Education in south africa: mathematic and scientific performance

This study is aimed at discovering the root cause and economic consequence of poor performance in Maths and Science in South Africa. The main objective of the research is to provide the South African Department of Education and the heads of governing bodies of school with information that will assist in the proper formulation of strategies drafted in the Action Plan, the execution of policies that address the root cause of poor Maths and Science performance in South African schools. The secondary objective is to emphasize the economic consequences that may arise as a result of the poor performance in Maths and Science and lastly to generate possible leads and ideas which can be used to formulate a realistic and testable hypothesis for future researchers.

The research was carefully constructed and designed using the qualitative methodology, since the scope of the subject is too complex to be addressed by a yes or no hypothesis. The research process comprised of two phases. The first phase consisted of questionnaires distributed to 10 professionals in the field of Maths and Science who passed Maths and Science at Matric/Grade 12 level; and the second phase 10 questionnaires distributed to Non-professionals in the field of Maths and Science who did not pass or complete Maths and/or science at a Matric/Grade 12 level, The third phase consisted of 5 questionnaires to educational specialists, economists and experts in the Maths and Science career stream. Four interrelated key performance index constructs within the Education system were used, namely Teacher practice, Student achievement, Government and Curriculum content.

The results of the research found that the core issues in relations to poor performance in Maths and Science was due to (To be continued)".. The economic consequences as a result of the poor education system showed that (To be continued)"

Keywords: root cause, poor performance, Maths and Science, economic consequences

" Physics, chemistry and mathematics form the basis for many Scientific or technological applications and discoveries, and as innovation and technological advancement are the driving force behind today's globally competitive economy, it makes good career sense to gain the versatile skills an enabling science degree will award you."

Professor Bruce Milthorpe

CHAPTER 1: INTRODUCTION TO THE RESEARCH PROBLEM

Introduction

Maths and Science is a driving force of a strong performing economy, it is a key area of knowledge whose competency is necessary for individual and economic development and an important factor of global competitiveness especially in a world of rapid technological changes (Tatira, Mutambara & Chagwiza, 2012). McGrath and Akoojee (2007) further adds that the rationale in focusing on education is that it's crucial for competitiveness, they emphasize that education should be a core objective in the South African national development strategy to enable competitiveness in globalisation and the knowledge economy.

The twentieth century has seen education rise above the ranks as a base for social economic development and as a prime influential factor of a countries level of wealth by being able to alleviate poverty, increase the workforce and stimulate intellectual flexibility among its societies (Ozturk, 2001). The research seeks to act as a point of reference or set a standard for the Department of education and the heads of governing bodies whose role is primarily the execution of policies and strategic action planning within the education system, specifically in the Maths and Science arena.

Whilst Human capital investment within a country draws in different skills which are highly valuable due to the impact it has on the vital parts of everyday life, skills in Maths and Science are the most crucial for social and economic welfare, typical examples include important career streams in the life sciences, behavioural and social sciences, earth and environmental sciences, math and computer sciences, engineering, interdisciplinary and physical sciences (Ozturk, 2001).

Education aspires nation building and promotes interpersonal tolerance due to its integration nature hence Societies are able to transcend beyond cultural and national boundaries due to the advantages and assurances that education brings, especially Maths and science (Romagnolo & Anderson, 2010).

1. 2 Background to the study

1. 2. 1 The State of Maths and Science in South Africa

In Sub-Saharan Africa about 1% of GNP is spent on Science, technology and development, this amount is comparatively low, compared to developed

countries (Govender and Gruzd, 2011). Although South Africa's expenditure on education and training is more than most developed countries especially in the last 4 decades. The result show a growth of 48 million in embedded human capital in 1960 to 230 million in 1996 (Measured in completed school cycle), the downfall is the quality of the education (Simkins, 2002).

The issues lies in strategies in terms of budget spending efficiency, the struggle to draw the interest of foreign direct investment and to preserve the most favourably experienced Africans in Maths and Science (Govender and Gruzd, 2011). Consequently the short supply of high-level skills is extensively confining the ability to develop the economy (Simkins et al, 2009).

