DOUBLING FOR GROWTH

Addressing the maths and science challenge in South Africa's schools

Centre for Development and Enterprise

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CENTRE FOR DEVELOPMENT AND ENTERPRISE
Informing South African Policy

DOUBLING FOR GROWTH

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This report has been written by Professor Charles Simkins, Dr Stephen Rule and Ann Bernstein. Margie Keeton also made a major contribution.

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The Centre for Development and Enterprise
Transmedit Place, 5 Eton Road, Parktown
Johannesburg 2193, South Africa
PO Box 1936, Johannesburg 2000, South Africa
Tel 2711 482 5140 • Fax 2711 482 5089
info@cde.org.za • www.cde.org.za

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Contents

EXECUTIVE SUMMARY 5

MAIN REPORT 21

Introduction 23

Why so few HG maths and science passes? 29

Key themes from CDE's research 31

The Dinaledi Programme 43

Summary of key findings 48

'Doubling for Growth': CDE's recommendations 50

Summary of recommendations 70

Concluding remarks 73

Appendix A: Research reports commissioned by CDE 76

Appendix B: CDE's 2004 recommendations, and the response 77

Endnotes 80

Acronyms and abbreviations

AsgiSA	Accelerated and Shared Growth Initiative for South Africa
CDE	Centre for Development and Enterprise
DET	Department of Education and Training, which controlled schools for Africans under the apartheid system
Dinaledi	Programme of Department of Education to promote specialist maths and science schools (literal meaning: 'stars')
HG	Higher Grade
HoA	House of Assembly – former white parliament that controlled schools for white learners under the apartheid system
HoD	House of Delegates – former Indian parliament that controlled schools for Indian learners under the apartheid system
HoR	House of Representatives – former coloured parliament that controlled schools for coloured learners under the apartheid system
HSRC	Human Sciences Research Council
IEA	International Association for the Evaluation of Educational Achievement
JIPSA	Joint Initiative on Priority Skills Acquisition
Model C	One of three types of state schools reserved for white learners until the early 1990s; non-racial since 1994
MHG	Maths Higher Grade
MSG	Maths Standard Grade
NAPTOSA	National Professional Teachers Association of South Africa
NATU	National Teachers Union
NGO	Non-government organisation
NIHE	National Institute for Higher Education
NOCCI	Northern Cape Chamber of Commerce and Industry
NSC	National Senior Certificate
SADTU	South African Democratic Teachers Union
SAOU	Suid-Afrikaanse Onderwysunie
SC	Senior Certificate (matriculation examination)
SG	Standard Grade
SMECK	Science and Maths Education Committee of Kimberley
TIMSS	Trends in International Maths and Science Study

EXECUTIVE SUMMARY

"I urge South Africans to affirm excellence and reject mediocrity in the interests of nation-building, socioeconomic development, and true liberation. The levels of underperformance in our education system are unacceptably high, and an unjust subversion of the historic promise of freedom and democracy that we've put before our people.

At the system level in research and in protest we have spent a great deal of time focusing on the negative, we have appeared far too tolerant of mediocrity in its many guises, and extremely neglectful of that which works and of those who are doing what must be done.

This year we will promote and affirm this excellence. We will also actively challenge and reject mediocrity.

We will affirm excellence through performance rewards for teachers, for schools, universities and colleges.

We will also act more decisively against underperformance, and provide necessary support where disadvantage or inequity exists.

All the departments of education will have to substantially improve their performance. Faster action on agreed priorities and effective support and monitoring of the system will be strengthened."

– **Naledi Pandor**, Minister of Education, tabling departmental budget vote in parliament for the 2007–8 financial year, 29 May 2007

THE SOUTH AFRICAN schooling system continues to produce far fewer passes in maths and science – particularly in the higher grade – than the country's economy requires. Many university degrees and professional and technical careers require a grounding in maths and or science, and the critical shortfall in learners leaving the schooling system with HG maths and science is a significant constraint on economic growth. It also impedes the development of state capacity, and undermines both public and private programmes for black economic empowerment.

This problem is compounded by demographic trends. Over the past half-century or more the South African population expanded significantly. However, given falling levels of fertility, the rate of increase in children of school-going age is dropping rapidly, and South Africa can therefore not continue to rely on an expanding pool of learners to meet its growing need for human capital. Instead, it will have to concentrate on improving the quality of output from a pool that will not get much bigger than it is today.

There is widespread agreement that a radical improvement is necessary. Maths and science education are firmly on the agenda of the government's Accelerated and Shared Growth Initiative for South Africa (AsgiSA) and Joint Initiative on Priority Skills Acquisition (JIPSA). Business is concerned about the supply of quantitative skills, especially in the context of a higher economic growth rate.

The critical shortfall in learners leaving the schooling system with HG maths and science is a significant constraint on economic growth

CDE AND THE DEPARTMENT OF EDUCATION

CDE liaised with the Department of Education at numerous stages in the course of this project. In August 2007 it presented a near-final draft of this report to the Deputy Minister, Enver Surty, and invited him and the department to comment on it.

In response, the Deputy Minister and the department supplied us with very useful comment as well as updated information on various aspects of the maths and science education system and the Dinaledi initiative. Where appropriate, this information has been incorporated into this report.

The Deputy Minister stressed the close convergence of goals between the department and CDE, and reiterated that the department remained firmly committed to the goal of doubling the number of SC HG maths passes, which CDE espoused in its first report.

Some differences of emphasis and opinion remain. The department has to run a complex and often fragile system within political, fiscal and interest constraints. As an independent policy think-tank, CDE is concerned with the coherence and efficacy of policy in the field of secondary school maths and science education. Our function is to assemble the facts, examine assumptions, get to grips with the achievements and limitations of the policies which follow from them, and consider new options. As a result, we retain a critical perspective on the maths and science schooling system.

The Deputy Minister accepted that there were some differences in perspective between CDE and the ministry, and said he regarded these as part of the normal debate in any democratic society. The ministry and CDE share a common objective of improving the maths and science schooling system in South Africa. CDE appreciates this constructive approach which should, in our view, prevail in all government sectors.

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Black economic empowerment will benefit greatly if this key constraint on black participation in the economy is broken, and learners and their parents will benefit from improved schools. The Department of Education is responding to these pressures. The private sector is involved through corporate social investment and other educational ventures.

This report is intended as a contribution to extending and strengthening both public and private sector interventions. CDE shares common concerns with the Ministry of Education: the need to affirm excellence and reject mediocrity, substantially improve performance, act against underperformance, and act faster on agreed priorities. In particular we share the Ministry's desire for dramatically improved school results, and strongly support the concept of Dinaledi schools and a focused attention on vital initiatives that will achieve tangible and substantial results.

Annual passes in HG maths have fallen increasingly short of the Department of Education's stated targets for achieving the doubling goal

About this report

CDE published its first report on maths and science education in 2004. It found that the education system was producing far too few Senior Certificate (SC) maths and science passes, particularly in the higher grade, and that this would increasingly constrain economic growth. It recommended that all stakeholders should make a concerted effort to double the number of SC HG maths and science passes (from about 25 000 to about 50 000) over the next five years. In 2006 the government formally adopted this goal, and leading government figures – including President Thabo Mbeki – have urged all key role players to help improve the national performance in maths and science education.

