciplining them when necessary. However, it was also noted that this could be because of the fact that they are illiterate and would therefore not be in a position to provide the necessary support. Socio-economic factors such as poverty come into play then.

Resources and the use thereof were also cited as the cause of poor performance. This aspect was discussed in detail in chapter two of this report with other scholars arguing that non-availability of resources leads to good performance and some maintaining that resources have no bearing on how learners perform. Respondents 1 and 4 strongly stated that the GDE has done everything in its power to provide all schools in Gauteng with the necessary teaching and learning resources such as scientific calculators and laboratory equipment.

Respondent 1 had this to say about this issue: “Resources are kept in boxes and this is because laboratories are used as classrooms due to overcrowding. Experiments are not done yet science is a concrete subject”.

Poor management and misappropriation of funds were also viewed as the causes of poor performance. This translates in the form of heads of departments at schools not monitoring classroom teaching which results in teachers going to classes unprepared. It is also condoned by principals who fail to discipline teachers who are constantly late and absent from school and never make up for lost time.

4.4.2. Systems to improve the quality of learner performance

Both provincial coordinators have put in place subject specific support strategies and the researcher was informed that all mathematics and science teachers and subject advisors in the Gauteng province have copies of these strategies. However, the researcher could not verify this information due to the fact that Gauteng has more than 749 schools and it would have been difficult to check with every school in the province. Nonetheless, coordinators with the help of subject advisors or district facilitators monitor the implementation of these strategies. Provincial coordinators deemed the support strategies effective on the basis that the overall provincial results are gradually improving since the implementation of these subject strategies. However, they also noted that the pass percentage increase is not just as a result of the strategy but is a combination of various initiatives which complement one another. .

SSIP was unanimously cited by all respondents as the GDE's main initiative meant to improve the quality of mathematics and science learner performance. It is done in collaboration with Sci-Bono Discovery Centre and districts and is part of the Gauteng MST Strategy which was discussed earlier on in this chapter. As indicated in the literature review chapter, SSIP targets underperforming schools. Respondents indicated that a comparison was made between schools that were part of the SSIP programme and those that were not. The findings revealed that mathematics and science pass rates of SSIP schools improved and more learners in SSIP schools choose mathematics and science in grade 10. Furthermore, the gap has narrowed between SSIP and well performing schools. They, however, could not precisely state by the rate by which the pass rates have improved.

Resource provisioning is another system that was identified during interviews. All respondents stated that schools have been supplied with mathematics teaching and learning resources. Respondent 4 stated that mathematics, science and technology teachers are provided with lesson plans which serve as frameworks of what needs to be done in classrooms. Respondent 6 indicated that the GDE has provided schools with a lot of resources; the difficulty is that there are no measures put in place to assess the effectiveness of these resources so the actual matric results serve as a measure of impact.

Jansen (2012) stated earlier on that well managed schools produce good results. So school management support for principals, deputies and heads of departments is another system that the GDE has put in place to improve the quality of learner performance in mathematics and science. This service is provided by the Matthew Goniwe School of Leadership which is also a GDE's agency. Coupled with this is teacher training on content knowledge and methodology, a task coordinated by the Sci-Bono Discovery Centre. Pre and post assessments are done after the training to assess the effectiveness of the training and the resources that have been provided. The hurdle raised was that of poor workshop attendance.

Other systems put in place that were identified include the girl learner programme, Mathematics Week and diagnostic analysis of June and preliminary exams and districts support teachers based on the findings of the analysis. These systems are implemented on a small scale and their effectiveness is not evaluated. The general consensus was that the systems that the GDE, in collaboration with Sci-Bono Discovery Centre and Matthew Goniwe School of Leadership, has put in place are effective because for three consecutive years the Gauteng results have gone up by nearly 13%. Moreover, in 2012 Gauteng was the top performing province which was the second time in the past three years that the province took the number one spot nationally. Respondent 1 acknowledged that although there is upward movement in terms of percentages focus still needs to be on the quality.

4.4.3. Mathematics and Science in 2022

Five out of the six respondents that were interviewed were positive and hopeful so they painted a bright picture of the future of mathematics and science education. The picture is mainly dominated by a shift from quantity to quality on every level of education. The respondent believed that various interventions that have been employed at primary level will soon bear fruit so there will be a different generation of mathematics and science learners. Respondent 3 believes that interventions like the Gauteng Primary Language and Mathematics Strategy will result in better learners entering high schools so the number of learners choosing mathematics will gradually go up.

Respondents envisaged the type of learners who will be dedicated and motivated and most of them will be getting more than 50% and qualify for the Bachelor's degree which will enable entrance into universities. In addition, more learners will take and pass mathematics which will ultimately contribute to reduced unemployment.

"80% of the results will be of good quality. South Africa will have more engineers as more learners will enroll in universities and obtain qualifications in the areas of scarce skills." (Respondent 1).

Secondly, respondents 1, 4 and 5 painted a picture whereby good mathematics and science teachers will be recruited. The province will be having qualified and dedicated teachers who will be experts in their fields and will not rely on teachers from Zimbabwe which is the practice at the moment. These teachers will not only master the content but will also be committed. Respondent 3 stated that there will be fewer interruptions in teaching time, as a result. Closely linked to the issue of teachers is the use of resources. Respondent 3 asserted that textbooks will be obsolete in ten years time. There will be more use of technology in classrooms and as more technology becomes effective it will become cost-effective. Lastly, due to technological advancement, it is envisaged that parents will be more informed and will then be able to support their children.

Respondent 2, on the other hand, painted a gloomy picture whereby the shortage of mathematics and science teachers will have escalated and this will be because current mathematics and science teachers will have retired. The fact that universities are not producing enough mathematics and science teachers annually will exacerbate the situation. The respondent further stated that there will be a huge drop of learners doing mathematics because of the political pressure to produce good results; so more learners will opt for mathematics literacy. Respondent 6 concurred with this respondent; however he perceived the decline in the number of learners taking mathematics as a positive move. He justified this by stating that when the number decreases mathematics class sizes will be manageable and teachers can then provide intensive support to all learners. Respondent 5 felt that, albeit excelling in mathematics and science content, learners will lack values and skills that will help them thrive in the society. This is because CAPS focuses solely on subject specific content so Life Orientation teachers will have to play a critical role of instilling societal values.

4.4.4 Changes required for the preferred future

Respondents listed a number of changes that are required in order to have a mathematics and science education future that is characterized by quality, efficiency and effectiveness. Some of them are institutional and others are systemic changes. The first desired change that was listed by respondent 2 is the re-introduction of a new improved version of teacher training colleges in a bid to address the shortage of mathematics and science teachers. These colleges will help train local mathematics and science teachers and Gauteng will not rely on Zimbabwean teachers. Another systemic change addressing the same issue that was suggested by respondent 5 is a massive teacher supply strategy that must be developed by the National Department of Basic Education and HEIs. This strategy should be informed by and should be done based on the analysis of personnel data base and in terms of needs of schools.

Another systemic change suggested by respondent 5 is to stem migration of learners into the Gauteng province because it leads to overcrowding in schools. This is caused by lack of inter-sectoral collaborative planning whereby all departments such as the Gauteng Infrastructure Development will ensure that schools and houses are built to accommodate these extra learners and their families, GDE to ensure schools have sufficient teachers and Social Development to cater for the social needs of these learners. To ascertain that all departments fulfill their roles accountability measures should be put in place across all levels.

Closely tied to this is a need for mechanisms to encourage good mathematics learners to pursue the teaching career. Respondents were of the view that this can only work if there is political will and government pushes the mathematics and science agenda. The general belief was that if there is that political will more funding will be released into mathematics and science education. Therefore, there will be better salaries for teachers to keep them in the system and other incentives for both mathematics teachers and learners. Respondent 6 stressed the point that these incentives do not necessarily have to be monetary but could be certificates and sponsorship to attend conferences and exchange programmes for both learners and teachers. Rewards go hand in hand with punishment, so another suggested change is that of taking action against non-performing teachers without the interference from the unions.

At an institutional level, the changes that were suggested included the empowerment of SGBs so they can be able to govern the schools and principals in order for them to be able to effectively manage schools without the influences of the unions. Lastly, respondent 5 suggested that schools need to take the subject Life Orientation seriously. Other than using this subject to develop learners holistically, through career guidance which is part of the Life Orientation content, teachers can help learners realise the advantages and benefits of choosing mathematics and science and the different careers that they can pursue when they have these subjects.

4.4.5. Driving Forces

Question five required respondents to list political, economical, social, technological, environmental and legal factors that they viewed as being critical to the future of mathematics and science education in Gauteng. Their responses are presented as part of Annexure E step number 3 because they form part of the scenario development process.

4.4.6. Mathematics and Science education future barriers

Several barriers were identified and these range from administration factors at provincial level to management factors at school level. The main barrier that was unanimously identified by all respondents is the lack of funding which results in budgets cuts. The ramification of this is that teacher development programmes will not take place and the poor quality of teaching in the Gauteng schools will persist. The same situation will continue even if funds are not an issue because teachers do not attend developmental workshops. Lack of incentives for mathematics and science teachers also serves as a barrier. This will result in these teachers exiting the teaching profession and joining the private sector leaving behind a huge gap.

Respondent 5 identified lack of participation of the private sector as a barrier that could impact on mathematics and science education in the future. A number of mathematics and science programmes and projects are funded by the private sector and would not be running if the private sector was not involved. The GDE does not have the capacity nor the funds to run all these programmes all by itself so the private sector is playing a major role in creating awareness and promoting mathematics and science in the province.

Misappropriation of funds could also serve as a barrier. The province has over the years injected a lot of funding into mathematics and science education and if these funds continue to be not accounted for this could lead to their withdrawal and this will present a lot of challenges such as lack of resources among other things. Another barrier closely tied to this is lack of proper management at districts and at school level. The consequences of this are lack of alignment between policy and practice and lack of discipline.

Lastly, respondents noted the present set up of unions as a barrier that could have a negative impact on the future of mathematics and science education. Unions are perceived as destructive; instead of focusing on positive aspects like teacher development and conditions of service they interfere with the running of schools. They insist on teachers being appointed to management positions at school on the basis of union membership and not on their level of competence. They hinder district officials from monitoring the performance of teachers which would actually help teachers perform better.

4.4.7. Policy direction to address the quality of mathematics and science passes

All interviewees unanimously felt that there's a need for legislation that clearly spells out the role of teacher unions. The general feeling was that as much as teacher unions are a necessity and have a significant role to play they are currently serving as a hindrance to the quality of learner performance. They in fact have created a barrier not to deal with non-performing teachers. This is because principals and the labour directorates at districts and at the provincial office cannot charge these teachers because unions interfere and defend them. Incompetent teachers are appointed into positions of mathematics and science heads of departments mainly because they are staunch SADTU members. One way of disempowering the unions that was suggested by respondents is legislating education as an essential service with a clear stipulation that strikes can only be done after teaching hours. One respondent made the following comment:

"The national department of basic education needs to reduce the implications of teacher unions and make them focus on quality issues as well as teacher development and not just on conditions of service. Unless this is done, the education system will not improve and this will always affect learner performance not only in mathematics and science but in all subjects and across all phases" (Respondent 5).

