NSTF
National Science & Technology Forum

PO Box 9823, Pretoria, 0001 • Tel:+27 12 841 3987 • Fax:+27 12 8413025 • E-mail:enquiries@nstf.co.za• Website: www.nstf.org.za

CONCEPT PAPER

proSET/NSTF in collaboration with Ukuqonda Institute

STEM Education with a focus on Maths, the ultimate building block of the sciences, engineering and technology

Introduction

South Africa continues to suffer from problems in its school education system, notably in the science, technology, engineering and mathematics (STEM) subjects. The university graduation rate for Life Sciences, Physical Sciences, Mathematics and Statistics is a meagre 3%. For all STEM related courses, including engineering and Information technology, it is only about 18%, contributing to a dire need for high level skills in STEM areas in both the economy and academia. All along the education 'pipeline' there are problems affecting the next level, and it is recognised by government that the greatest impact will be achieved by intervention at the lowest levels. It makes sense to intervene at primary school level so that secondary and tertiary level achievement will be strengthened.

Background

2015 Trends in International Mathematics and Science Study (TIMSS) reports

In a NACI article by Petrus Letaba in January 2017, the results of the TIMMS study are summarised and he writes:

"For grade five mathematics (TIMSS-Numeracy), South Africa achieved 376 points (47th out of 48 countries although the scale difference with 46thand 45th is not statistically significant). In a simple language, statistically the mathematics achievement at grade five is 45th out of 48 countries (a position shared with Morocco and Saudi Arabia)".

"The following is the international benchmark distribution of the country's performance at TIMSS 2015":

Summary of South African Performance on 2015 TIMSS			
International Benchmark	**Grade 5**	**Grade 9**	
	Mathematics	**Mathematics**	**Science**
Advanced (>625)	1%	1%	1%
High (550-625)	4%	3%	4%

Summary of South African Performance on 2015 TIMSS			
International Benchmark	**Grade 5**	**Grade 9**	
	Mathematics	**Mathematics**	**Science**
Intermediate (475-550)	12%	10%	9%
Low (400-475)	22%	21%	18%
Potentials (325-400)	28%	35%	28%
Not Achieved (<325)	33%	31%	40%

Although much was made of the improvement in TIMSS results from the previous time South Africa participated, it is obvious that these results are disappointing and inadequate in themselves. All these results can be represented by a pyramid with the overwhelming level of achievement being at the lowest level.

Matric results

Although the overall national pass rate for the National Senior Certificate (NSC) has improved over the years, the quality represented by these results has often been questioned. There has also been a trend of a declining proportion of passes in maths and physical science. This is clearly unsustainable in terms of the skills pipeline in the country.

In 2017, a total of 802 636 candidates sat for the NSC exams. 7 861 distinctions were achieved in Physical Science, and 6 726 distinctions were in Mathematics. Although these numbers appear high and show that there is great talent amongst our learners, proportionally these figures are too low – namely 1% and 0.8% respectively.

Unemployment among matric school leavers

At the same time the number of people with matric have increased dramatically:

The Education Series Volume III - Educational Enrolment and Achievement, 2016 of Stats SA, provides the following background:

"Between 1996 and 2016, the number of the population aged 15 years and older who completed matric increased from 3,7 million in 1996 to 11,6 million in 2016. This is almost a 211% increase over the 20-year period."

There is great concern about the unemployment rate among this large number of young people with matric certificates. It begs the question – what is the quality of this qualification, which seems to have become the minimum level of education required to get a job? Does it prepare learners adequately for employment, creating businesses, and to embark on further studies?

In 2012, the Medium Term Strategic Framework (MTSF) 2014–2019 was approved by Cabinet to implement the policies set by the National Development Plan (NDP). The MTSF targets include the achievement of the following by 2017, among others:

- 75% of learners in Grades 3, 6 and 9 tested through the ANA should achieve above 50% in literacy and numeracy;
- 57 000 graduates in engineering must be produced;
- 45 000 human and animal health graduates must be produced;
- 36 000 natural and physical sciences graduates must be produced; and
- The number of entry-level academic staff receiving teaching and research development opportunities from the Teaching and Research Development Grant will increase to 400 academics (MTSF 2014–2019).

To achieve these ambitious targets there had to be, and must be, a dramatic change at school level.

Mathematics

Besides being a research discipline in its own right, maths contains a crucial set of tools for scientists and engineers, and many other professionals. Mathematical tools have to be understood in order to be applied. Computers have taken over the tedious work of calculations and applying algorithms, so this is no longer required of various STEM professionals and students, but it is critical to have the insight to interpret a problem, instruct a computer program correctly, and interpret the outcome in order to apply it and find the solution. This ability has to be nurtured and developed from early on at school.

South African Curricula

During the transition to democracy around 1994, the school curriculum was perceived as one of the tools of social transformation. Outcomes Based Education (OBE) formed the vehicle for educational transformation across the education systems in South Africa.

OBE aimed to change the focus of education to acquiring 'competencies' as opposed to 'pass' or 'fail'. Assessment criteria were explicitly stated so that learners knew on what basis their progress was assessed. These criteria were also meant to be holistic, taking into account the various competencies the learner may have achieved during a section of work, not only knowledge acquisition. Teaching methodology was also supposed to change completely – from a teacher-led process to a learner-centred approach. A variety of teaching and learning activities was encouraged, including group work in the classroom. The learning experience was intended to be meaningful and relevant to the learners, and teachers were expected to create such experiences.