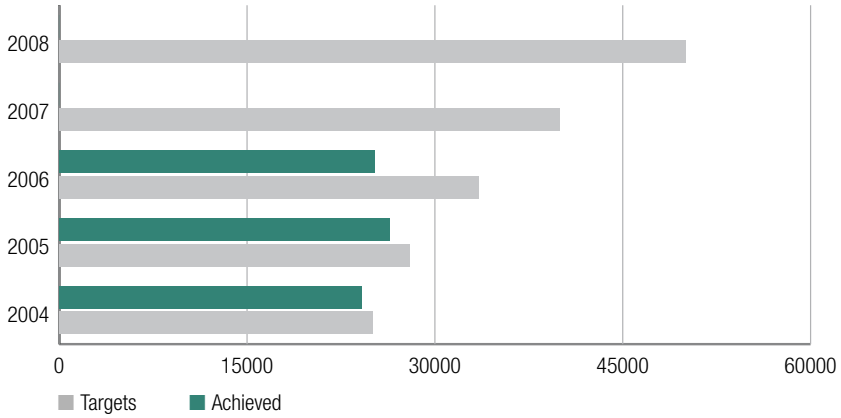
However, despite new commitment and energy, little progress has been made. Annual passes in HG maths have fallen increasingly short of the Department of Education's stated targets for achieving the doubling goal, and from 2005 to 2006 they actually declined (see Figure 1).

This report provides an updated review of the state of maths and science schooling and a revised set of recommendations for increasing its output over the next few years, as the first phase of a broader strategy to improve the South African education system. Much of the analysis that follows will focus on maths. CDE regards maths as a bigger problem than science, because there are fewer passes in SC HG maths than in HG science, and more fields of higher education require maths than science.

Some major findings

South Africa spends proportionately more on education than many other developing countries, yet its learners perform far worse than those of other developing countries – including African countries – in international tests. This indicates that the public education system is inefficient, making ineffective use of resources. Its poor performance in respect of maths and science is strikingly illustrated in Figure 2.

Figure 1: Government targets for doubling SC HG maths passes versus actual passes



Sources: Department of Education, Education Statistics in South Africa at a glance, 1999-2005; Department of Education, Expanded Maths, Science and Technology Strategy, Presentation by Deputy Director-General P Vinjevold to ISASA NBI breakfast, 19 October 2006; Department of Education, Report on Dinaledi Initiative in 2006; Department of Education, Senior Certificate Examination Results, 2006.

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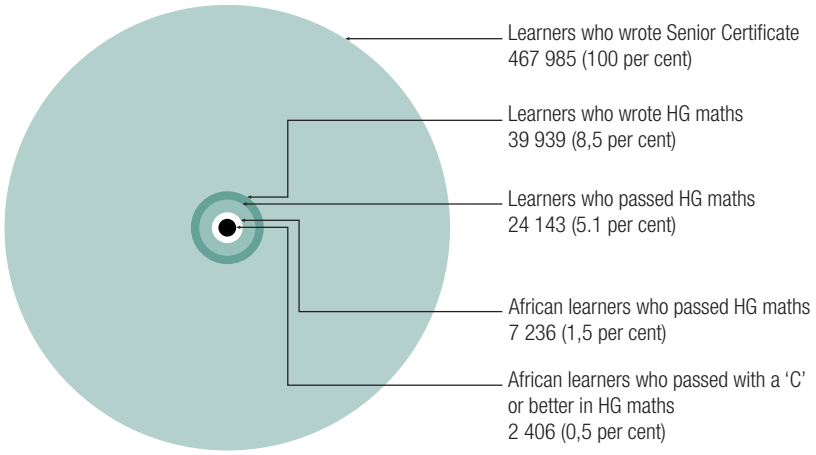
Figure 2: HG maths output of the SA schooling system, 2004



Note: Data for the 2006 SC examination needed to update the diagram were not available at the time of writing; however, the outcome was much the same. Figures drawn from Department of Education, Senior Certificate Examination Results, 2004.

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Statistical analysis indicates that only about half the SC candidates who could pass HG maths do so

Achievement in maths and science is very closely correlated to proficiency in the language of instruction

Performance across schools is very uneven; most HG maths passes (about 70 per cent) are produced by a very small number (about 11 per cent) of schools. Conversely, about 80 per cent of secondary schools produce only about 16 per cent of HG maths passes – an average of one each.

Statistical analysis indicates that only about half the SC candidates who could pass HG maths do so. Some have chosen to do SG maths; others have chosen not to do maths at all; and others attend schools that do not offer HG maths. Therefore, the potential for doubling the number of HG maths passes exists. To realise this potential, more learners must be persuaded to take this subject, and if it isn't offered at schools close to where they live, learners with aptitude for maths must be given the opportunity to attend schools where it is.

Major changes are being made to senior secondary education. The Senior Certificate is being phased out and is being replaced with the National Senior Certificate. The NSC will be fully in place from 2008 onwards, and 2007 will be the last year in which the SC examination will be written. HG and SG maths are being replaced with mathematics and a more rudimentary subject, mathematical literacy. Mathematics will fall somewhere between HG and SG maths in terms of difficulty. Under the SC, HG or SG maths have been elective subjects, but under the NSC either maths or mathematical literacy will be compulsory. Science will remain an elective subject.

This has major implications for maths teaching. At the moment, about 275 000 senior secondary learners (about 60 per cent of the total) study either HG or SG maths. Under the NSC system, this figure will jump to more than half a million. This will place huge additional demands on the maths teaching system. In particular, the large number of schools that have previously not offered maths at all or have not managed to secure more than a handful of SC passes each year will come under enormous pressure.

Data on teachers is inadequate, but indications are that there is already a shortage of teachers, particularly in specialised subjects such as maths and science; that some teachers teaching specialised subjects are not adequately qualified; that teachers are unevenly distributed throughout the education system, with rural areas in particular being starved of specialised teachers; and that specialised teachers are often not adequately utilised.

Levels of enrolment of student and trainee teachers (particularly Africans) are very low. At the end of 2006, only 550 potential maths and/or science teachers graduated from South African universities. How many of these actually will end up teaching is unknown – the attractions of private employment, emigration, and other options all reduce the potential pool. The Department of Education has launched a new campaign to encourage school leavers and university students to take up teaching as a career, and entice qualified people to enter or return to the teaching profession.

Although information on the number of teachers and their qualifications is collected in the Annual Schools Survey, there is no system-wide information about the competence of maths and science teachers at senior secondary schools. The

limited evidence available suggests that content knowledge and teaching techniques are frequently inadequate, and tha teachers spend far too little time on teaching (about 40 per cent of total work time instead of an expected 85 per cent). The education sector is highly unionised. This has hampered and complicated attempts to introduce accountability into the schooling system especially with regard to teacher performance.

Achievement in maths and science is very closely correlated to proficiency in the language of instruction. Improving the proficiency of learners and teachers in the language of instruction is as important as improving the quality of teaching in those subjects themselves.

Most SC HG maths and science passes are produced by a relatively small number of historically advantaged schools, and they also achieve the highest pass rate among African learners. Many of these schools remain better resourced than township schools; however, learner-to-educator ratios in these schools have also begun to rise, and government funding is declining. Many of them are admitting increasing numbers of learners from poorer communities, some of whom cannot pay school fees. The upshot is that these high-performing schools are experiencing increasing financial and other pressures. These institutions are established centres of excellence, and a valuable national resource. Their continued performance should not be taken for granted, and they should not be allowed to deteriorate through neglect or the unintended consequences of other policies.

The Dinaledi programme

Dinaledi, established in 2001, is the main initiative of the Department of Education to improve the performance of the schooling system in respect of maths and science. Some secondary schools are selected for Dinaledi status, and provided with additional resources for teaching these subjects.

The programme has concentrated on improving the performance of African learners and former African schools rather than former white, coloured and Asian schools. Currently, 490 of 6 264 secondary schools – or 7,8 per cent – are part of the programme.

In 2006 the Minister of Education announced that the number of Dinaledi schools would be increased to 400, and by August 2007 the number had increased to 490, with a further increase to 529 schools expected at a later stage. The criterion for inclusion was that the schools had to have achieved at least 35 SC maths passes by African candidates, either HG or SG. In Gauteng, the Western Cape and Kwa-Zulu- Natal, some former white schools which meet this criterion are now being included in the programme.