Another respondent suggested that there should be an in-service training policy for teachers. The reason behind this policy is that the current training is superficial because it can only be done over a period of 80 hours and these hours are not sufficient. Teachers will then be held accountable for not attending training and one way of doing that will be through contracting them and if they do not perform their contracts will not be renewed.

In the end, one clear point that came forth from all candidates was that the GDE has good policies in place and does not necessarily need new policies; the challenge seems to be the implementation of these policies and holding officials that are non-compliant accountable.

4. 5 Quantitative Findings

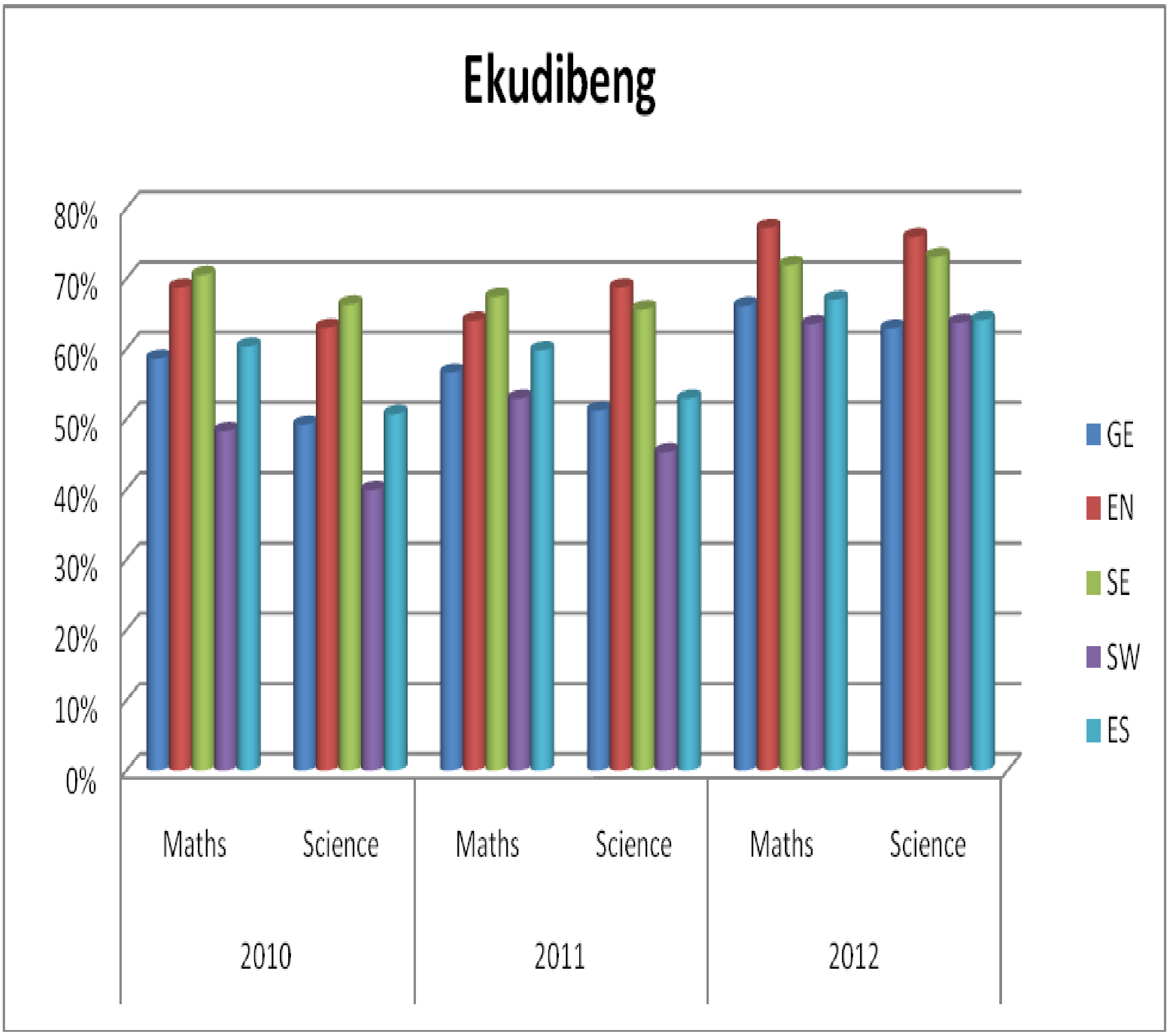
4.5.1 Presentation of findings in a table format

The Gauteng province has a total of 15 districts and these districts serve as a link between the provincial head office and the schools. Therefore, they have to represent and exercise the authority of the provincial office in all day to day professional and administrative management of schools. They have a crucial role of making certain that all learners have access to education of high quality and providing targeted support to improve practices within schools. Each district has to deliver services to the schools for which it is responsible in its area. All districts have mathematics and science district facilitators or curriculum advisors. In certain districts there are two mathematics facilitators and this is because of the number of schools in those districts and also because mathematics is regarded as a prioirity subject. Annexure C outlines the structure of the districts and tables 1 to 6 in Annexure D present the Gauteng mathematics and science results from 2010 to 2012.

4.5.2 Presentation of findings in a graph format

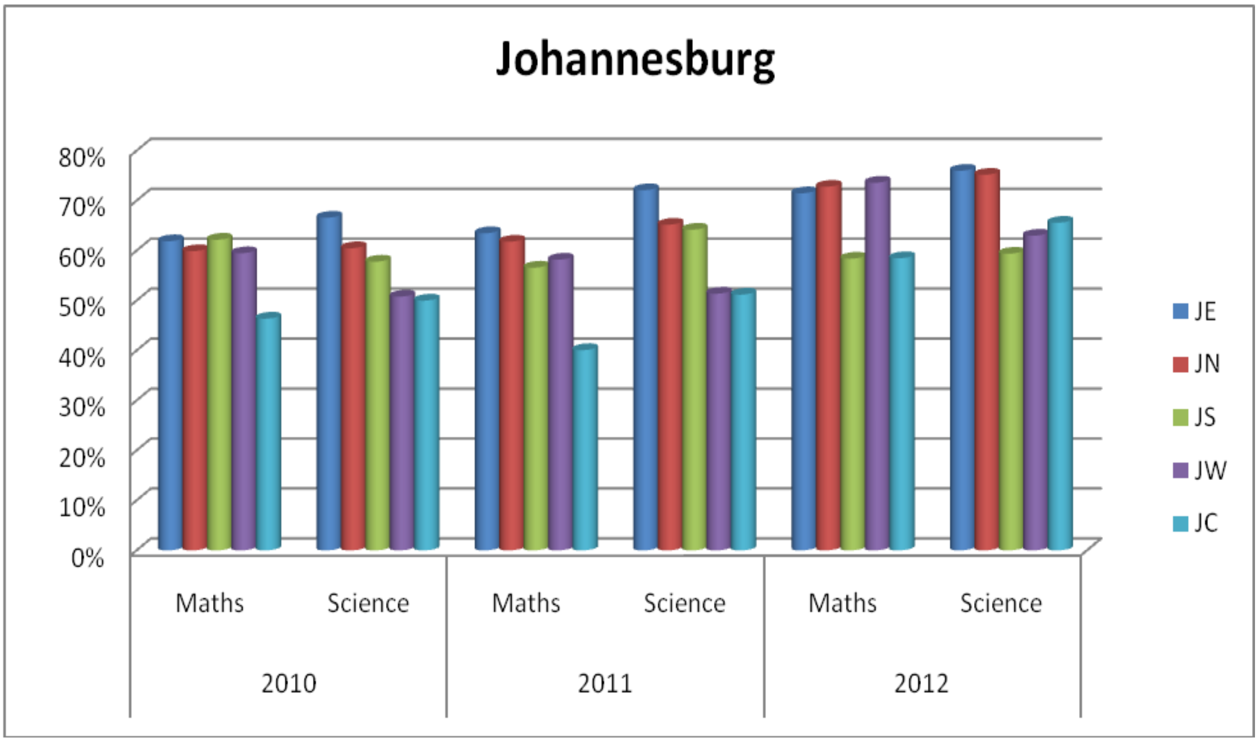
The 15 Gauteng districts are grouped into 3 clusters namely Johannesburg, Ekudibeng and Tswaga and each cluster comprises of five districts. The data presented in a table format above is converted into graphs in this section and districts are presented as clusters. The key on the graph indicates the districts that fall into that cluster. The researcher created the graphs using the raw data obtained from the GDE:

Figure 1 - Ekurhuleni and Sedibeng Cluster



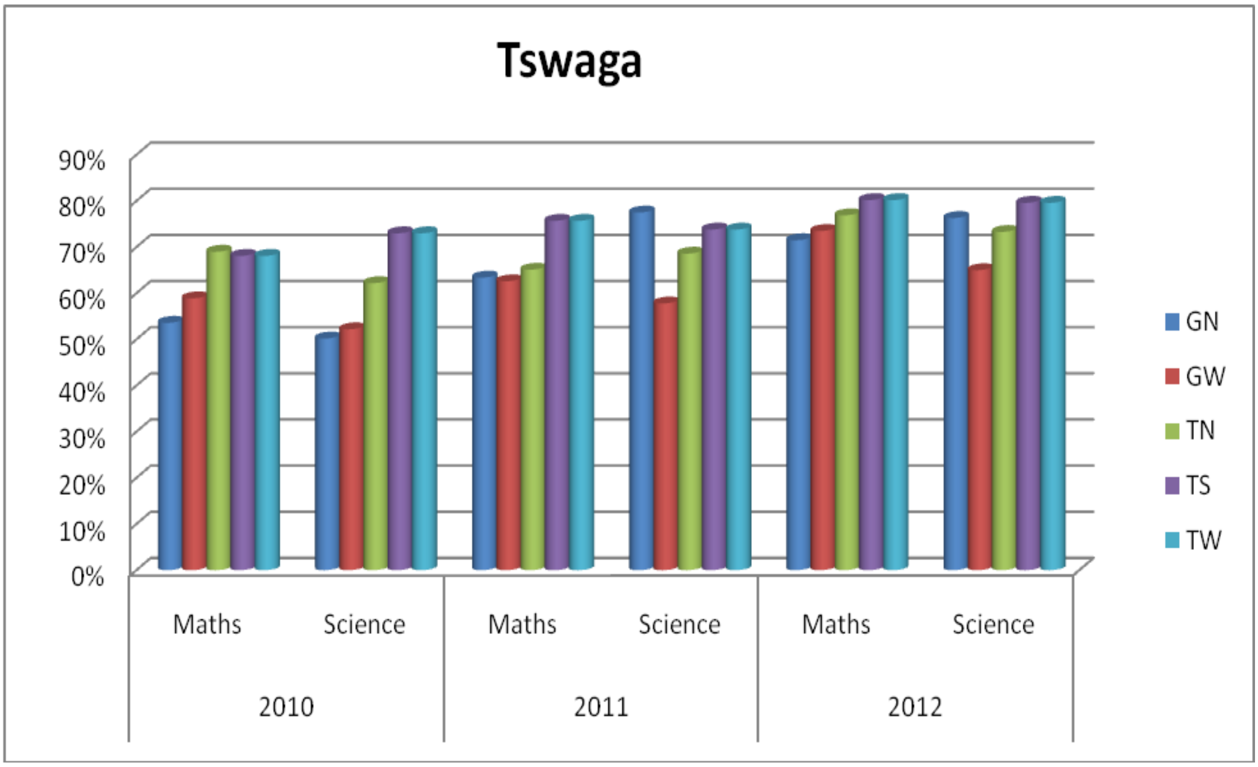
Source: Researcher's own

Figure 2 – Johannesburg Cluster



Source: Researcher's own

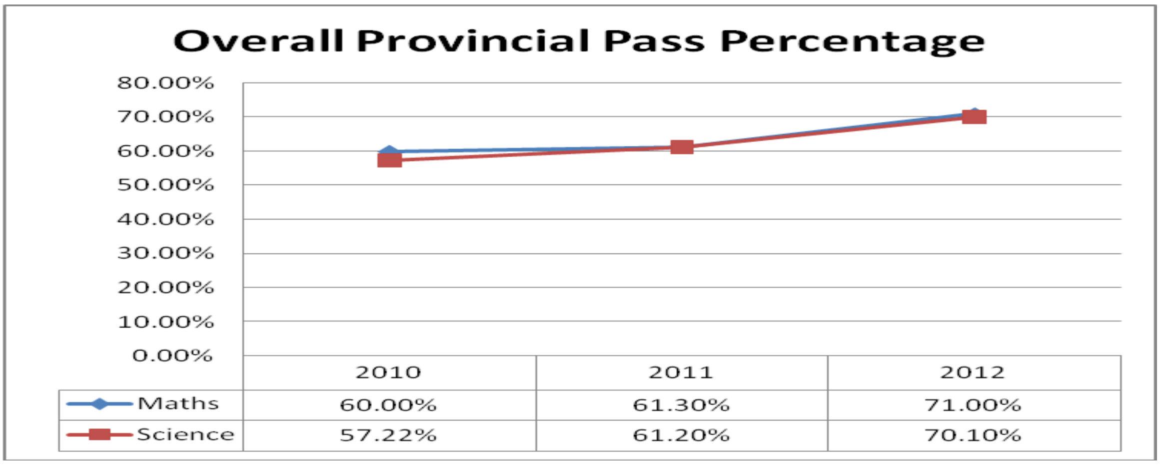
Figure 3 – Tswane and Gauteng Cluster



Source: Researcher's own

The graph below illustrates the Gauteng provincial percentage of learners who obtained between 30 and 100% and thus passed mathematics and science from 2010 to 2012.

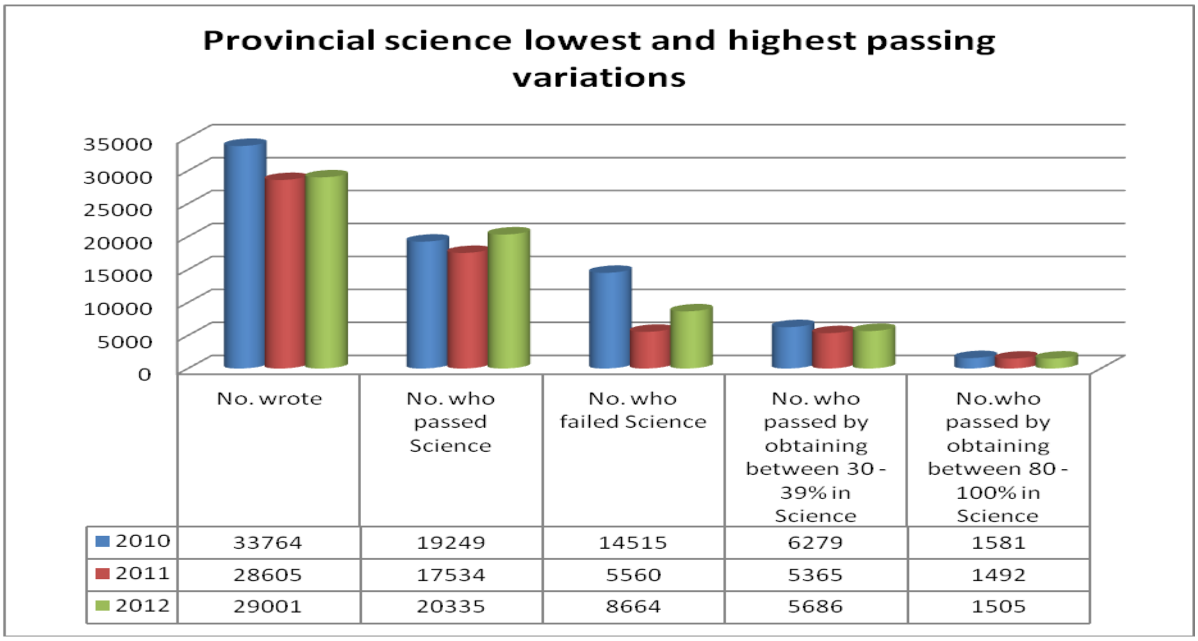
Figure 4 – Mathematics and Science Overall Provincial Pass Percentages



Source: Researcher's own

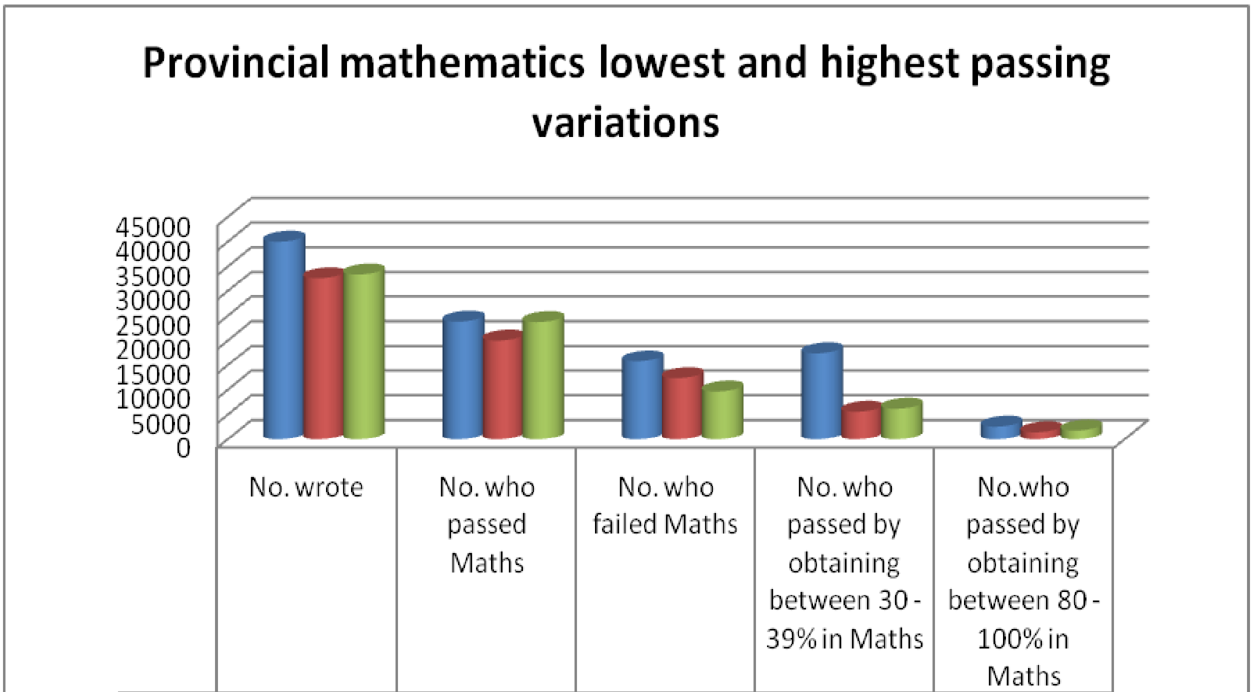
The two graphs below illustrate the different variations of science and mathematics passes from the lowest (i.e 30-39%) to the highest which is 80–100% from 2010 to 2012.

Figure 5 – Provincial Science Passing Variations



Source: Researcher's own

Figure 6 – Provincial Mathematics Passing Variations



	No. wrote	No. who passed Maths	No. who failed Maths	No. who passed by obtaining between 30 - 39% in Maths	No.who passed by obtaining between 80 - 100% in Maths
2010	40024	23839	15798	17465	2598
2011	32665	20027	12361	5596	1457
2012	33424	23749	9675	6212	1802

Source: Researcher's own

4.5. Conclusion

Based on the findings of the interviews there is enough evidence that suggests that the mathematics and science education in the Gauteng province faces many challenges that require urgent attention. At a glance, the quantitative findings present a picture that learners are performing well in mathematics and sciences since the pass rates escalate every year. However, it is important to take a closer look at the different degrees and variations of the passes to assess whether the quality of passes is good.

The next chapter closely and thoroughly examines these results and based on the perceptions and experiences of interviewees create mathematics and science education scenarios for the Gauteng Province.

Chapter 5 – Analysis and Interpretation of findings

5. 1 Introduction

This chapter analyses and interprets data presented in the previous chapter. The analysis is done by relating the data to the literature sources that were looked at in chapter two of this report. The quantitative analysis is presented first and the focus is on critical aspects such as failure and dropout rates among other aspects. Under the qualitative analysis the researcher looks at key factors that impact on the quality of learner performance in mathematics and science such as the teacher supply and demand. Other factors looked into include quantity versus quality, gender difference in learners studying and passing mathematics and science education as well as policies. The chapter ends with a presentation of four plausible matric mathematics and science education scenarios that are likely to unfold in 2022 in the Gauteng province.