There have been several iterations of the OBE philosophy. The first of these was the Curriculum 2005 (C2005). C2005 began in 1998 and was intended to introduce the OBE philosophy into the school education system. It was expected to be fully implemented across all grades by 2005.

The features of C2005 were: outcome statements, integrated knowledge with both realistic contexts and across subjects, and a learner-centred approach. The language of the new curriculum had to be known and understood by learners, teachers and parents. The classroom required a level of sophistication (comparable to that of a developed world context) to support teaching and learning in this iteration of OBE.

A review process was commissioned by the DBE in 2000. The second iteration of the curriculum was the Revised National Curriculum Statement (RNCS) (2004) which later became the National Curriculum Statement (NCS) (2007). It had fewer outcome statements and assessment criteria than C2005 to simplify the introduction and mastery of the curriculum's requirements. School phases became central to the new curriculum and teachers teaching in the same phase were expected to collaborate on decisions regarding outcomes, assessments, contexts and content. Teachers had autonomy in this regard. Assessment became more central.

There was much criticism of OBE, notably that teachers were ill-equipped to implement such an ambitious curriculum and that schools were poorly resourced.

Much concern has been expressed about the quality and standards of the NCS. Performance of students at tertiary level seemed to deteriorate, and the higher education institutions complained and devised interventions for their first year students to bridge the gap between matric and tertiary studies. Other role players became interested in the school education systems, because of their experiences of the product of the school education systems.

The next iteration of OBE was Curriculum and Assessment Policy Statements (Caps) and was introduced into the school education system in 2012. This was the first major departure from the original concept of OBE. Caps is a much more restricted curriculum where the content to be taught, how it is to be taught and at what pace have been predetermined. The overall minimum pass requirements were raised for each level, new minimum requirements were determined for a basic NSC, the credibility of school-based assessments

was improved and more focus was given to knowledge acquisition. Because of these characteristics, It is assumed that Caps has improved education in general during the past 6 years.

However, there are disadvantages to the developments associated with the Caps curriculum. The overemphasis on passing tests and exams has led to an under-development of conceptual understanding – which is crucial in the STEM subjects, whereas knowledge acquisition may be more important in non-STEM subjects.

It is likely that Departmental officials, Subject advisors and teachers do not understand how crucial it is to teach differently from the way in which they were themselves taught at school. A dramatic change is required, and should have taken place with the previous policy and curriculum changes, particularly when OBE was pursued. However this appears not to be the case. With the pressure to increase the matric pass rate, learners are discouraged from taking STEM subjects including maths, and when they do, they are coached for the matric exam – i.e. they practice the procedures that will allow them to pass the exams – instead of nurturing the insight that will allow them to build on their learning in tertiary education.

pro*SET* and NSTF

The National Science and Technology Forum (NSTF) is a non-profit forum representing all organisations in science and technology. There are more than 100 member organisations, including research councils, universities, businesses, NGOs, State Owned Enterprises, and professional associations. The NSTF was formed in 1995 as a collaborative effort of the diverse science community.

Professional bodies and learned societies are organised into a membership sector called pro*SET*. pro*SET* currently consists of 38 such organisations and represents a wide variety of professionals in STEM – including scientists, engineers, and STEM educationists. STEM education is of great interest to all these professionals as it is recognised that the pipeline from pre-school to tertiary education provides the essential foundation for the professions.

The August 2018 pro*SET* event

Purpose and outcomes:

- To facilitate interaction between the various SET professionals in pro*SET* on the one hand, and maths education experts on the other hand
- To gather the opinions of a wide range of SET professionals about STEM education in general in South Africa, and the type of skills required
- To intensively discuss the primary school maths curriculum in order to: identify the problems leading to rote learning and lack of insight, and come up with interventions to make substantial impact for the improvement of maths teaching in primary schools across the country.
- To collate feedback to be sent to the Department of Basic Education (who is due to revise national policies/curricula soon) and the Provincial Education Departments
- To introduce a project of pro*SET* - the interactive cartoon (a virtual reality type environment where children can explore the internal workings of various machines, structures, living organisms etc) to various stakeholders, get their feedback and input, and encourage their participation in establishing and expanding this project

**See http://www.nstf.org.za/memberships/current-members/#1443524787867-a359339f-4cef for a list of proSET members and their websites.*

Planned Outputs

- ✓ Presentations made available to the participants and, where suitable, to the public
- ✓ Video clips of presentations
- ✓ Media release/s

- ✓ Proceedings written up in detail, with a summary
- ✓ List of Recommendations – possibly two lists, one focusing on the maths curriculum only
- ✓ Collated results of audience evaluation forms
- ✓ Collated report for Departments of Education

The way forward:

A follow up meeting should be held with the proSET Committee and the organisers of the maths discussion days, to review the success of the event and discuss possible follow up actions.

Sources

http://www.sabcnews.com/sabcnews/2017-matric-pass-rate-increases-76-5/

https://www.iol.co.za/dailynews/opinion/sas-school-journey-1806392 - SA's school journey, 19 JANUARY 2015, LABBY RAMRATHAN

http://www.statssa.gov.za/publications/Report%2092-01-03/Report%2092-01-032016.pdf

Stats SA Report on Community Survey 2016