The precise impact of the Dinaledi programme is difficult to establish. Although the number of HG passes achieved by Dinaledi schools increased from 3 331 in 2004 to 3 815 in 2005 and 3 909 in 2006, the number of schools in the programme increased from 102 to 400 during this period. This is not nearly enough to achieve

The Dinaledi experience to date highlights the difficulties facing the country in its efforts to double the number of maths passes

the national goal of doubling maths and science passes – or their equivalent under the new curriculum – within the next few years. Moreover, analysis shows that most of the HG maths and science passes in Dinaledi schools are achieved by a relatively thin layer of high-performing schools, and that the performance of most other schools has remained the same or even worsened. In 2006, 65 Dinaledi schools (16 per cent) produced the same number of passes as before, while 155 (39 per cent) produced fewer; this means that for 220 schools the programme has yet to have a positive impact on results.

The private sector has a profound interest in an improved maths and science schooling system

According to the department, the 2006 HG maths exam was more demanding than previously. The Dinaledi experience to date highlights the difficulties facing the country in its efforts to double the number of maths passes. Without significant support and encouragement, even strong schools are able to do little more than hold their own.

The department is trying to increase its input into Dinaledi schools in various ways, including more learning resources and better teachers in maths, science and the languages of instruction. How many schools in the programme have received any or all of these inputs is not clear. Evidence from some high-performing schools suggests that few useful inputs have been received.

According to the department, the Dinaledi budget is R4,5 million for the current financial year, and provincial departments have allocated additional funds to Dinaledi schools. However, the state budget for Dinaledi is still inadequate, and few departmental staff are allocated specifically to the programme. Procedures for adding promising schools or excluding those that fail to perform are not clearly defined, and implementation in provinces differs considerably. The numbers and levels of expertise of teachers of maths and science in each school are not known.

A major new maths and science teacher upgrade programme is being piloted in Dinaledi schools. While the programme seems promising, its roll-out seems to have been delayed.

The role of the private sector

The private sector has a profound interest in an improved maths and science schooling system. The absence of high-level skills is significantly constraining its ability to expand the economy and meet its black empowerment targets.

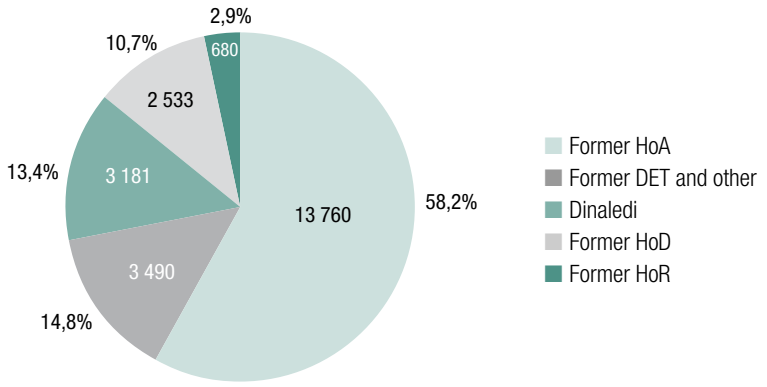
Private companies are already involved in a large number of national, regional and local initiatives aimed at improving maths and science education. However, CDE's research shows that the vast majority of these interventions have little lasting impact on the quality of the maths and science schooling system.

Private donors need to refocus their efforts on changes to the system that can have multiplier effects rather than single isolated projects. They should think about moving away from undifferentiated interventions in maths and science teaching in certain schools; piecemeal donations of science and other equipment; and ad hoc bursary schemes.

Research conclusions

A number of interlocking factors account for the inadequate maths and science output of the senior secondary school system. These range from the need for a greater 'skills agenda' orientation in school education, through an insufficient supply of teachers with both high levels of content knowledge and a determination to teach the curriculum fully and well, to the demands of a changing curriculum. The government's Dinaledi programme is a start, but it has weaknesses, and as currently constituted will not produce anything near a doubling of HG maths and science passes within the next few years. A more comprehensive and system-wide initiative is needed.

Figure 3: Distribution of HG maths passes by school type, 2004



Note: Dinaledi schools have been excluded from other categories.
Source: Derived from Department of Education, Senior Certificate Examination Results, 2004.

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All senior secondary schools meeting certain non-racial performance standards should be designated as full Dinaledi schools

'DOUBLING FOR GROWTH': A PRACTICAL PLAN TO ACHIEVE RESULTS

Improving the Dinaledi programme

Until now, performing schools in maths and science have been implicitly divided into two groups: former coloured, Asian and white schools on the one hand, and former African (Dinaledi) schools on the other. This distinction is becoming increasingly unclear and unhelpful, for the following reasons:

Some former coloured, Asian and white schools now qualify to be Dinaledi schools since they produce the requisite number of maths and science passes by African learners.

Some former coloured, Asian and white schools perform poorly in maths and science, but could help to achieve the doubling target with appropriate inputs.

The country urgently needs an audit of maths, science and language teachers in all schools essential to reaching the doubling goal

High-performing schools should not be taken for granted. Already some schools that have performed well historically are at risk of deteriorating, and need attention.

The increase required for doubling SC maths and science passes in the medium term cannot come from African learners alone; white, coloured and Asian learners have to contribute as well.

CDE therefore proposes that Dinaledi be restructured. All senior secondary schools meeting identified performance standards (irrespective of race) should be designated as full Dinaledi schools. Schools meeting lesser performance standards should be eligible for selection as candidate Dinaledi schools. Candidate Dinaledi schools should strive to become full Dinaledi schools within a specified period. Should they fail to do so, they should be dropped from the programme, thereby making way for other aspirant Dinaledi schools.

Schools and a new school contract

The Department of Education and each Dinaledi school (including its governing body) should sign a contract spelling out the rights and obligations of each party under the programme. This founding document could be an essential communication tool. Dinaledi schools should be provided with the infrastructure, teachers, equipment, and consumables needed for the effective teaching of maths, science and language of instruction. Capacity should be created at the national and provincial levels to give effect to this priority.

Teachers, principals and parents at Dinaledi schools should be trained to enable them to participate fully in the Dinaledi programme. Schools should commit themselves to certain performance targets; in return, the education authorities should commit themselves to providing certain benefits – including a 24-hour hotline – to help schools meet their commitments, for example by immediately replacing a teacher or principal.

Top-performing schools should accept additional obligations such as enrolling additional high-potential learners, or assisting neighbouring schools.

Identifying talented learners across the country

The Dinaledi strategy is important but not sufficient for achieving the doubling goal. It needs to be complemented by identifying good maths and science learners in schools that are ill-equipped to develop these aptitudes (some 81 per cent of South Africa's public schools) and are not part of the Dinaledi programme.

At the end of Grade 7, all learners in the country should write a test aimed at assessing their potential in maths and science. Learners with the potential to pass SC HG maths and science or its equivalent under the new NSC should be assisted to attend appropriate schools. The most promising learners should be given bursaries to Dinaledi schools, which should be equipped to receive them.

Improving the supply and quality of teachers

The new senior secondary curriculum will greatly increase the demand for maths teachers. At the very least maths and science teachers should be able to pass a HG SC paper in their subject with very high marks and quickly upgrade their skills to cope with the new curriculum. Heads of department should have several years' experience of successful teaching. Teachers who cannot meet these criteria should be assigned to tasks other than teaching maths and science in Grades 10,11, and 12.