5.2 Quantitative Analysis

At face value the mathematics and science results presented in this chapter look impressive but create a false picture that learners in the Gauteng province are doing well in mathematics and science. Figure 4 in the previous chapter, for instance, indicates an upward mobility trend in the pass percentages from 2010 to 2012. Mathematics pass percentage moved from 60% in 2010 to 71% in 2012 and this reflects an improvement of 11% in the province. Science, on the other hand, moved from 57,2% in 2010 to 70,1% in 2012 and this reflects an improvement of 12,9%. As much as these percentages indicate progress and advancement, it is however crucial to note the following:

5.2.1 30 – 39% passes

There is sufficient evidence to confirm that the quality of passes is poor. When examining the number of learners that have passed (i.e. learners who have obtained between 30 - 100%) it is clear that a big chunk of learners that pass mathematics and science fall in the category of 30 to 39% which is the lowest form of passing. Figure 5 in chapter 4 provides a summary of the provincial passing variations in science from 2010 up to 2012. According to this graph, 29 001 learners wrote the final matric exam in science in 2012 and out of that only 20 335 learners passed the exams. A total of 8 664 obtained between 30 and 39% and a mere 1 505 obtained between 80 and 100% which is the highest form of passing. The trend is the same even in 2011 and 2010. In 2011 28 605 learners wrote the matric science exam and only 17 534 passed with 1 492 of them obtaining marks ranging from 80 to 100% and 5 560 failed the exam. One can note that in 2011 the number of learners who failed the matric science exam is even higher than the 5 365 number of learners who obtained between 30 - 39 %. The quality of learner performance in science in 2010 was the poorest in the three year period. Out of the 33 764 learners who wrote the science matric exam only 19 249 passed and 14 515, which constitutes 43%, failed the exam. This means that nearly half of the learners who sat for the exam failed. Furthermore, only 4,6 % obtained marks ranging from 80 - 100% with 19% of learners scoring betweeen 30 - 39%.

Mathematics results follow more or less the same pattern and trend in Figure 6. In 2012, 33 424 learners sat for the mathematics final exam and 23 749 learners passed the exam; 6 212 of them obtained between 30 and 39% compared to a very small 1 802 who obtained between 80 and 100%. In 2011 the number of learners who enrolled for the mathematics exam was slightly lower than the 2012 enrolment. Out of a total of 32 665 who sat for the exam 20 027 passed the exam and 12 361 failed. A total of 5 596 scored between 30 – 39 % which is a much higher number compared to the 1 457 which obtained marks ranging from 80 to 100%. Like in science, the year 2010 had the highest number of mathematics enrolments. A total of 40 024 learners wrote the mathematics exams and 17 465 scored between 30 and 39% which means that 44% of the learners obtained the lowest form of passing which did not enable them to study further at higher education institutions.

It is evident that the majority of learners who pass in both subjects fall within the lowest category and such results are not considered quality results because they do not allow learners entrance into universities and universities of technology. Instead learners who pass in this manner can only do certificate courses. Scherer (2013) maintains that to gain entrance and attendance to South Africa’s 21 universities, learners should have at least 50% but even that does not guarantee acceptance at the university. He further states that in 2012, only 26.6% of the learners nationally achieved the university exemption status. Therefore, whilst on paper it looks like a majority of learners have passed their matric examinations and possess school leaving certificates but the reality is that most of them are unable to pursue tertiary education because of the nature of their results. Scherer's concluding remark is that the increase in matriculation pass percentage is only a superficial reflection of education in South Africa. It makes no meaningful statement on the competency levels of matriculants and educational standards.

5.2.2 Failure rates

A lot of focus seems to be on the increase in the pass rate and the number of failures is completely ignored. Every year when results are announced the public is never informed about the high failure rate. This is due to the fact that the education ministry is more interested in how many matriculants are passing instead of investigating how many of the learners who sit for exams actually fail and then put in place mechanisms of reducing the failure rate. Figures 5 and 6 reflect the number of learners that failed mathematics and science from 2010 until 2012. The science failure rate seems to be fluctuating; it started off at a very high rate in 2010 whereby 14 515 learners failed the science exams. The number significantly dropped to 5 560 in 2011 and accelerated to 8 664 in 2012.

The mathematics failure rate, on the other hand, seems to be declining year after year. It started off at a high rate with 15 798 learners out of a total of 40 024 failing the mathematics exam in 2010. The number slightly dropped to 12 361 in 2011 and then 9 675 in 2012 out of an overall total of 33 424 that sat for the exam. During the interviews the mathematics provincial coordinator stated that the decline in the failure rate can be attributed to the fact that schools have shifted learners from mathematics to mathematics literacy in a bid to improve the schools' results. As much as this shift has resulted in the declining number of failures; it has limited utility in many science related careers because learners with a matric qualification are unable to pursue any studies in the fields of engineering and other sciences when they do not have pure mathematics which is a requirement in these fields of study.

In conclusion, it can be noted that on average the failure rates in both mathematics and science are declining. The science failure percentage was 43% in 2010 and it dropped to 30% in 2012, whereas the mathematics failure percentage was sitting at 39% in 2010 to 29% in 2012. These percentages mean that 3 out of 10 learners failed mathematics and science and if the percentages were calculated based on the actual number of learners that registered for matric they would even be higher.

5.2.3 Drop-out rates

The good picture painted by the overall provincial percentage for matric passes is a false and misleading one also in a sense that the results do not reflect the large number of learners who drop out of school before the end of their matric year. It also does not reflect learners that are held back in grade 11. Scherer (2013) confirms this by stating that the excitement and the celebrations around result releases are little more than a distraction from the cold reality of South Africa's stifled education system. He further points out that the percentage that is announced is picked insincerely for its suggestion of progress. Scherer believes that the intention is to mask the problematic reality that haunts the future of South African school children particularly those from township schools.

Table 3 in Annexure D, for instance, indicates that in 2010 a total of 34 198 learners registered for science exams in Gauteng and only 33 764 wrote the exam. This means that 434 learners dropped out and were not included when the provincial average was calculated. The drop out numbers shifted from 345 in 2011 to 250 in 2012. The mathematics picture is completely different, whilst the science drop out rate is decreasing the mathematics rate seems to be increasing. In 2010 a total of 478 learners dropped out, in 2011 the number went down to 382 only to increase to 483 in 2012. If all these numbers were included the end results would have been a further decline in the provincial average. These learners are deliberately excluded out of fear that their inclusion will lower the provincial average. During the interview process the researcher discovered that the GDE does not have a unit or directorate that looks into the issue of drop outs by investigating reasons why matric learners drop out, what happens to them thereafter and how they can be brought back to the system. The provincial subject co-ordinators unequivocally stated that their roles start and end with curriculum policy implementation and compliance and therefore another unit should handle the drop outs.

Nevertheless, the drop out problem does not only affect the Gauteng province but it is a national problem. Most learners who complete matric are unable to use their results to either get into higher education insitutions or find employment. Less than half of learners who started school in 2001 obtained school-leaving certificates in 2012. This clearly indicates that the quality of education at South African public schools is insufficient (Scherer, 2013). It is against this backdrop that the researcher concludes that the South African education system is poor and fails to equip learners with the necessary skills.

5.2.4 Classification of matric results

When national and provincial results announcements are made a blanket report of all the schools is given without disaggregating the results into rural, urban, township, suburban and former model C schools. Even the results that the researcher obtained from the EMIS unit at the GDE were not classified accordingly; there were just notes next to the schools indicating whether it is a public or independent school. The researcher observed that a majority of independent schools performed much better than public schools. This is confirmed by the Department of Education's (2010) statement that the majority of mathematics and science passes are still from independent schools and teacher quality is stated as a common feature of all the best performing school systems in these schools.

However, Anderseen (2012) disputes this point and argues that there is no definitive evidence that indicates that independent schools perform any better in general than public schools. Anderseen's argument is based on the fact that there are a number of very good public schools which produce results that are just as good as or even better than those of more expensive private schools. Secondly, he argues that only 11.5% of learners attend independent schools in Gauteng and this percentage is too small to boost the entire provincial percentage. Anderseen's arguments may be sound but the contribution made by independent schools cannot be ignored. Similarly, the fact that underperforming public schools place a meaningful drag on the country's overall educational performance can also not be ignored.

South African public schools are divided into quintiles which refer to poverty rating index of the schools. These quintiles range from 1 to 5 and quintile 1 to 3 are located in rural areas and townships. Quintile 4 and 5 are in wealthy areas where schools are fully resourced and therefore perform much better than quintile 1 to 3 schools. In Gauteng the districts which have more quintile 4 and 5 schools and less quintile 1 to 3 schools tend to perform much better than other districts whose structure is different. A typical example is Tshwane South in Pretoria. Looking at Table 1 in Annexure D it can be noted that this district obtained 79,6% in science in 2012 which was even higher than the 70,1% provincial pass percentage. The same trend happened in mathematics in Table 4 of Annexure D whereby the same district obtained 80,2% which was much higher than the provincial pass percentage of 71,0%. It is districts like this which push the provincial pass percentage up because of their ex-model C schools which produce good results whereas districts with more township schools like the Johannesburg Central district (JC) are always rank at the bottom.

Nkosi (2013) asserts that when the 2012 Gauteng's 83,9% pass percentage was announced no mention was made of the fact that Gauteng has the most number of schools in quintiles four and five compared to other provinces. He further argues that it is crucial to finely disaggregate schools in order to make it elementary to identify and compare learner performances among schools across different categories like township, rural or former model C schools. Furthermore, this would allow the sharing and exchange of good practices by schools.

5.3 Analysis Findings

5.3.1 Teacher quality, supply and demand

Judging from the interviewees' responses and arguments raised by scholars like Kriek and Grayson (2009) the quality of teaching and the type of teachers who teach mathematics and science seem to be at the heart of the quality of learner performance. One of the concerns that came out during the interviews is that mathematics and science teachers tend to use the product driven approach which is a methodology that focuses on giving learners the solutions instead of explaining the process towards finding solutions. In the literature review chapter Taylor et al (2007) raised more or less the same concern when they stated that rote learning and teacher talk is still the common practice in most classrooms. This means that as long as mathematics and science teachers continue using ineffective teaching methodologies and lack content knowledge the quality of matric learner performance in mathematics and science in Gauteng will not improve.

According to the data presented by respondents the Gauteng province has a shortage of qualified teachers and the few that are qualified are being poached by industry. Unfortunately the teachers' statistics were not available for the researcher to verify this information. Nevertheless, in the literature review chapter Mji and Makgato's (2006) assertions validated this by pointing out that very few students graduating with mathematics and science choose teaching as a career. Since mathematics and science teachers are poorly trained and do not have the qualifications to teach these subjects the implications then are that the teaching standards will remain poor. Teachers will not be able to improve the quality of teaching and ultimately the quality of learner performance in mathematics and science in Gauteng will not improve. The researcher also discovered that programmes like the Dinaledi Programme have made some great strides in increasing the number of learners choosing mathematics and science; the challenge however is that in the long run the likely consequence will be the mismatch between teacher supply and demand. In fact there are indicators already that Gauteng is headed this direction because during the interviews the researcher learnt that the number of Zimbabwean teachers who are teaching in Gauteng schools is gradually increasing because of teacher shortages.

5.3.2 Focusing more on quantity than quality

During the course of the interviews the researcher discovered that the GDE officials view everything from the quantity perspective and very little attention is paid to the quality aspect. A typical example is that of the provincial mathematics coordinator disputing the point made by the researcher that the quality of results is poor on the basis that mathematics provincial percentage has improved from 60% in 2010 to 71% in 2012. Such a statement was made without thoroughly examining the results and actually looking at the nature of the passes. The conclusion that the researcher drew from such statements is that if these are the standards of measurements that are used by officials at strategic level then the quality of learner performance in mathematics and science at matric level in Gauteng is not likely to improve.