South Africa however is at an alarming state with the worst performance in both Maths and Science as released in an international study coordinated and released by the Human Sciences Research Council (HSRC) on 24 November 1996. The study was conducted by the International Association for the Evaluation of Educational Achievement (IEA) assessment on Trends in International Maths and Science Study (TIMMS, 2003). The president of the HSRC, Dr Rolf Stumpf commented at the release of the assessment results " These alarming results show that merely tinkering with the symptoms without addressing the root causes of our poor performance in mathematics and science will be a waste of time and money" (HSRC, 2004).

South Africa ranked 45th out of a total of 45 countries surveyed, in terms of Grade 8 Maths and Science assessment. The study highlights South Africa's country average at 244 for Science and 264 for Maths compared to the international average of 467 for Maths and 474 for Science at the eighth

grade level. The results unveil a substantial variation in Maths achievement between the highest and lowest performing countries, from an average of 605 for Singapore to 264 for South Africa in the mathematics assessment.

The problem starts at primary level with approximately 75% of the poorly performing school system experiencing poor arithmetic ability from their learners and consequently further mathematical education becoming incomprehensible. South Africa is therefore confronted with a massive challenge to address the numeracy failure, unless it will not accomplish the system-wide and prolonged improvement in the Maths and Science education reform, in terms of remedying the poor performance symptoms (Rule & Bernstein, 2009).

There is an increasing need to excel in Maths and Science education, as it is the doorway towards building a developed country and to achieve that requires a scientific and technological advancement that will facilitate growth and development of the economy, this is necessary especially to face the fierce global economic competition (Mji & Makgato, 2006; Dimmock, 2011). Commenting before the release of the assessment results, the executive director of the assessment technology and education evaluation research programme in the HSRC, Dr Anil Kanjee stated that “ This is especially relevant for mathematics and science education in South Africa, an area that the nation has recognized is in need of significant improvement if we are to participate and excel in the global economy” (TIMSS SA, 2003).

Problem Statement

In light of the persistent national crisis in Maths and Science education and the role that Maths and Science plays in citizenship empowerment. It is necessary to understand the intimate relationship between unemployment, inequality, poverty and the role that Maths and Science education plays in dealing with the factors in South Africa. South Africa is amongst the worst in the world in terms of inequality, with a Gini-coefficient in the range of 0. 58 – 0. 68. Between 18-24 million of the South African population is in poverty and about 36. 7% is unemployed including those who are not actively looking for employment. (McGrath & Akoojee, 2007).

The government plans to eradicate poverty through creating 5 million jobs through the new growth path by 2020 by redressing the inequality through deliberate affirmative action and practices. The education system is a key element of the new growth path. It plays a vital role in the transfer and development of skills and technology. In terms of Maths and Science, the new growth framework seeks to strengthen procedures to guarantee better and more reasonable admission to science and Maths education at secondary level (Patel, 2010).

Purpose Statement

The subject of Education, especially Maths and Science has been at the helm of many discussions in South Africa and globally, especially with about 90% of our schools failing to meet the minimum performance standards in Maths and Science. In spite of the above, there’s currently insufficient data on the root cause of poor performance in Maths and Science although South Africa

is facing a national predicament and this poor performance is actually congesting system-wide remedies (Simkins, 2010).

The role of this research is to close the gap in the exploratory literature of Maths and Science by introducing practical data in the root cause and consequences of poor performance in Maths and Science by South African schools. The research exclusively deals with poor performing schools in South African Primary and Secondary schools both in the public and private sector.

Primary goal of the study

This study's fundamental purpose is to determine the root cause of poor performance in the area of Maths and Science in South Africa. The aim of the primary goal is in the exploration of the central phenomenon (Creswell, 2008). Achieving the secondary objectives normally implies the recognition of the primary objective (Struwig & Stead, 2001). The aim of the secondary objectives is to explore the complex set of factors surrounding the central phenomenon (Creswell, 2008). Hence listed below are the formulated secondary objectives.