The country urgently needs an audit of maths, science and language teachers in all schools essential to reaching the doubling goal, and a database that will enable education authorities to manage their placement throughout the country. More teachers should be trained, and the quality of their training improved. In the meantime, maths and science teachers should be recruited immediately from abroad – India, for example – to make up the local shortfall.

Maths and science teachers should be intensively trained and retrained, and their efficacy and performance closely monitored. The Department of Education should negotiate with the teachers' unions to enable this. School organisation should be improved to allow teachers to spend more time actually teaching.

Improving proficiency in the language of learning

A private foundation is funding a new pilot programme for training language teachers in selected Dinaledi schools in four provinces, starting with two provinces in 2007 and two more in 2008. It will provide teachers with a highly structured learning programme for Grades 10 and 11. The 2007–8 programme in the first two provinces should be carefully evaluated, and if it proves to be successful it should be rolled out to all other Dinaledi schools and then to all other schools as soon as possible.

The transition from the SC to the NSC

The transition from the SC to the NSC will have a major impact on senior secondary maths and science. Many schools and teachers are uncertain about the new curriculum, or how best to cover the syllabus. The Department of Education should communicate more effectively with schools as well as the public about the new curriculum, and provide teachers with more detailed guidance on teaching it.

New capacity required in the Department of Education

If the Dinaledi project is to be effectively implemented, state capacity will have to be significantly expanded. We strongly recommend that the 'Doubling for Growth' project becomes a self-standing national project with increased powers, funding and responsibility for its implementation at the national level. In order to run such a large, multi-million rand and complex programme of innovation, intervention and monitoring, executives with extensive management experience should be appointed to head it. The Minister of Education should consider the South African

If the Dinaledi project is to be effectively implemented, state capacity will have to be significantly expanded

Revenue Service – which is operationally autonomous, and whose effectiveness is widely acknowledged – as a possible model for running such an important national programme.

A maths and science education forum

In 2004 CDE recommended the creation of a national task force with responsibility for the whole system of maths, science, and language education. More recent consultation indicates that a forum for maths and science education would be more appropriate.

Participants should include representatives of national and provincial government, business, and civil society more generally. Its key function should be to serve as a forum for debate and the exchange of information between public and private sectors in the interests of doubling maths and science output at the SC level.

The forum would need an independent secretariat, funded and staffed by the private sector. Among other things, the secretariat should play an important role in collecting and analysing information, monitoring and evaluating developments in maths and science education, sharing new 'learning', and co-ordinating inputs from all sectors of society.

Detailed studies of Kimberley and Springs suggest the potential for innovative local experiments to double maths and science HG pass rates

The private sector

CDE has identified scores of national, regional and local private initiatives and literally hundreds of projects. They are not having the desired impact, and independent evaluation confirms that very few interventions have a lasting impact on the quality of the schooling system or school performance in maths and science. Private donors should consider the findings of this report and its implications for current expenditure (see box, facing page).

Experiments with innovative systemic programmes are likely to motivate policy changes aimed at achieving significant increases in the number of HG maths and sicence passes. The main report provides numerous practical suggestions for private donors. Among other things, they could:

- help to improve and analyse quantitative databases on the maths and science education system;
- launch regional pilots of the aptitude tests to be taken by all learners at the end of Grade 7;
- provide bursaries to selected learners;
- supply resources to those schools that accept those additional students;
- monitor and evaluate the Dinaledi programme;
- fund selected capital developments such as new hostels at Dinaledi schools to accommodate learners with bursaries; and
- encourage schools with rewards for performance.

QUESTIONS WHICH THE PRIVATE SECTOR SHOULD ASK ABOUT ANY PROPOSED INITIATIVE IN MATHS AND SCIENCE EDUCATION

The big questions

1. Where do you want South Africa's maths, science and language teaching to be in five to ten years' time? What can your company's (limited) resources do to help the country get there?
2. What should the government do to fund maths and science schooling? Within this framework, how can private funds help to make a difference?
3. How can private money play a catalytic role in improving South Africa's maths and science schooling system?
4. How can private money play a 'risk or venture capital' role? In other words, how can private money be used to test new ways of doing things?
5. Will your proposal help the 'Doubling for Growth' initiative? And if so, in what way exactly?

The main report contains more questions aimed at assisting private sector decision-making.

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'Doubling for Growth' should become a self-standing national project, and should be run by senior executives with extensive management experience

Pilot projects and regional experiments

The 'Doubling for Growth' initiative can usefully experiment with mobilising energy, capacity and commitment outside traditional parts of the schooling system.

Our detailed studies of Kimberley and Springs suggest the potential for innovative local experiments to double maths and science HG pass rates. There are encouraging opportunities for the formation of public–private partnerships to achieve and exceed this goal in local areas. Regional initiatives can create networks for co-operation among schools and for the identification of learners with aptitude. They can also provide a focused arena in which to 'learn by doing', and speed up the doubling process.

These are ideal areas for private sector involvement and funding. However, such funding needs to be part of an agreed public–private partnership, and private funding must involve a commitment from the state that, if these experiments are useful, it will implement them at scale.

The Minister of Education and senior education officials have shown an unprecedented interest in partnerships aimed at improving maths and science education. The private sector should take advantage of this window of opportunity, and work together with government to forge such partnerships now.

Concluding remarks

The target of reaching 50 000 SC HG maths passes (or their equivalent under the new curriculum) a year needs to be achieved as quickly as possible. This can be done if all learners who are capable of passing HG maths or the new subject of mathematics enrol for it, and are well taught and supported in other ways.

CDE believes that improving maths and science in senior secondary schools presents a unique opportunity to influence the whole education system

As the performance of the Dinaledi programme since 2001 demonstrates, substantially improving the performance of the maths and science schooling system will not be easy. Important though these contributions may be, it will not suffice for the public sector to concentrate solely or mainly on the current Dinaledi approach, or for the private sector to continue with its existing mix of projects. Given present trends, we are likely – at best – to achieve 30 000 of the target of 50 000 HG maths passes set by the Department of Education for 2008.

Success will require an improved broad-based initiative involving substantially more state funding and executive capacity. What is required is an overall strategy with clear and achievable targets, commensurate budgets and staff, and a mechanism – the proposed forum – for bringing the combined interests and expertise of the public and private sectors (at the local, regional and national levels) to bear on this common objective.

CDE believes that:

- **We have to look across the whole school system to achieve the doubling target**, and we propose a system of categorising schools for inclusion in the Dinaledi project that moves away from race but maintains an affirmative character.
- **We have to expand the pool of potential HG maths candidates** by looking outside the current performing and Dinaledi schools to the 80 per cent of schools that produce one or fewer HG passes a year. Our proposed aptitude test coupled with bursaries for learners with potential to enable them to attend better schools will expand the pool of potential HG matriculants and provide opportunities for thousands of individuals who could succeed if only they were at a performing school.
- **We have to have effective teachers operating in functioning schools to make this all happen**. At present we don't know which maths teachers can actually teach maths. Endless upgrading programmes are not working, and, given past experience, there is no reason to expect that they will work in the future. We have to find a way of testing the current teacher corps so as to assess exactly where we have maths teaching skills, and where these need to be supplemented.

'Testing the teachers' should immediately become a prerequisite for becoming a Dinaledi school (see box, facing page).

TESTING TEACHERS' COMPETENCE IN PERU

Peru has done relatively well at getting children into school: more than 90 per cent of children complete primary schooling, and two thirds complete secondary schooling, a better record than in richer Argentina and Mexico. The problem is that Peruvians do not learn much in the classroom. In a 43-country international test in 2000, Peru came last, well behind even the other Latin American participants.

In December 2006 the education ministry announced that all teachers would have to take a proficiency exam. Union leaders, most of whom belong to radical Marxist parties, had long rejected teacher evaluation. They got hold of the exam paper and posted it on their website. According to the minister of education, José Chang, this was 'the most serious mistake' in the union's history, resulting in the public losing 'what little confidence it still had in the union'.