The focus on quantity rather than quality was also reflected in the way the GDE prides itself in the systems that it has put in place to improve learner performance. Judging from the interviewees' responses the researcher deduced that the concentration is more on the number of initiatives, programmes and projects that are currently running in schools. Respondents listed SSIP, Mathematics Week, Dinaledi Programme, MST Strategy and subject strategies amongst other things and yet there are no concrete monitoring mechanisms that are put in place to assess the impact made by these programmes on the quality of learner performance. The form of monitoring that is done focuses mainly on compliance. If such practices continue the quality of learner performance in mathematics and science at matric level will definitely not improve. The department will continue investing funds into these programmes without realising the value for money.

The focus on quantity instead of quality was also seen in the way resourcing is done in the province. Provincial subject coordinators counted the type and the number of items that schools have been provided with and these include items such as laboratory equipment, textbooks, lesson plans and calculators amongst other things. The researcher noted that these resources were provided without conducting needs analysis of schools but on the basis that these resources are necessary for the effective teaching and learning of mathematics and science. Secondly, the process begins and ends with supplying schools with these resources; there are no mechanisms put in place to assess the impact made by these resources on learner performance. Ultimately resourcing does not necessarily translate to quality results particularly because in most instances these resources end up in boxes because they are not necessarily what schools need. This point validates the researcher's proposition that poor performance is due to poor decision-making at both strategic and operational level.

All of these things are indicative of the fact that the GDE is driven by numbers and activities are done in isolation and yet quality, in the education context, as defined by UNICEF (2000) encompasses five key dimensions namely: learners, the learning environment, content, process and outcomes. This means that learners coming to a school environment bring with them a range of issues such as health, social, language and economic issues that should be considered. The learning environment, on the other hand, entails adequate facilities like class sizes, health service and sanitation facilities that have an impact on teaching and learning. Content looks into curriculum matters and learning materials that are appropriate to the level of learning and understanding. Process deals with ensuring that teachers are well trained and managed and can use the appropriate technologies in their classrooms. Lastly, the outcomes component looks at ensuring that learners can pass and play a meaningful role in the society (UNICEF, 2000). The conclusion drawn, therefore, is that unless the GDE changes its strategy and holistically focus on all these key dimensions then the quality of learner performance in mathematics and science at matric level in Gauteng will not improve.

5.3.3 Gender differences in mathematics and science

The South African Schools Act states that all educational institutions should observe the basic rights provided in the Constitution. As a result the National Department of Basic Education has policies that advance gender equality and strategies that are geared towards improving representation, participation and performance of girls in the mathematics, science and technology fields (Moletsane and Reddy, 2011). In addition, one of the Dinaledi programme's objective is to increase the number of girl learners doing mathematics and science in the FET phase and provinces are tasked with ensuring that the objectives of this programme are met.

When analysing the mathematics and science results the researcher discovered that the GDE does not clearly disaggregating girl and boy learners' results. In fact this has never been done and results are only classified according to districts. Secondly, the researcher also discovered that the province does not have the statistics of girl learners who are doing mathematics and science in the FET phase. This means that girls' access to, participation and success in mathematics and science is not measured and monitored. Other than the girl learner programme that was mentioned during the interviews the GDE does not have other school programmes that assist girl learners to improve their performance. There are also no other mechanisms put in place to ascertain that gender equality and improved access to mathematics and science education for girls are sustained.

Moletsane and Reddy (2011) contend that the mathematics and science material is viewed as being girl unfriendly and they believe that this is clearly demonstrated by the illustrations and activities in the textbooks that tend to be male orientated. This implies that provincial subject coordinators are not fullfilling their roles of managing the implementation and monitoring of mathematics and science curriculum policies in the Gauteng province. The researcher makes this argument on the basis that one of the responsibilities tied to this role is that of screening textbooks before they are published and distributed to schools and ensuring that the content is politically correct, gender sensitive and that the language used is age appropriate. Ultimately the implications of all these factors raised here is that the GDE will not be able to achieve the Dinaledi programme's objective of increasing the number of girl learners unless all these issues are dealt with.

5.3.4 Policies

Just like any other organisation the GDE has a plethora of good policies the challenge is in the implementation phase. The one policy that is sorrounded by a lot of controversy is the National Policy on Promotion and Progression Requirements, Grades R-12. This is the policy that states that learners can pass matric subjects with a mark of 30%. However, this not a provincial policy but a directive from the national office and provinces have to implement it. The researcher shares the views of scholars like Jansen (2012) who argue that allowing learners to pass with 30% is actually lowering the standards of South African education. Jansen believes this sends a wrong message to learners, teachers, parents, employers and tertiary institutions. He questions the kind of capacity, future, brains and leadership the 30% pass mark builds.

This policy has far reaching implications and the message being conveyed is that learners need not worry about mastering the entire subject content and should only focus on mastering 30% of it and that will be enough for them to get a matric certificate. The fact that a majority of learners that pass mathematics and science fall within the 30-39% category is an indication of the unintended and negative effects of the policy. Learners are not encouraged to stretch themselves, work harder and maximise their potential. This will also ultimately result in higher education institutions lowering their standards and entrance requirements in order to accommodate these learners.

This point validates the researcher's proposition stated in chapter 1 of this report that if policy does not change for the better, the state of mathematics and science education will deteriorate further. Nonetheless, all the respondents that were interviewed disagreed with Jansen's points of view. They were unanimous in their defence of this policy on the basis that it promotes inclusive education by accomodating learners with all types of learning abilities and styles.

5. 4 Four Futures for Mathematics and Science Education in Gauteng

This section presents four scenarios of what mathematics and science education at matric level in Gauteng is likely to look like in 2022. The researcher did not conduct a fully fleshed scenario planning exercise but created these scenarios based on the data collected using a questionnaire during the interviews.

5.4.1 Scenario 1 – Scientific boom

This scenario typifies a high road scenario whereby good decisions are made in a conducive environment where all the required resources are available. It is a dream scenario in which the GDE becomes the top performing province in the country. It has the highest numbers of learners who are doing mathematics and science nationwide. All schools are producing hundred percent passes with an average of 80% in mathematics and science. The Universities of Witwatersrand and Johannesburg produce an average of 70% mathematics and science teachers per year. These are young innovative and creative teachers who are committed to teaching and there is a balance in terms of gender equity. All schools have laboratories and laboratory equipment, all mathematics and science teachers and learners have tablets and these are used to enhance teaching and learning. Intersectoral planning is done at strategic level and the GDE's policies are aligned to those of other departments. Schools and universities produce learners with mathematics and science related skills that are absorbed by the world of work and the economy of the province booms as a result.

5.4.2 Scenario 2 – Scientific waste

This scenario is characterised by good plans but no human and capital resources to implement them. The GDE formulates good policies around curriculum matters that will address skills shortage and contribute towards economic development. However, districts are short staffed so the mediation of the policies is not done and the implementation of these policies is not monitored. They also design strategies, projects and plans that can drastically improve the quality of learner performance but there aren't enough mathematics and science teachers who can carry them out and the number of learners taking mathematics and science gradually drops. There is no budget for mathematics and science education and schools can not procure teaching and learning material so teachers have to rely on talk and chalk and learners share textbooks. The contracts of temporary teachers are not renewed in order to save costs. Teacher unions incite teachers to disengage so this results in instability in schools. Ultimately this affects learner performance and the overall provincial average sits at about 50% and so is the mathematics and science average.

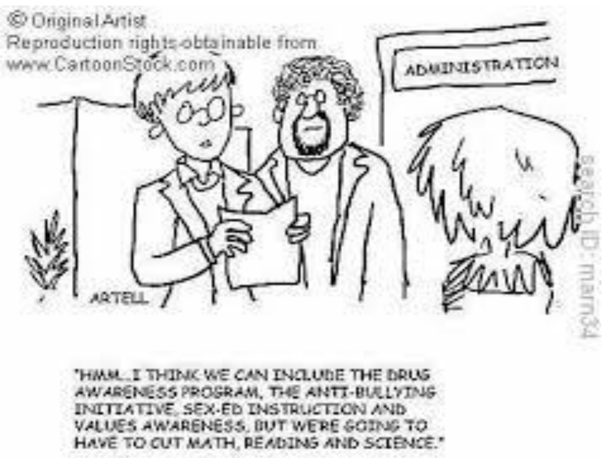
5.4.3 Scenario 3 – Scientific collapse

The scenario is a classical case of a low road in which poor decisions are made at strategic level and there is a severe shortage of resources. There is a confluence of negative events in the political, economical, social, technological and legal resources. Only 10% of teachers teaching mathematics and science are South African citizens and 5% of them are left with a few years before they reach the retirement age. Ninety percent of mathematics and science teachers are from African countries like Zimbabwe, Cameroon and Nigeria. Even though they master the mathematics and science content they fail to impart knowledge to the learners due to language barriers. Learners are frustrated so they resort to strikes and are supported by the teacher union SADTU which is also against the employment of foreign teachers. During these strikes school properties are vandalised resulting in school buildings that have dilapidated with no teaching and learning resources. There is a downward spiral characterized by extremely poor performance in mathematics and science, high failure rates, poverty, teenage pregnancy, drug abuse and high drop out rates.

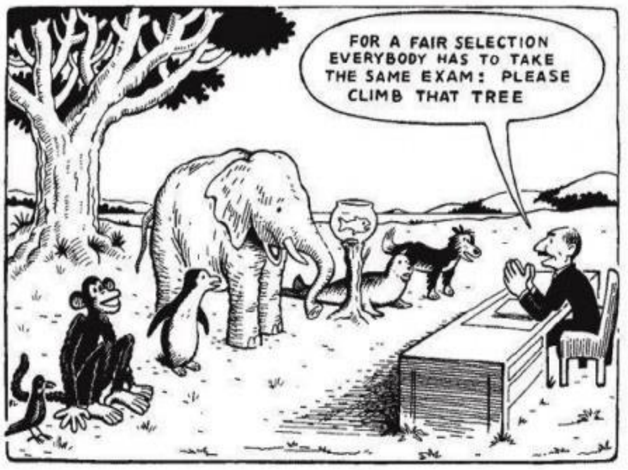
5.4.4 Scenario 4 – Scientific wilt

In this scenario the livelihood of mathematics and science education is at risk. The quality of learner performance in mathematics and science is good; starting off at provincial average of 70% because of committed teachers and learners. The province has sufficient and qualified mathematics and science teachers and about 60% of the learners are doing mathematics and science. A new curriculum, which requires teachers to attend a lot of training during contact time leaving children unattended, is introduced. This new curriculum creates a lot of paper work for teachers and they end up spending more time doing administrative work instead of teaching. The staff morale becomes low and affects productivity. Out of frustration some of them resign and join industry leaving a gap in the schools. A lot of money set aside for mathematics and science education is channelled towards other programmes like HIV and AIDS. Due to underspending the mathematics and science budget is further cut so programmes like SSIP are suspended. In the long run, learner performance declines and schools start encouraging learners to take mathematics literacy.