Secondary goals of the study

To explore the economic consequences produced by the poor performance in respect of Maths and Science in South African schools.

To identify the success determinants of the economies with high Maths and Science performance

The above represent the preliminary goals of the research but as the research proceeds the objectives may shift as the findings surface (Struwig & Stead, 2001).

Research Questions

The research is planned to concentrate on the following crucial questions:

Research question 1: What is the leading, underlying issue which leads to the poor performance in terms of Maths and Science?

Research question 2: What are the economic impact as a result of poor performance in Maths and Science?

Research question 3: What role should the South African government play to remedy the root cause of the poor performance in Maths and Science?

Layout of chapters

The research report consists of seven chapters as follows:

Chapter 1: Introduction

A comprehensible indication of what the study concerns is highlighted and the goal of the study is discussed to shed light to the topic. The overview of the research problem, purpose statement, primary and secondary goal and the research questions channeling the study. The following issues are addressed: the role that education plays in the economic development of the country, the state of Maths and Science in South Africa, Cleary highlighting the Maths and Science sectors performance.

Chapter 2: Literature review

An argument that supports the study is presented using relevant, current literature review. The statement of the research problem is refined and an argument is built using the literature. The chapter shows and looks at literature on the topic of Maths and Science, the economical impact associated with poor performance in Maths and Science and the various types of remedies available for a developing economy.

Chapter 3: Research Questions

The purpose of the research is defined through research questions, since the research is under-researched. This chapter builds up to the point that the following chapters will provide practical evidence to explore the dimension.

Chapter 4: Research methodology

This chapter highlights the method of data collection that will be used. It highlights the unit of analysis, the population, the sample size and sampling method, the research instrument, outlining clearly how the data was collected and the process adopted. The limitations to the study and the ethical considerations are outlined.

Chapter 5: Results

The results are presented in this chapter especially focusing on the qualitative approach; the results of the root cause and the economic consequence are presented in a form of figures and tables.

Chapter 6: Discussion of results

The results in chapter 5 are presented with a link to the research question, the research questions are presented as the major headings. An in-depth analysis of the result is conducted, clearly linking to the literature review and confirming that the research objective is met.

Chapter 7: Conclusion

This chapter summarizes the findings into an organized format, ending with recommendations to the stakeholders and future research.

CHAPTER 2: LITERATURE REVIEW

2. 1. Introduction

The objective of this literature review in accordance to the research problems is to further describe the problem. The literature review contextualizes research conducted locally and globally. Relevant publications, journals, reports and academic books were reviewed in order to collect data and discussions on the proposed research, mostly to determine if research of a same nature was not conducted in prior years.

The theory reviewed in this section is categorized into three sections: poor performance in Maths and Science, economic impact and success determinants. The first part provides a general perspective on Maths and Science poor performance looking at the variables underpinning the subsystems in terms of teacher practice, student achievement, curricular content and state of the government (Reddy, Kanjee & Diedericks, 2007).

The second part is an overview of economic impact with particular reference to Maths and Science, looking at the economy of South Africa, China and Brazil. Thirdly the success determinants are discussed looking at the important influences in Maths and Science achievement and the respective predictors. There is a need for specific insight in the factors that determine the success of Maths and Science as this builds on to the solution of the root cause.

2. 2. Poor performance in Maths and Science

A large number of studies seem to gravitate towards the problem of Maths and Science education in South Africa as illustrated by the poor performance of matriculants who failed to meet the admission requirements of Maths and Science faculties (Mabila et al, 2006). The problem of poor performance in Maths is one of the most paramount fears of teachers and other Maths educators globally.