The ministry rewrote the exam paper and required the country's 250 000 teachers to complete it in January 2007. Four out of five of them did, in defiance of the union's boycott. Almost half of those who sat for the exam were unable to solve elementary maths questions, and a third failed a reading comprehension test.

Drawn from The Economist, 20 April 2007.

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A priority national project

The programme of recommendations we are calling 'Doubling for Growth' should become a self-standing national project, and should be run by senior executives with extensive management experience. The South African Revenue Service provides a model of an operationally autonomous (and highly effective) public institution, and the Minister of Education should consider this as a viable way of boosting such an important programme.

The South African Revenue Service provides a model of an operationally autonomous (and highly effective) public institution

Our contribution is to place a package of concrete and achievable suggestions on the table. We recognise that most primary and secondary schools in South Africa desperately need attention. Our proposals are meant to be a first step in a much broader and longer-term process. It may seem unfair to start with maths and science and language at secondary schools, but this is the most practical starting point, and will rapidly benefit national economic growth and South African society more generally. If we can achieve results in this area, we can start to build the capacity to move deeper into the schooling system as a whole. We cannot fix everything at once.

CDE believes that improving maths and science in senior secondary schools presents a unique opportunity to influence the whole education system. The scale of the intervention is large enough to make a real difference in several ways, but small enough to be understood by all stakeholders, the implementation closely monitored, and the results visible to all. About 1 200 schools should be affected. Yet the impact on economic dynamics, the lives of many young people, and the morale of all those participating will be enormous, if the programme succeeds.

There will, of course, be difficulties in implementation, and some tough negotiations with stakeholders not immediately convinced of the value of the programme, such as teachers' unions, over assessments of current capacity and the recruiting of teachers abroad. Nevertheless, CDE firmly believes that its research, the attitudes of scores of stakeholders interviewed, the willingness of the private sector to get involved, and the stand taken by the Minister of Education point to the success of a bold, co-ordinated programme to improve the quantity and quality of maths and science education.

CDE calls on all concerned parties to give immediate and earnest attention to this report.

MAIN REPORT

PRESIDENTIAL COMMITMENT

We will, of course, also make other interventions in the area of education and training. These include eliminating fees for the poorest quintile of primary schools, targeting 529 schools to double the maths and science graduate output to 50 000 by 2008, and re-equipping and financing the Further Education and Training Colleges.

– **President Thabo Mbeki**, State of the Nation Address,
Joint Sitting of Parliament, 3 February 2006.

A PENITENT CONFESSES

I have decided to save the worst for last. I am not being facetious in declaring that our woeful performance in educating our people is the worst of the problems we are in denial about. As a former government spin doctor, it was once my job to defend destructive educational experiments and policy gimmicks – which included Curriculum 2005, the closure of teacher colleges and the severance packages given to teachers we could not afford to lose.

What kind of developmental state recklessly endangers the future of its children in this manner and spends years making political decisions about educational imperatives?

I find it difficult to be enthusiastic about our celebrated economic fundamentals and strategies to improve economic growth when a serious overhaul of what we are doing in education is not part of such a strategy.

I am not unaware of the urgency with which government communicates about programmes aimed at transferring skills to our people. I am, unfortunately, more aware of the crisis in rural and township schools and how our schooling system continues to deny children from these communities a decent education. I am painfully aware of how our dual public education system condemns the poor to twelve years of a road to nowhere with a matric certificate as their licence.

– **Aubrey Matshiqi**, *Business Day*, 24 November 2006

Introduction

South Africa spends a larger proportion of its gross national product on education than almost any other developing country. Yet the education system is performing very poorly, especially in respect of maths, science, and literacy. These failures are the biggest single obstacle to black economic advancement. State expenditure on education is ineffective and inefficient. Failures in the school education system perpetuate social inequality, and contribute to unemployment. South Africa is hamstrung by an endemic shortage of skills, and growth could accelerate significantly if school-leavers have the skills its economy needs. The education system can not supply the number of skilled blacks the state's black economic empowerment (BEE) programme requires. This is especially true of skills based on maths and science. In economic terms, we have reached the limits of our human capital. It can only be replenished by appropriate and successful education and training.

The education system is performing very poorly, especially in respect of maths, science, and literacy

In short, the legacy of the education system prior to 1994 and the relatively poor performance of the school education system since then are a major constraint on the country's development, and continue to hold back millions of black South Africans. Nothing can substitute for systematic, well-managed initiatives to correct this state of affairs and release the potential of the population served by the system. This requires tough, politically difficult choices, aimed (among other things) at achieving far higher levels of competence in literacy, maths and science, especially at the senior secondary level.

CDE AND THE DEPARTMENT OF EDUCATION

CDE liaised with the Department of Education at numerous stages in the course of this project. In August 2007 it presented a near-final draft of this report to the Deputy Minister, Enver Surty, and invited him and the department to comment on it.

In response, the Deputy Minister and the department supplied us with very useful comment as well as updated information on various aspects of the maths and science education system and the Dinaledi initiative. Where appropriate, this information has been incorporated into this report.

The Deputy Minister stressed the close convergence of goals between the department and CDE, and reiterated that the department remained firmly committed to the goal of doubling the number of SC HG maths passes, which CDE espoused in its first report.

Some differences of emphasis and opinion remain. The department has to run a complex and often fragile system within political, fiscal and interest constraints. As an independent policy think-tank, CDE is concerned with the coherence and efficacy of policy in the field of secondary school maths and science education. Our function is to assemble the facts, examine assumptions, get to grips with the achievements and limitations of the policies which follow from them, and consider new options. As a result, we retain a critical perspective on the maths and science schooling system.

The Deputy Minister accepted that there were some differences in perspective between CDE and the ministry, and said he regarded these as part of the normal debate in any democratic society. The ministry and CDE share a common objective of improving the maths and science schooling system in South Africa. CDE appreciates this constructive approach which should, in our view, prevail in all government sectors.

CDE 2007

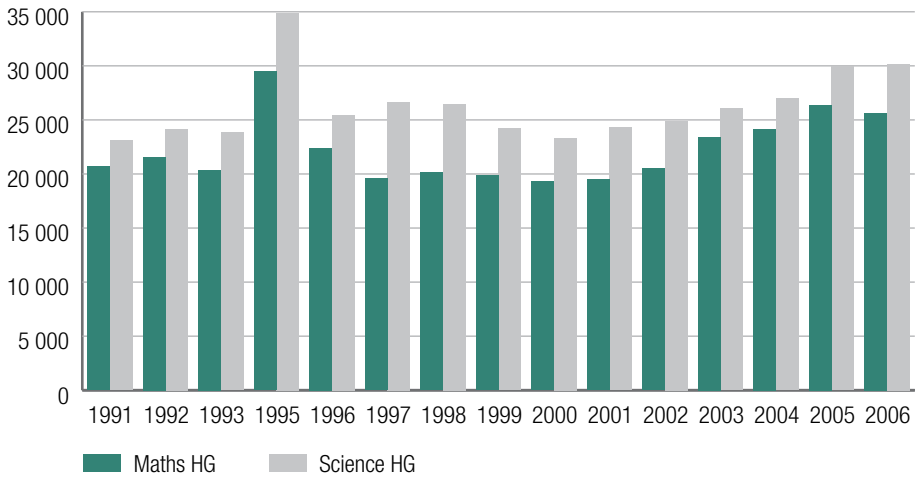
The private sector has a close interest in improving maths and science education.[1] The most important factor likely to slow down economic growth is the absence of high-level skills. In a modern economy, many of these skills are based on maths or science and associated language skills. The private sector could hardly have a more direct interest in funding initiatives outside its own business operations. In addition, the Minister of Education, Naledi Pandor, and the Department of Education have shown an unprecedented interest in partnerships aimed at improving maths and science education. The private sector should take advantage of this window of opportunity, and forge such partnerships now.