Scenario 3 – Scientific wilt



Scenario 1 – Scientific Boom

Scenario 3 – Scientific collapse	Scenario 2 Scientific waste
	

Source:Science Cartoons Plus

5.5. Conclusion

The detailed analysis and interpretation of both quantitative and qualitative findings done in this chapter have revealed that the quality of mathematics and science result in Gauteng is poor. The majority of mathematics and science learners in Gauteng are obtaining the lowest form of passes which do not enable them to study further at tertiary institutions. The picture created by politicians when announcing matric results every year is a false one and it misleads the public into thinking that the education system is improving when infact the type of policies that are formulated are lowering the standards even further.

The next chapter summarises the entire study and presents recommendations for the beneficiaries of the study.

Chapter 6 – Recommendations and Conclusion

6.1 Introduction

This chapter presents a summary of the entire study and highlights key issues. It also makes recommendations to the GDE. It concludes with recommendations for future research studies.

The purpose of the study is to investigate the factors leading to poor performance in mathematics and science at matric level in Gauteng. The main focus of the study is the quality of passes and how they can be improved rather than the total number of mathematics and science passes in matric. The introduction and background looks at the state of matric mathematics and science education in South Africa and then centres on the Gauteng province. Mathematics and science education in Gauteng is failing and requires urgent attention if the province is to address the shortage of scarce skills. Gauteng schools are producing the type of matriculants that can not be absorbed by the job market due to lack of skills. Neither do they produce the type of learners that can cope in academic settings due to poor levels of education.

The literature review deals with various themes and the factors that have a negative impact on the quality of learner performance in mathematics and science. To validate the research proposition that matric learner performance in mathematics and science is poor due to poor decision-making and weak planning, the study examines the decision-making and planning theories that underpin the education context.

The mixed research methodology serves as an effective tool to frame the complex answers to the research questions. This methodology brings out very rich qualitative and quantitaive findings that enabled the researcher not only to identify the patterns and trends of learner performance in mathematics and science in Gauteng but to develop mathematics and science scenarios for 2022.

The developed scenarios are meant to be used to bring about improvement on the quality of learner performance in mathematics and science at matric level in Gauteng.

6.2 Study Recommendations

The researcher makes the following recommendations:

6.2.1 A policy on drop-outs

As stated in the previous chapter the number of learners that register for the matric exam and not write exams is unacceptably high. The recommendation therefore is that the GDE needs to formulate a policy to address this matter and set up a directorate that will be responsible for the implementation of this policy. This directorate will track matriculants who drop out, investigate the causes of the drop outs. The directorate will also be responsible for devising mechanisms of restoring learners who drop out back into the system. The directorate will also look into preventative measures.

6.2.2 Lobby for a policy to be reviewed

The GDE including all provincial education departments, civil society and all parties that have an interest in education need to lobby for the National Policy on Promotion and Progression Requirements Grades R-12 to be reviewed. It was established in the previous chapter that this policy has contributed towards lowering the standards of education. The pass mark should be raised to 50% so that it can match with tertiary requirements. The immediate effects of this will be an increase in the failure rate but eventually the quality of results will improve. This will also address the constant criticism that the South African matric qualification does not adequately prepare learners for university entrance or the world of work.

6.2.3 Using foresight to improve decision-making

The study recommends that the GDE should integrate foresight into the decision-making process because it enhances flexibility, broadens perspectives and encourages thinking outside the box. Foresight can also assist decision-makers in taking on a number of complex challenges and it can reduce technological, economical or social uncertainties by identfiying various futures and policy options.

6.2.4 Put scenarios into action

The GDE should share the scenarios presented in this report with all GDE employees and they should be used as learning tools. The study recommends that opportunities and threats should be identified in each scenario and the outputs of this analysis should guide the strategic choices for future success. This means that the GDE should then prepare itself for all outcomes but work towards identifying the preferred scenario. This will be the application of the scenario planning's Wack Test which highlights that the value and usefulness of scenarios depends upon their ability to influence decision-makers to act.

6.3 Future Research

The researcher recommends the following topics for future research:

- The impact made by the private sector and NGO's initiatives on the quality of learner performance in mathematics and science.
- Differences in the quality of performance in mathematics and science between girl and boy learners.

6.4 Conclusion

This research contributes modestly to the existing body of knowledge that deals with the application of scenario planning in the field of education. The researcher hopes that the findings of this study will lead to better and informed decisions around interventions and initiatives aimed at improving the quality of mathematics and science learner performance at matric level in Gauteng. The proposed recommendations could offer insights into policy making and the role played by foresight in educational planning and decision-making.

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Annexure A

Documentary Analysis Template

1. Type of document

   ____

2. Unique physical qualities of the document
   - ✓ Logo, Letterhead -
   - ✓ Signatures -
   - ✓ Language used -
3. Date of document

   ____
4. References

   ____

5. Author of the document

   ____

6. Designation

   ____

7. Recipients / Audience

   ____

8.1 The document's key ideas. Themes or issues identified in the document

____

____

8.2 Why was the document written and what evidence is there for this conclusion?

____

____

8.3 What questions are left unanswered by the document?

____

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Source: Adapted from Fitzgerald (2012)

Annexure B

Interview Questions

1. What do you think are the causes of the constant poor performance in mathematics and science at matric level in the Gauteng province?

2. What systems has the GDE put in place to improve the quality of learner performance in these subjects? Have these systems been effective/ are they effective?

3. What does the future of mathematics and science education look like? Paint a picture of how it will look like in ten year's time.

4. What driving forces (political, economic, social, technological, environmental and legal factors) would you view as being critical to the future of mathematics and science education?

5. What do you think needs to happen for this kind of future to occur?

6. What do you see as barriers that could have a major impact on mathematics and science education in the future?

7. What are the policy directions that you strongly feel the GDE should adopt in order to improve the quality of mathematics and science pass rates?

THANK YOU FOR YOUR TIME AND COOPERATION

ANNEXURE C

The district profile is as follows:

Districts	District Name	No. of FET schools in the district
1. GN	Gauteng North District	16
2. GW	Gauteng West District	46
3. TN	Tshwane North District	37
4. TS	Tshwane South District	79
5. GE	Gauteng East District	48
6. EN	Ekurhuleni North District	65
7. SE	Sedibeng East District	24
8. SW	Sedibeng West District	48
9. JE	Johannesburg East	62
10. JN	Johannesburg North	54
11. JS	Johannesburg South	62
12. JW	Johannesburg West	37
13. JC	Johannesburg Central	57
14. TW	Tshwane West	53
15. ES	Ekurhuleni South	61
Total number of FET schools in the province		**749**

Annexure D

Table 1 - Science results per district 2012

District	Total Entered	Total Wrote	Achieved 30-100%	Pass percentage	Achieved 0-29%	Achieved 30-39%	Achieved 40-49%	Achieved 50-59%	Achieved 60-69%	Achieved 70-79%	Achieved 80-100%	No t Resulted
GN	546	538	411	76.3	127	132	111	70	45	27	26	8
GW	1926	1911	1243	65.0	668	359	286	205	173	127	93	15
TN	1988	1977	1451	73.3	526	378	341	259	209	145	119	11
TS	4115	4086	3256	79.6	830	586	575	545	577	505	468	29
GE	1649	1629	1025	62.9	604	347	273	195	107	65	38	20
EN	2428	2412	1831	75.9	581	513	452	321	270	167	108	16
SE	818	813	595	73.1	218	151	136	108	94	60	46	5
SW	1800	1772	1129	63.7	643	393	271	223	131	69	42	28
JE	2111	2093	1592	76.0	501	395	339	291	227	209	131	18
JN	1841	1829	1376	75.2	453	336	278	237	227	181	117	12
JS	1782	1758	1046	59.4	710	366	243	198	115	83	41	24
JW	1210	1200	756	63	444	215	179	121	102	82	57	10
JC	2159	2148	1410	65.6	738	461	366	230	158	123	72	11
TW	2027	2015	1406	69.7	609	495	384	236	152	89	50	12
ES	2851	2820	1808	64.1	1012	559	411	346	242	153	97	31
Grand Total	**29251**	**29001**	**20335**	**70.1**	**8664**	**5686**	**4645**	**3585**	**2829**	**2085**	**1505**	**250**

Source: GDE

Table 2 - Science results per district 2011

District	Total Entered	Total Wrote	Achieved 30-100%	Pass percentage	Pass 0- 29%	Pass 30-39.9%	Pass 40-49.9%	Pass 50-59.9%	Pass 60-69.9%	Pass 70-79.9%	Pass 80 -100%	Not Yet Resulted
GN	446	440	341	77.5	31	119	80	59	35	32	16	6
TS	3777	3741	2764	73.8	506	491	461	450	461	404	497	36
JE	2057	2029	1463	72.1	248	374	327	236	209	150	167	28
EN	2415	2399	1649	68.7	289	498	409	285	197	152	108	16
TN	1887	1868	1282	68.6	252	386	281	242	135	123	88	19
SE	827	817	536	65.6	137	156	115	77	85	58	45	10
JN	1954	1932	1259	65.2	332	344	242	233	176	137	127	22
JS	1594	1553	997	64.2	238	328	244	150	124	95	56	41
GW	1968	1943	1124	57.8	398	401	238	187	144	92	62	25
TW	1839	1819	1027	56.4	351	390	259	177	122	44	35	20
ES	2985	2955	1565	52.9	750	572	320	283	186	116	88	30
JW	1118	1105	568	51.4	326	161	128	89	73	58	59	13
GE	1777	1756	900	51.2	436	374	200	143	83	56	44	21
JC	2252	2223	1140	51.2	641	413	271	182	125	85	64	29
SW	2054	2025	919	45.3	652	358	239	154	82	50	36	29
Grand Total	**28950**	**28605**	**17534**	**61.2**	5560	**5365**	**3814**	**2947**	**2237**	**1652**	**1492**	**345**

Source: GDE

Table 3 – Science results per district 2010

District	Total Entered	Total Wrote	Achieved 30-100%	Pass percentage	Pass 0-29%	Pass 30-39%	Pass 40- 49%	Pass 50- 59%	Pass 60- 69%	Pass 70- 79%	Pass 80- 100%	Not Yet Resulted
GN	712	709	356	50.21	353	153	89	46	36	23	9	3
GW	2353	2333	1218	52.20	1115	433	298	213	125	73	76	20
TN	2321	2306	1435	62.20	871	470	335	244	192	107	87	15
TS	4020	3974	2903	73.00	1071	574	440	455	444	426	564	46
GE	2106	2082	1025	49.23	1057	371	254	165	120	64	51	24
EN	2960	2933	1847	63.00	1086	608	424	334	226	156	99	27
SE	910	902	598	66.30	304	192	132	111	79	41	43	8
SW	2709	2660	1009	37.93	1651	418	242	152	101	54	42	49
JE	2393	2327	1550	66.65	777	434	322	278	197	166	153	66
JN	2116	2083	1262	60.59	821	321	237	218	183	157	146	33
JS	1835	1786	1033	57.83	753	357	232	166	127	89	62	49
JW	1336	1326	674	50.82	652	233	133	101	81	59	67	10
JC	2556	2542	1271	50.00	1271	516	290	197	122	85	61	14
TW	2445	2431	1357	55.82	1074	531	325	241	148	73	39	14
ES	3426	3370	1711	50.77	1659	668	367	280	187	127	82	56
Grand Total	34198	33764	19249	57.00	14515	6279	4120	3201	2368	1700	1581	434