Allegations point to the fact that poor performance capitulate negative behaviour and even trepidation of Maths by pupils (Wadesango & Dhliwayo, 2012). South Africa had a very low minimum pass rates requirement for Maths and Science at 29% and 30% respectively in 2010 but learners are not motivated to study Maths and Science as they’ve observed the failure of others (Mji & Makgato, 2006). Maths and Science were mostly disguised as subjects not for the weak and so this becomes a self-fulfilling prophecy that Maths is a subject for those with greater intellectual ability. The author further adds that the education system methodology of measuring grade passes vs. the provision of educational quality is at the core of the Maths and Science learner fear complicacy.

Mabila et al. (2009) argued that there were several factors that contributed to this phenomenon of poor performance, namely lack of regulation, inadequate resources, poor drive in students and teachers, implementation of policies and lack of parental involvement. Govender & Gruzd (2011) added that Maths and Science has a potential of unlocking the continents economic and developmental decline but education in Africa required remarkable development; the authors cited that education was disregarded and was not in the focal point of Africa's expansion plan, the author further noted the factors responsible for poor performance in Africa such as lack of qualified teachers, proper infrastructure, learning equipment and enrolment into the Maths and Science subjects bears fruit to the need for development. Bradbury & Miller (2011) differ in their argument in that the unequal schooling system produced various drawbacks that necessitated restoration but agreed on the factors such as lack of qualified teachers as part of the inequality amongst the others which they express as a " lack of excess to successive education levels".

It is clear from the evidence that Maths and Science education failure is caused by various factors and that poor performance is characterized by inequities, scarce resource and strategy.

2. 2. 1 Teaching Practice

South Africa is reported to be the leading technological giant in Africa but in terms of Maths and Science it fell below its economic opponent Indonesia, Chile and Malaysia. The reason for this lag was due to the lack of Maths and Science graduates who can propel progress forward in terms of knowledge sharing in the space of Maths and Science. The central part of this national

dilemma is due to the minimal levels of Maths and Science education in classrooms across Africa (Govender & Gruzd, 2011).

The Department of Education in South Africa changed the curriculum to enforce Maths into the curricular by adding Maths literacy into the equation as an alternative to Maths; this was done in order to increase Maths participation to a 100%. Although this was an outstanding government initiative, it added a need for more Maths and Science teachers. Govender & Gruzd (2011) indicated that Africa needed atleast 3 million more teachers to cope with the growing enrolments. Simkins et al (2009) qualified the statement by illustrating that South Africa was experiencing the same predicament with an escalating burden of more Maths classes and therefore teachers, this was due to the initiative to enforce Maths learning. This was further aggravated by the shortage of properly qualified and skilled Maths and Science teachers. The issue lies in the education departments failing to recruit talented and bright Maths and Science graduates who understand and could teach Maths and Science, these crucial skills could not be attracted into the system due to the lack of incentives and low pay.

Govender & Gruzd (2011) revealed shocking statistics in terms of educators in South Africa, which stated that up to 60% of the educators, had not been trained in Maths and Science, part of the main reason is that government was failing to translate their commitment to education into budgetary allocations. Education policies are drafted but the commitment lacks i. e. the scrapping of teacher colleges, inefficiency in training teachers and outdated teacher practices resulted in untrained teachers who struggled with the topics and hence imparted knowledge with a lack of foundation in content

knowledge and imagination. This has created a poor foundation for the future development of Maths and Science graduates (Govender & Gruzd, 2011).

(Mji & Makgato, 2006) said that Maths and Science are practical subjects and the teaching adopted in classes does not continually suggest practice, in the teaching of Maths and Science problems such as poor time management and incomplete syllabuses as a result of no school learning plan, continued to affect the practical method of teaching.

2. 2. 2 Student achievement

Firstly in order to measure and gain understanding of the variances in student learning, there is a need for suitable and correct Maths and Science assessment tools. South Africa’s inability to participate in most Maths and Science assessments shows the countries inability to recognize the state of the problem or even a need to know how they fare in the global context so as to improve the performance of its student (Venkat, Adler, Rolinick, Setati & Vhurumuku, 2011).