CDE has already completed a major study of maths and science education in South Africa's schools, encapsulated in its research report entitled *From Laggard to World Class: Reforming Maths and Science Education in South Africa's schools* (2004). Among other things, it called for Senior Certificate (SC) passes in higher Grade (HG) maths and science to be doubled within five years. Encouragingly, the education authorities responded to that call, and many other points made in that report have become part of the national debate (see Appendix B: CDE's 2004 recommendations, and the response thus far).

South Africa's educational crisis does not arise from a lack of access to schools, but from a lack of efficiency

South Africa's educational crisis does not arise from a lack of access to schools, but from a lack of efficiency. The public education system is characterised by high enrolments and low quality. The current Minister of Education has repeatedly emphasised that the need now is for quality education for all. Ninety per cent of children of the appropriate age groups are enrolled in primary schools, and 62 per cent of young people of the appropriate age groups in secondary schools. Slightly more females than males are enrolled. Twenty eight per cent of the total population is in school, compared to an average of 20 per cent worldwide. However, for the past 16 years, fewer than 7 per cent of SC candidates have passed HG maths. In 2006, some 33 per cent (or 174 413 of 528 525) candidates failed the SC examination, and only 16 per cent (84 564) passed with Grades needed to enter university. Only 4,8 per cent (25 633) passed HG maths, and only 5,7 per cent (30 174) passed HG science.

Figure 1: Passes in SC HG maths and science, 1991–2006



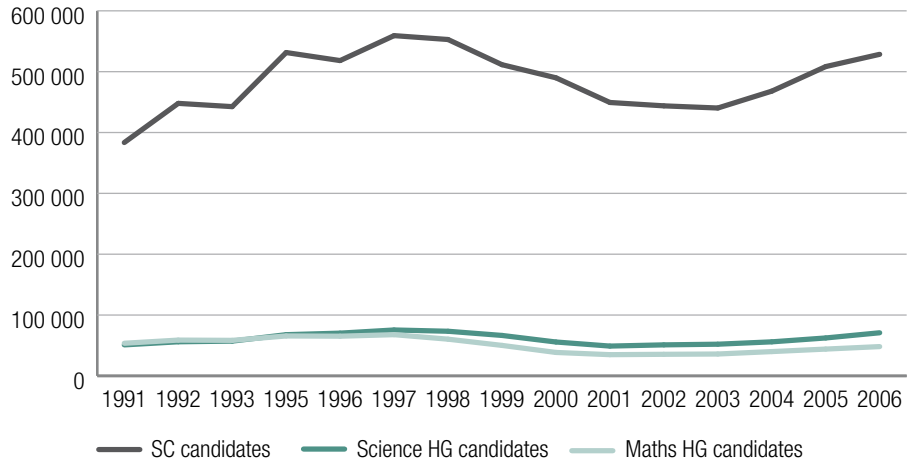
Source: Department of Education, Education Statistics in South Africa at a glance, 1999–2005; Department of Education, Senior Certificate Examination Results, 2006. Data for 1994 is not available.

CDE 2007

Figure 1 shows the number of passes in SC HG maths and science from 1991 to 2006. It shows that passes have not increased significantly over this period, and that from 2005 to 2006 the number of passes in HG maths actually declined.

In order to assess the performance of the system in respect of HG maths and science in greater detail, we first need to examine trends in enrolment, and then trends in performance against trends in the SC as a whole.

Figure 2: Enrolment for SC and SC HG maths and science, 1991–2006



Source: Department of Education, Education Statistics in South Africa at a glance, 1999–2005; Department of Education, Senior Certificate Examination Results, 2006. Data for 1994 is not available.

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While the enrolment rate for HG science is now roughly the same as it was 15 years ago, the enrolment rate for HG maths is still significantly lower

Figure 2 displays trends in enrolment for SC, SC HG maths, and SC HG science since 1991. It shows that very small proportions of senior secondary students choose to study HG maths and science, and that, despite efforts to improve the maths and science output of the education system, enrolment for these subjects have not improved in recent years.

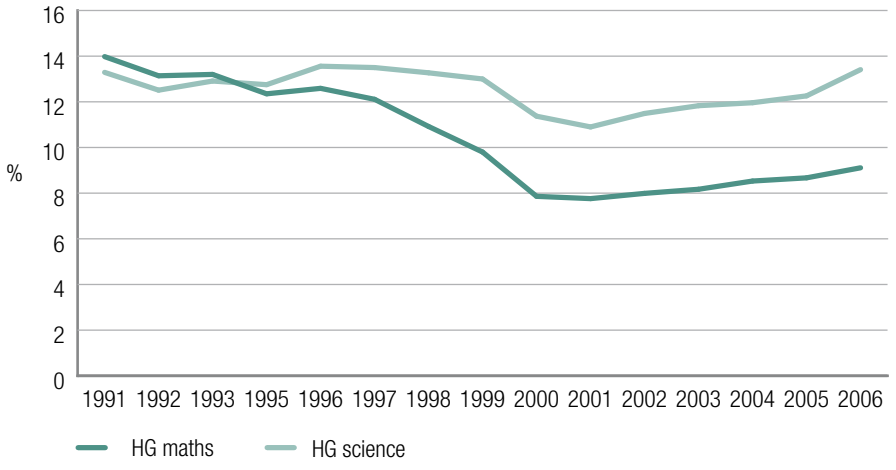
Figure 3 displays enrolment for HG maths and HG science as percentages of total SC enrolment. It shows that the proportion of senior secondary learners who chose to study HG maths and science declined sharply until 2001, and has improved gradually since then. However, while the enrolment rate for HG science is now roughly the same as it was 15 years ago, the enrolment rate for HG maths is still significantly lower. Put differently, the percentage of SC learners choosing to study HG maths has declined from nearly 14 per cent in 1991 to about 9 per cent in 2006.

Figure 4 displays the pass rates for the SC in general as well as those in HG maths and science from 1991 to 2006. It shows that pass rates in HG maths and science broadly mirror those for the SC in general, but are significantly lower, and have declined more sharply in the past few years than those for the SC as a whole.

The poor performance of the system is strikingly demonstrated in Figure 5.

The percentage of SC learners choosing to study HG maths has declined from nearly 14 per cent in 1991 to about 9 per cent in 2006

Figure 3: Enrolment for SC HG maths and science as percentages of SC enrolement, 1991–2006



Source: Department of Education, Education Statistics in South Africa at a glance, 1999–2005; Department of Education, SC Examination Results, 2006. Data for 1994 is not available.

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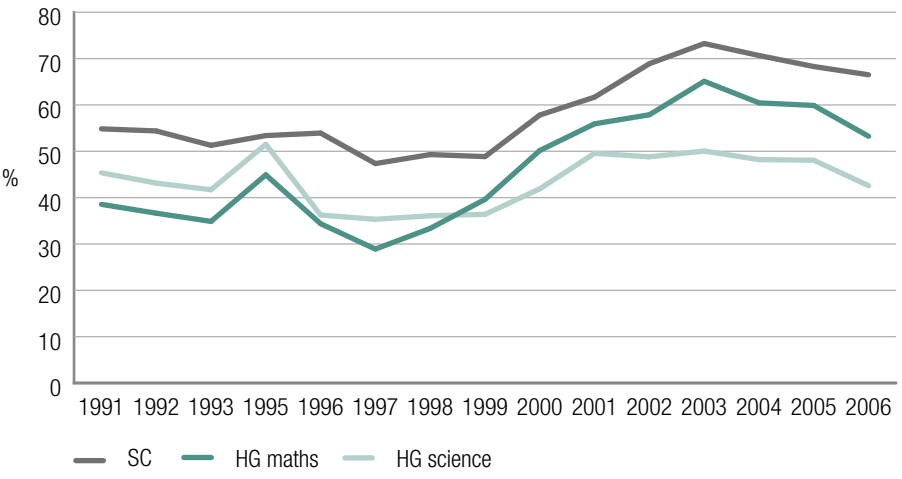
Figure 4: Pass rates for SC and SC HG maths and science, 1991–2006



Source: Department of Education, Education Statistics in South Africa at a glance, 1999–2005; Department of Education, SC Examination Results, 2006. Data for 1994 is not available.