Source:GDE

Table 4 – Mathematics results per district 2012

District	Total Entered	Total Wrote	Achieved 30 – 100%	Pass percentage	Achieved 0- 29%	Achieved 30- 39%	Achieved 40- 49%	Achieved 50- 59%	Achieved 60- 69%	Achieved 70-79%	Achieved 80- 100%	No t Resulted
GN	632	623	446	71.5	177	135	122	84	54	31	20	9
GW	2053	2044	1503	73.5	541	389	331	298	213	170	102	9
TN	1984	1975	1519	76.9	456	353	346	279	230	163	148	9
TS	5041	5013	4021	80.2	992	680	702	789	707	597	546	28
GE	1623	1608	1063	66.1	545	333	281	202	129	75	43	15
EN	3110	3096	2391	77.2	705	644	583	461	386	191	126	14
SE	976	973	700	71.9	273	179	146	150	114	72	39	3
SW	1783	1765	1121	63.5	644	391	300	210	123	57	40	18
JE	2954	2933	2098	71.5	835	516	459	398	274	252	199	21
JN	2511	2487	1813	72.8	674	419	346	360	310	207	171	24
JS	2055	2031	1188	58.4	843	377	263	231	162	98	57	22
JW	1157	1151	848	73.6	303	241	197	146	114	91	59	59
JC	2736	2717	1590	58.5	1127	504	416	284	172	133	81	81
TW	2104	2090	1491	71.3	599	479	373	283	185	118	53	53
ES	2939	2918	1957	67.0	961	572	451	363	265	188	118	118
Grand Total	**33907**	**33424**	**23749**	**71.0**	**9675**	**6212**	**5316**	**4538**	**3438**	**2443**	**1802**	**483**

Source: GDE

Table 5 – Mathematics results per district 2011

District	Total Entered	Total Wrote	Achieved 30 – 100%	Pass percentage	Achieved 0- 29%	Achieved 30- 39%	Achieved 40- 49%	Achieved 50- 59%	Achieved 60- 69%	Achieved 70-79%	Achieved 80- 100%	No t Resulted
GN	553	542	344	63.4	193	115	85	74	42	22	11	11
GW	2102	2083	1306	62.6	759	388	320	252	166	125	73	19
TN	2009	1994	1299	65.1	670	356	310	241	202	118	97	15
TS	4795	4763	3606	75.7	1129	647	686	702	621	501	477	32
GE	1486	1473	834	56.6	619	288	224	144	102	58	38	13
EN	3123	3097	1984	64.0	1086	599	483	390	259	169	111	26
SE	924	913	616	67.4	287	175	124	125	96	76	30	11
SW	1703	1679	889	52.9	769	345	248	149	91	49	28	24
JE	2995	2940	1869	63.5	1053	482	436	347	272	192	158	55
JN	2496	2469	1528	61.8	928	356	325	305	237	177	141	27
JS	1965	1915	1085	56.6	815	332	263	187	161	79	78	50
JW	1294	1285	749	58.2	527	230	173	137	99	79	40	9
JC	2915	2876	1155	40.1	1703	392	268	206	137	106	64	39
TW	1987	1970	1168	59.2	771	416	337	224	116	77	29	17
ES	2700	2666	1595	59.8	1052	475	373	322	232	130	82	34
Grand Total	**33047**	**32665**	**20027**	**61.3**	**12361**	**5596**	**4655**	**3805**	**2833**	**1958**	**1457**	**382**

Source: GDE

Table 6 - Mathematics results per district 2010

District	Total Entered	Total Wrote	Achieved 0 -29%	Pass percentage	Achieved 30-100%	Achieved 30- 39%	Achieved 40- 49%	Achieved 50- 59%	Achieved 60- 69%	Achieved 70-79%	Achieved 80-100%	No t Resulted
GN	807	801	390	53.69	405	277	96	89	40	36	16	6
GW	2466	2443	976	58.92	1447	1060	369	272	182	104	133	23
TN	2611	2591	916	69.06	1640	1240	394	336	201	147	163	20
TS	5203	5153	1310	68.18	3808	3238	651	616	618	500	853	50
GE	1915	1892	772	58.65	1096	755	275	189	135	80	76	23
EN	5818	3866	1385	68.76	2435	1745	599	463	293	215	176	37
SE	1154	1146	375	70.58	766	539	197	138	93	51	60	8
SW	2742	2696	1472	48.39	1186	744	308	192	114	69	62	46
JE	3465	3377	1280	61.99	2072	1558	452	393	271	193	249	88
JN	2944	2898	1116	59.97	1761	1390	367	297	259	208	259	48
JS	2187	2146	893	62.21	1237	865	289	197	161	98	120	42
JW	1535	1521	586	59.55	917	664	215	160	101	77	111	14
JC	3696	3667	2064	46.42	1573	989	387	243	157	90	113	29
TW	2600	2588	929	65.25	1623	1099	475	305	154	92	73	12
ES	3271	3239	1334	60.37	1873	1302	492	299	234	143	134	32
Grand Total	**42414**	**40024**	**15798**	**60.0**	**23839**	**17465**	**5566**	**4189**	**3013**	**2103**	**2598**	**478**

Source: GDE

Annexure C - The Deductive Approach – Scenario Development Process

The deductive approach

This deductive approach is described in chapter 3 on page 51. The researcher motivated why this approach was adopted and gave a detailed explanation of the eight steps of this approach.

1. The focal question

The process began with identifying the focal issue:

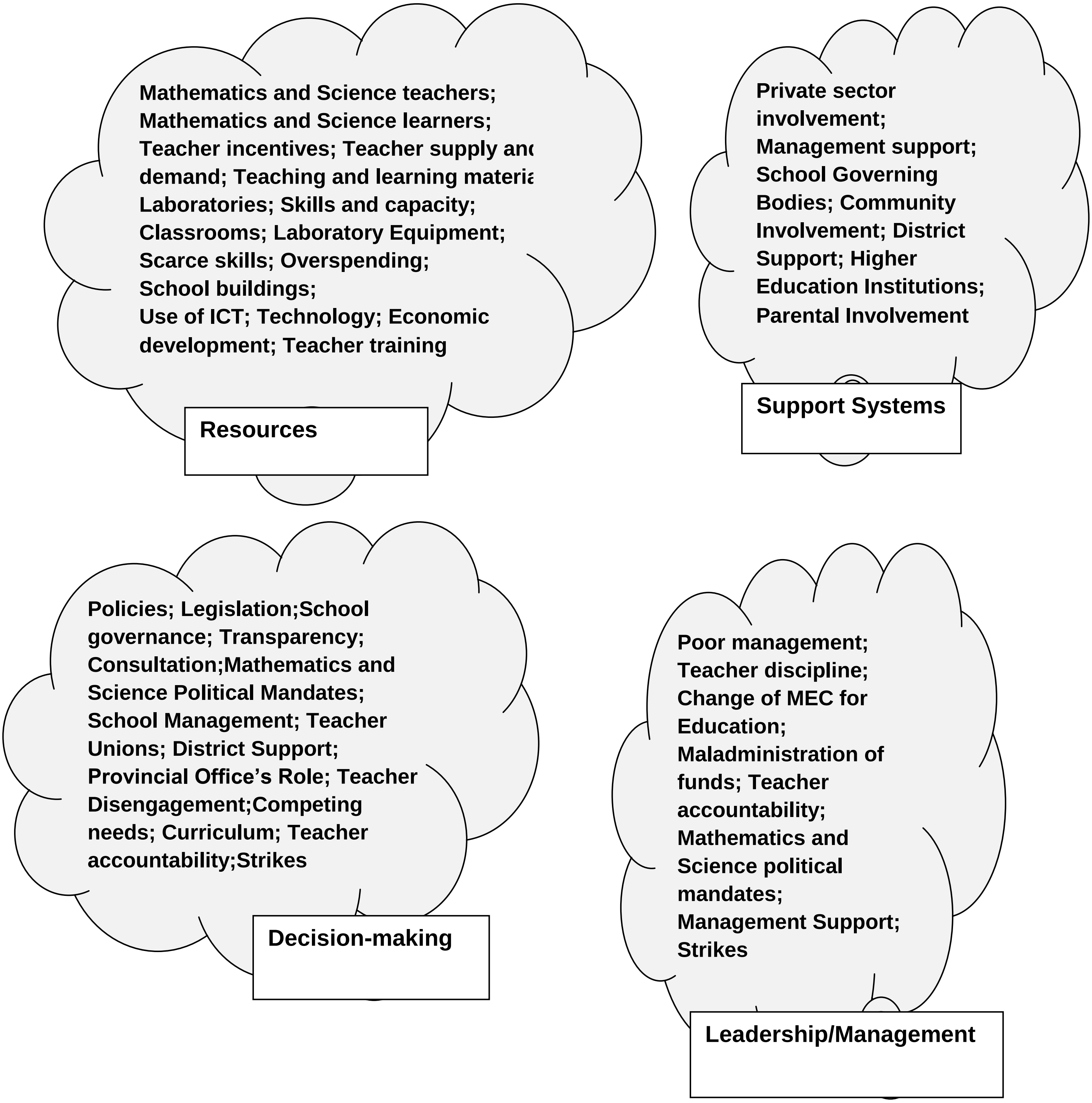
What will the quality of matric learner performance in mathematics and science be like in 2022?

2. Key forces in the local environment

The key factors which will determine whether or not the quality of learner performance at matric level will improve in 2022 were identified.

Environmental factors		
Curriculum	Mathematics and Science Teachers	Mathematics and Science learners
Budget	School Governing Bodies	Teacher Unions
Strikes	Teacher Disengagements	Laboratory Equipment
Training	Technology	Legislation
Private sector involvement	Policies	Teaching Time
School Buildings	Community involvement	Parents
Consultation	Teaching and learning material	Skills and capacity
Transparency	Parental involvement	Overspending
Laboratory	Textbooks	School management
Mismanagement	Maladministration	District Support
Management support	Teacher incentives	Provincial role
Teacher discipline	Teacher supply and demand	Higher Education Institutions

Use of ICT	Change of MEC for Education	Competing needs
Corruption	Economy	Scarce skills
Teacher accountability	Mathematics and science political mandates	School governance



3. List of driving forces

The third step entailed listing driving forces that will create a change in the macro environment. The PESTEL technique was applied which included political, economical, social, technological, environmental and legal factors that could impact on the quality of learner performance in mathematics and science at matric level in Gauteng. Candidates that were interviewed identified the following factors. The factors written in bold are the ones which candidates viewed as the most critical and the most uncertain.