According to Taylor (2010) the overall level of achievement amongst South African children is extremely low; this is not shocking as there are two educational systems in South Africa. The first covers 80-85% of the learners who experience the historically disadvantaged system with traits of low proficiency in reading, writing and numeracy, the second system covers the 15-20% of the students from the affluent groups who achieve world class results. The first system is further aggravated by poor school management,

due to lack of resources such as textbooks, study materials and proper school facilities.

Teachers who were qualified and experienced tended to flock towards the more urban and developed provinces to teach in schools with proper school management (Taylor & Derekyu, 2009), hence the situation in the first system is further disadvantaged by inadequate experienced teachers who lack the proper resources or support to elevate their skills. The majorities of the graduates who obtained university entrance were produced in the second system and further enjoyed a social mobility and performance advantage.

Taylor (2010) further indicated that the socio economic status was still the core indicator of student achievement as supported by the results in performance in the different school systems. The author noted the following results as conducted in a national socio-economic status, Schools which did not perform satisfactorily had not completed their curriculum coverage which in turn affected the learning capability of the students but this could be due to the learning shortfall from prior years which in turn slows the curriculum coverage.

Math and Science teachers were tested in a simple maths test and the deficient teachers scored 40% or less, those with higher marks produced students who performed better in Maths and Science, these results showed the importance of teacher knowledge and experience to the student achievement. Taylor (2010) noted that the more materials were available as

well the better the student performed, which concludes the point that schools which are properly managed produces better student achievement.

2. 2. 3 Curriculum content

Although the change in curriculum by the Department of Education (2008) was an excellent initiative in terms of rendering Maths education non-negotiable, adding Maths Literacy as a mathematical wing has caused a nationwide debate The question is what is meant by mathematics in the concept of Maths literacy and the use of the word " Literacy" in conjunction with Maths (Vithal & Bishop, 2011). Looking at the factors that contributed to the poor performance in Maths and Science, the question that arose in regards to Maths literacy was whether Maths literacy was going to contribute to the knowledge required in a Maths economy or will this addition exert pressure on the system and subsequently on to the poor performance?

Table 1 below illustrates the design of the competencies that the Department of Education aimed for with the Maths, Maths Literacy and Science Curricula. According to Simkins et al (2009) the alteration of the curriculum has added up to 60% to the mathematical instructional problem since Maths or Maths literacy have become compulsory with the new National Senior Certificate changes. The CDE noted that the introduction of Maths literacy has actually resulted in students, who would have qualified to study Maths with a successive pass enroll for Maths literacy instead. This means that South Africa is losing out in terms of potential Maths graduates into the Maths and Science system (Simkins et al., 2009).

2. 2. 3. 1 The language issue

According to the findings by Wildsmith-Cromarty & Gordon (2009) dialect differences cause uncertainty in terms of what the terms mean and adds difficulty in comprehension, teachers preferred to have a standardized book in the language of instruction for Maths and Science and as well in the home language for ease of reference. Probyn (2009) stated in his finding that when home language was used in class, it increased the level of class participation. The author argues that the student need to cross borders in order to understand the information within the curriculum as the wording is written as if the reader is of the mother tongue, he further adds that learning in a second language infringes on the value system of the student. Probyn (2009) argued that the issue is that learners past experiences are entrenched in their cultural and traditional beliefs, norms and values.

MATHS

This curriculum is designed for those who intend to follow a career path requiring Maths, or those who are interested in the subject.

The competencies aimed for include:

1. Mathematical process skills, such as making conjectures, proving assertions, and modeling situations;

2. Confident calculation, with and without calculators;

3. Manipulation of algebraic expressions;

4. Financial calculations; patterns and transformation of functions;

5. Two- and three-dimensional geometry and trigonometry;

6. Basic statistics and probability;

7. Differential calculus; sequences and series;

8. Solution of unseen mathematical problems;

9. Historical development of Maths in various cultures;

10. and use of technology in calculations, and the development of models.