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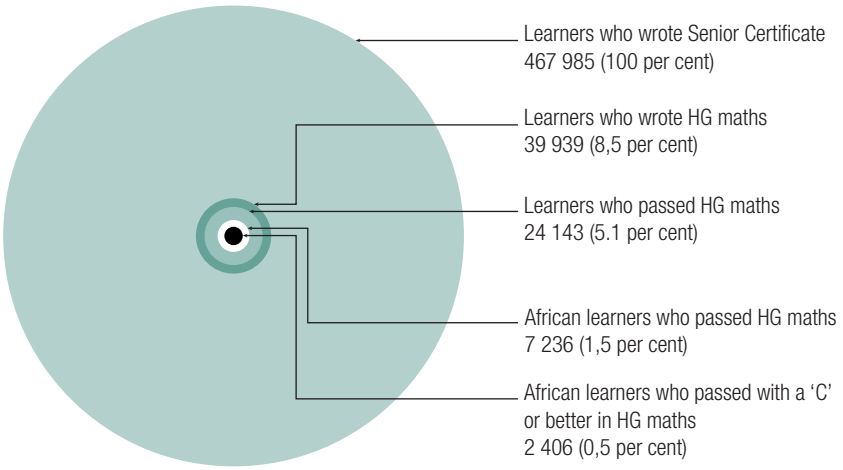
Figure 5: HG maths output of the South African schooling system, 2004



Source: Department of Education, Education Statistics in South Africa at a glance, 1999-2005; Department of Education, Senior Certificate Examination Results, 2006. Data for 1994 is not available.

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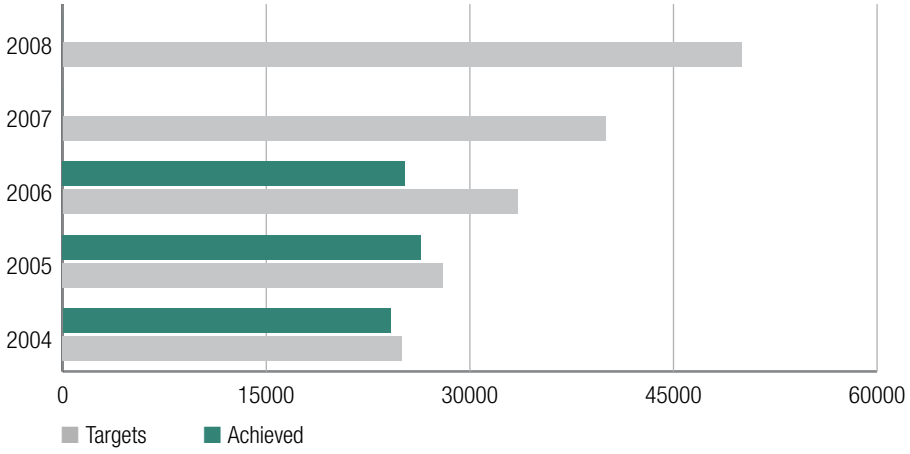
Passes fell increasingly short of the department's targets, and – as noted earlier – even declined slightly from 2005 to 2006

In 2006 the Department of Education set out its annual targets for achieving the goal of increasing the number of SC HG maths and science passes to 50 000 learners by 2008 – ie, doubling the number of passes in 2004. As can be seen in Figure 6, passes fell increasingly short of the department's targets, and – as noted earlier – even declined slightly from 2005 to 2006.

Figure 6: Government targets for SC HG maths passes versus actual passes



Sources: Department of Education, Education Statistics in South Africa at a glance, 1999-2005; Department of Education, Expanded Maths, Science and Technology Strategy, Presentation by Deputy Director-General P Vinjevold to ISASA NBI breakfast, 19 October 2006; Department of Education, Report on Dinaledi Initiative in 2006; Department of Education, Senior Certificate Examination Results, 2006.

CDE 2007

The department attributes this to the introduction in 2006 of a national examination paper (as opposed to different provincial papers) in mathematics, in which the cognitive demand was higher than in previous years. It also notes that the questions in the national examination were less predictable than those in the previous provincial examinations. However, CDE believes this underachievement will continue unless:

- the government deepens and broadens its efforts to improve maths and science education; and
- the private sector plays an appropriate role in helping the educational system to achieve more.

Underachievement will continue unless the government deepens and broadens its efforts to improve maths and science education

This document summarises the findings and recommendations of the second phase of CDE's research into maths and physical science output at the SC level. The findings are reported in greater detail in a longer companion document.

In general, CDE regards maths as a bigger problem than science, because there are fewer passes in HG maths than in HG science (see Figure 1), and more fields of higher education require maths than science. Maths, not science, is usually required for degrees in commerce as well as for diplomas and degrees in computing and information technology. Much of this analysis will therefore focus on maths.

THE COMPLICATIONS OF DATA AND TERMINOLOGY

The Department of Education releases data about the SC examination in two stages: it first releases data at the school level, and later releases data at the individual candidate level. At the time of writing, only data by schools was available for the 2006 SC examination, and this has been used in a number of places in this document. When most of the detailed analysis of individuals was done, individual data was available for 2004 only.

Moreover, there are three official sources of data about the 2004 SC results, and these statistics do not entirely correspond – hence some differences in the figures quoted in this report, depending on whether we used the database of individual SC candidates, the consolidated database for schools, or Education Statistics in South Africa at a Glance (2004). Some sources may include passes in supplementary examinations, while others do not.

These analyses could have been updated using the 2005 individual results, but this would have been an expensive exercise, and the cost was not justified by the few, if any, new insights which would have been gained. The underlying structural relationships have changed slowly. Data for 2006 is cited whenever it can be; for the rest, 2004 data from the three sources is used.

The term 'black' in this report refers to African, coloured and Asian people, and the term 'African' is used in the narrower sense.

CDE 2007

Why so few HG maths and science passes?

HG maths is widely regarded as a difficult subject, and many learners believe they cannot pass it. Learners need to be in the top decile of ability (as measured by aggregate marks in the SC examination) to be confident of passing HG maths.

However, statistical analysis indicates that only about half the SC candidates who could pass HG maths do so.[2] Some have chosen to do SG maths rather than HG maths. Others have chosen not to do maths at all, even when they had the opportunity to do this at HG level. Yet others have the ability, but have been educated in schools that do not offer HG maths. The potential for doubling the number of HG maths passes exists. Realising this potential requires two things: more learners must be persuaded to take this subject, and if it isn't offered at schools close to where they live, they must be given the opportunity to attend schools where it is. The whole system is underperforming, which is very wasteful of its own resources as well as the potential of learners. Career counselling is essential to inform and guide learners about the tertiary level study options and career opportunities that open up if they pass SC HG maths.

Statistical analysis indicates that only about half the SC candidates who could pass HG maths do so

Thirdly, the difference in performance across schools is staggering, as the following table shows.