Political Factors	**Respondent 1: Less destructive unions (SADTU);** Poor decision-making, strikes during working hours **Respondent 2: ANC led government that understands the value of education,** Unions that focus on teacher development **Respondent 3: Better relationship between government and unions,** Political will regarding the improvement of mathematics and science **Respondent 4: Policymakers understanding the relationship between mathematics and economic development and sustainability** **Respondent 5: Political mandate of mathematics and science** **Respondent 6: Political buy-in into provisioning of resources,** Unions

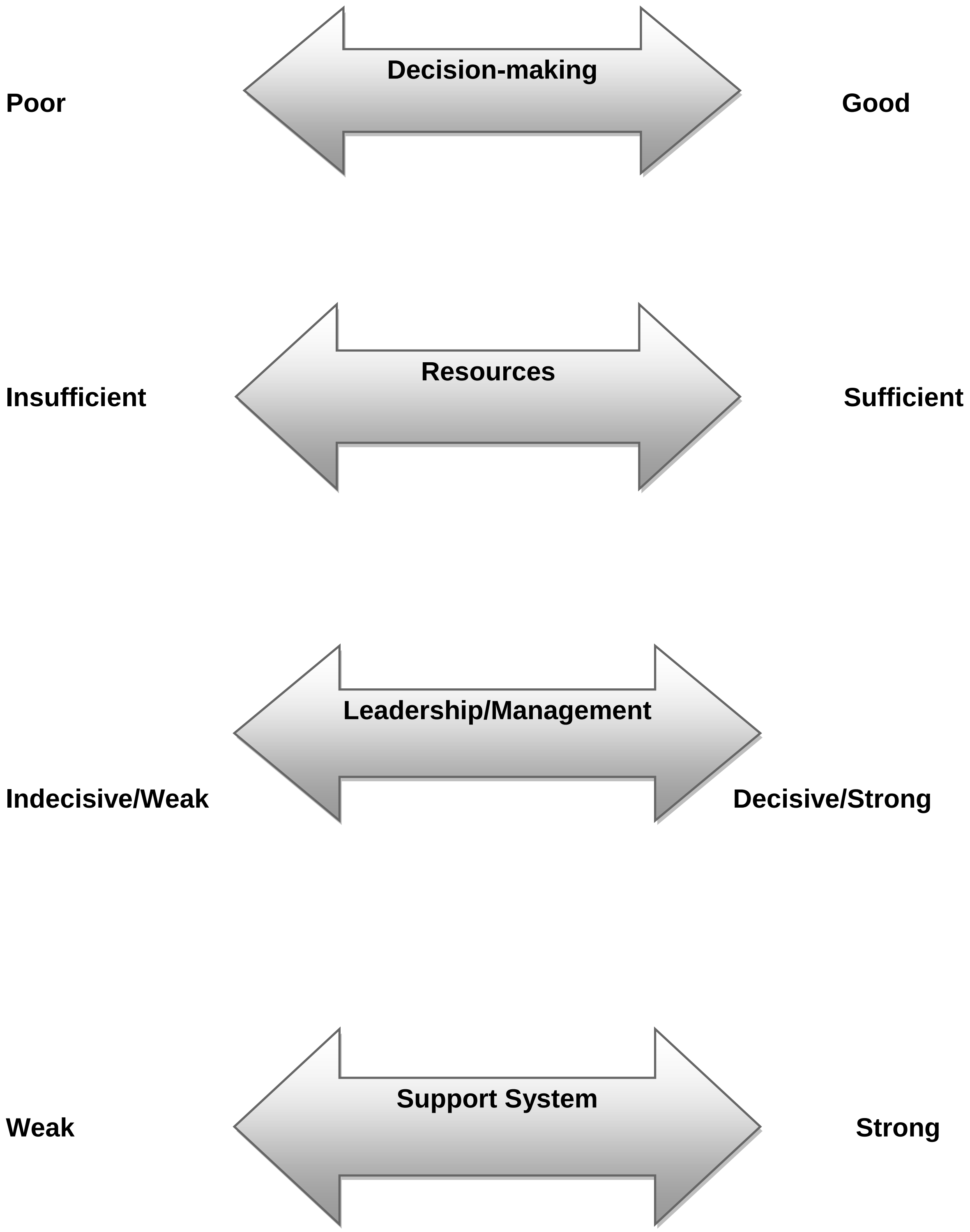
Economic Factors	**Respondent 1:** Better economy; **Strict control of schools' budgets** **Respondent 2: Employment for individuals having mathematics and science,** Innovation, Demand for mathematics and science related skills **Respondent 3:** Inequality**, Limited budget** **Respondent 4:** Prioritisation of material and human resources for this field **Respondent 5: Economic growth,** People with technical skills **Respondent 6: Better incentives for mathematics and science teachers**
Socio-economic Factors	**Respondent 1:** Better standard of living; **Changed attitudes towards learning** **Respondent 2: Supportive families that encourage learners to take mathematics and science** **Respondent 3:** Better communication**, Persistent poverty,** Drug abuse, teenage pregnancy, HIV- AIDS, Crime. **Respondent 4: Prioritization of resources** **Respondent 5: Unemployment alleviated,** Emphasis on education, Stop the dependency model created by social grants, crime, drug abuse **Respondent 6: Social constructs of mathematics**
Technological Factors	**Respondent 1: More use of ICT in science** **Respondent 2: Availability of technological resources,** More use of ICT in mathematics and science classes **Respondent 3:** Improved communication through technology, **Access to resources like laboratories**

	Respondent 4: Utilization of technological resources **Respondent 5: Use of technology to enhance learning** **Respondent 6: Lack of resources,** Lack of demonstration of the real application of mathematics and science
Environmental Factors	**Respondent 1: Conducive learning space/ environment** **Respondent 2: More science centres that create awareness of mathematics and science,** Science exhibitions **Respondent 3: Shortages of water and energy** **Respondent 4: Environmental friendly material** **Respondent 5**: E-learning conducive environment, Greening economy, Food security, Sustainable environment, **Redesign classroom setting** **Respondent 6: Realistic curriculum addressing environmental issues**
Legal Factors	**Respondent 1:** Strict discipline measures for teachers; Policy review; **Legalize workshops for teachers**; Better recruitment systems; Charging principals who mismanage schools **Respondent 2: Hold government accountable for providing mathematics and science teachers;** Do away with mathematics literacy and make mathematics compulsory **Respondent 3:** Implementation of education legislation, **Less cases between the GDE and school governing bodies** **Respondent 4: Union involvement** **Respondent 5: Review policy framework and align it to technological advancement,** Less cases against the provincial education department **Respondent 6: Union interference,** Managers holding teachers accountable

Source: Researcher's own

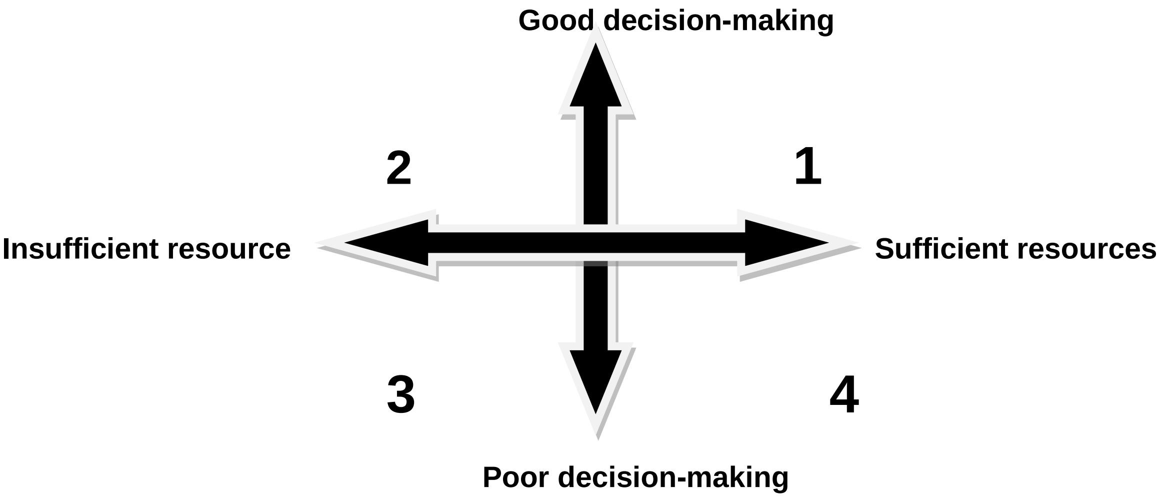
4. Ranking by importance and uncertainty

The identified driving forces and key factors which could impact on the quality on the quality of learner performance in mathematics and science at matric level were then ranked based on the degree of importance and uncertainty.



5. Selecting scenario logics

The two most important and critical uncertainties were then selected and used to create scenario frameworks and which were presented as a matrix with two axes.



6. Fleshing out scenarios

Four scenarios of mathematics and science education that are likely to play out in Gauteng in 2022 were created using the above matrix. The first scenario is the high road scenario where there is a confluence of good decision making both at strategic and operational level and sufficient resources particularly human resources. The second and fourth scenarios are middle scenarios and the third scenario is a low road scenario characterized by a negative spiral of poor decision-making and insufficient resources.

7. Scenario implications and selection of indicators

The researcher combined steps seven and eight of the deductive scenario planning approach. The starting point was to explore the implications of the four scenarios that had been created and the purpose was to discover unknown interconnections. The process ended with the selection of signpost and indicators that would guide the GDE that any of the scenarios is beginning to unfold and this vital information can be used to inform policy around improving the quality of learner performance in mathematics and science at matric level. It can also be used for the adaptation of current strategies in order to prepare for the preferred future.

Good decision-making

Insufficient resources	**Sufficient resource**
Scenario 4: Scientific waste **Wild card:** Foreign investment for mathematics and science programmes **Implications:** Erosion of the education system **Indicators:** Severe cuts of the mathematics and science education budget and retrenchment of teachers	**Scenario 1:** Scientific boom **Wild card:** Closure of Wits and UJ **Implications:** Education levels equivalent to those of First World Countries **Indicators:** Increase in the numbers of teachers and learners in mathematics and science
Scenario 3: Scientific collapse **Wild card:** Opening up of improved version of teacher training colleges **Implications:** Matric qualification not recognised by HEIs **Indicators**: Appointment of foreign teachers and strikes and stay aways	**Scenario 2**: Scientific wilt **Wild card:** New leadership pushing the mathematics and sc ience agenda **Implications:** Falling standards of education **Indicators:** Declining pass rates and increase in the number of teacher resignations

Poor decision-making