MATHS LITERACY

Maths literacy is driven by the life-related applications of Maths. It enables learners to develop the ability and confidence to think numerically and spatially in order to interpret and critically analyse everyday situations, and solve problems. The competencies aimed for include: use of numbers to solve real-life problems; modelling of situations using suitable functions and graphic representation; description, representation, and analysis of shape in two and three dimensions using geometrical skills; critical engagement with the handling of data (statistics and probability), especially the manner in which these are encountered in the media; and use of technology in calculations.

PHYSICAL SCIENCE

Maths introduces a more extensive range of mathematical techniques, whereas Maths literacy

Starts with real-life situations and develops a more limited range of techniques to deal with them. Physical science is divided into six core knowledge areas:

1. Matter and materials (integrated);

2. Systems (chemistry);

3. Change (chemistry);

4. Mechanics (Physics);

5. Waves, sound and light (physics) and electricity and magnetism (physics)

Source: Simkins et al (2007. p. 36)

2. 2. 4 State of government

Dimmock (2011) undertook research in schooling policies, the author explored the development and investigated the consequence of the policies from the changing context of the central government in terms of school relationship. The author compared the policies of two contrasting countries, which had the best performing schools in terms of international assessments, Dimmock (2011) notes that the two policies are more different than similar in the context of cultural values, politics and economic situations influences but the results are satisfactory in the global context despite the differences.

In relation to the study by Dimmock (2011) it is possible to establish that governmental intervention besides the context of the country can produce

results which are adequate, as long as they adopt policies which incorporate the country’s culture, politics, and economical standing.

South Africa’s involvement in terms of school relationship is questionable beyond the budgetary relationship where South Africa spent more than any other developing country in Africa yet 80% of the overall government spending was on personnel (Taylor, 2010). In a system where teachers are underpaid, the 80% is not justifiable. Simply there has been a lack of targeted investments in innovative solutions and a strong political commitment over a long period of time to change the social compositions of schools which is more important than school spending in educational achievement (Taylor & Derekyu, 2009).

Education increases productivity and the overall labour market, it develops the ability to innovate and aids in the transmission of critical knowledge for the development of the country. The South African government requires this productivity, labour market and innovation in order to further transform the social compositions of schools, hence without the investment in the school relationships, the government will still lack the resources to innovate (Taylor & Derekyu, 2009).

2. 3 Economic impact

2. 3. 1 South African economy

2. 3. 2 China

2. 3. 3 Brazil

2. 4 Success determinants

Ndlovu (2011 as cited by Gipps, 1993: 40) stated that in terms of Maths and Science education for social justice it should be structured in a way that the teacher is trained to be capable of creating learners who are able to analyze situations, conceptualize and justify critical decisions and so forth. Chipaike (2012) further stated that science formed part of the social environment and connected issues of social development; the author noted that science is not merely about manipulation of equipment and laboratory experimentation. It is about education for social development. “ Social development is laden not only with concepts but also skills and values such as the development of human potential, moral, cultural and gender sensitivity, participatory democracy, collaboration, unity and peace” (Chipaike, 2012). Ndlovu (2011) commented that without Maths and Science, inequality in terms of opportunities and social isolation are exacerbated as Maths and Science enforces citizenship empowerment.

Hickling-Hudson (2004) stated that in Cuba which has a dedicated programme to develop teachers in Maths and Science education and has outperformed all the other Latin countries, the teachers have atleast a 5 year university degree, Master or PhD level, foreign exposure in terms of expertise and also receive consistent training. Dimmock (2011) argued that

a school policy which has a designated segregation of talent is more likely to achieve excellence, in Singapore they have a specialist school in science and technology, which is endorsed by the government and allocated the cream of the crop in resources.

CHAPTER 3: RESEARCH QUESTIONS

3. 1 Introduction

Education in South Africa specifically in Maths and Science has an underlying deep failure rate due to reasons lin