Table 1: Senior Certificate results, 2006

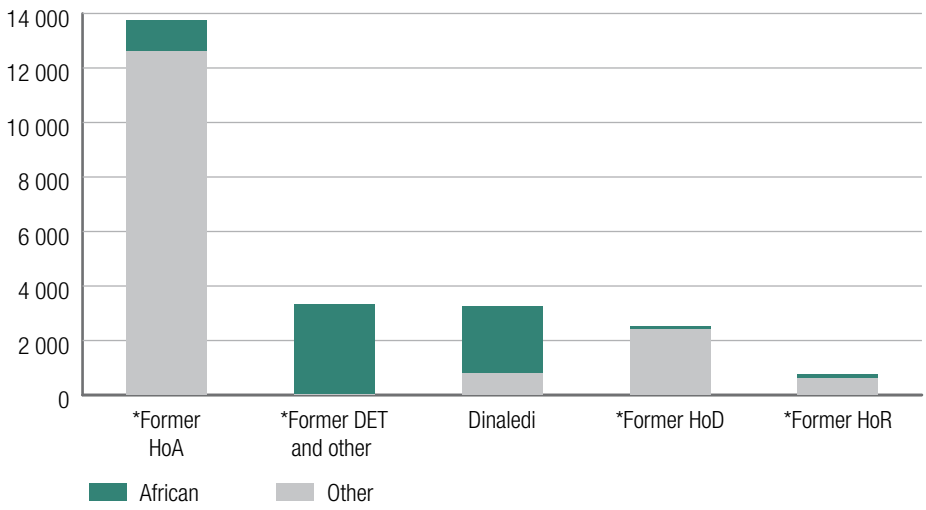
HG maths passes as a percentage of total SC passes	Number of schools	Number of HG maths passes
20% or more	343	12 542
At least 10% but less than 20%	362	5 606
At least 5% but less than 10%	486	3 318
More than zero but less than 5%	1 629	4 162
None	3 444	0
Total	6 264	25 628

Source: Department of Education, Senior Certificate Examination Results, 2006.

The top 11 per cent of schools (705 in number) accounted for 71 per cent of HG maths passes. These schools produced an average of 26 HG maths passes per school. Conversely, 5 073 (81 per cent) schools fell into the bottom two categories, and accounted for a mere 16 per cent of HG maths passes. These schools produced an average of less than one HG maths pass each. In 2006, more than half of secondary schools failed to achieve a single HG maths pass.

There is abundant evidence that in the poorly performing three quarters of the system, the problem starts in primary school

Figure 7: Maths HG passes in 2004 by race and school type



** excluding the Dinaledi schools in these categories.*
Note: The proportions of Africans in each category have increased since 2004, but recent data could not be obtained. Source: Department of Education, Senior Certificate Examination Results, 2005.

CDE 2007

Figure 7 breaks down HG maths passes in 2004 by race and school type. It shows that by far the greatest proportion of passes are produced by former House of Assembly (HoA) schools, followed by former DET schools and Dinaledi schools. Interestingly, it also shows that former DET schools are producing more African HG maths passes than Dinaledi schools, and that former HoA (or former white) schools are now producing a significant proportion of African passes.

Fourthly, there is abundant evidence that in the poorly performing three quarters of the system, the problem starts in primary school. Limited time on task, poor curriculum coverage, lack of progression in abstraction and cognitive demand, and deficits in teacher content knowledge all contribute to a situation in which the majority of learners fall increasingly short of the learning objectives for their Grades. If there is a poor command of arithmetic at primary school level, maths at secondary school level will seem incomprehensible.

Certainly, the primary school numeracy failure needs to be addressed, and until it is, system-wide and sustained improvement will not be possible. However, CDE has chosen to look closely at the top end, namely secondary schools, and our proposals are aimed at improving conditions and performance at that end of the schooling system. We acknowledge that this is a limited intervention, but we also believe that a concentrated effort at this level would help us to reach the doubling target more rapidly than any other initiative. It is not necessary – and not possible – to solve every problem right away. It is necessary to undertake bold new initiatives that can be achieved and that will establish a solid foundation for reforming the entire system over time.

Key themes from CDE's research

Demography

In 1921 there were 581 168 learners at South African schools; by 2000 this had increased to 11 903 455, a more than 20-fold increase over 79 years. But the 21st century experience will be different. Rapidly falling levels of fertility mean that the rate of increase in children of school-going age (5–19) is dropping. South Africa cannot continue to rely on an expanding pool of SC candidates to meet growing demands for human capital. Instead, it will have to concentrate on improving quality in a pool that will not get much bigger than it is today. Everything discussed in this report must be seen against the new demographic backdrop.

South Africa cannot continue to rely on an expanding pool of SC candidates to meet growing demands for human capital

The political economy of South African schooling

In a study of the performance of the South African schools system, Luis Crouch and Firoz Patel (a highly rated international consultant to the Department of Education, and a deputy director-general of the Department of Education) distinguish between a 'rights agenda' (tackling poor conditions in South African schools), and a 'skills agenda' (becoming more efficient at turning resources into skills imparted to young learners).[3] They argue that the rights agenda has been implemented more fully than the skills agenda, which is not surprising since the 1996 constitution mandated the progressive realisation of socio-economic rights, and the emphasis on this agenda has not provoked serious objections from those with a vested interest in the educational system. It has also resulted in great improvements in the equity of financial and other inputs into schools, though a weakness remains in upgrading physical infrastructure. Crouch and Patel find that inputs into schools are now distributed much more evenly than household income. However, good educational results are distributed very unevenly, and the skills agenda is lagging badly.

Crouch and Patel also observe that South Africa has long had a cavalier attitude towards monitoring or enforcing teaching quality, partly because of the decentralised nature of the schooling system, and partly because systemic information is not used at the micro level to provide teachers with feedback and support, and hold them accountable. To change this situation will not be easy. Nothing effective has been put in the place of inspection as a mechanism of accountability. Progressive education philosophy, in vogue since 1994, emphasises the self-chosen development of learners within classrooms rather than achievement in terms of external norms. Improved accountability also has to be negotiated with powerful teachers' unions. Nonetheless, improved accountability is central to the realisation of the skills agenda on which improved maths and science outputs will depend.

The Crouch and Patel[5] recommendations are sound. Improvements in maths and science output at the SC level will require their implementation throughout the school system. This document argues that they need to be supplemented by specific measures aimed at maths and science in the senior secondary system (the 'further education and training band').

Two other issues need to be dealt with here. First, in a country with 11 official languages the school system will inevitably struggle with language policy. The current policy is that each school may decide on its own language policy in the light of local circumstances and a general policy of 'additive bilingualism': the notion that additional languages must

THE CROUCH AND PATEL SKILLS AGENDA[4]

Following their analysis, Crouch and Patel make a number or proposals for advancing the 'skills agenda', which would result in an improvement in the output of the education system. Their key goal is to improve the skills of teachers, while holding them accountable for using their skills in ways that lead to demonstrably improved results among learners. The basic steps advocated by Crouch and Patel are:

1. Learning goals must be more clearly specified, and must be communicated more clearly to teachers via in-service training.
2. The testing and assessment of learners should be greatly improved. These should be detailed enough to diagnose the gaps being left by teachers. Testing for diagnostic purposes could be done on a sample basis. But testing for accountability needs to take place on a census basis.
3. Teachers should receive highly specific in-service training in both learning goals and the identified learning gaps. Training needs to move away from generic approaches in order to focus on specific skills.
4. Detailed year-long learning plans must be developed. It may be argued that these will undermine teacher professionalism and will intrude on classroom processes. One approach is to hold teachers accountable for results. Those who are achieving results should continue to use their existing methods. Those who are not will have to follow far more detailed learning plans than those used up to now, even if these impinge on classroom autonomy.
5. Teachers achieving results, or following a clear instructional programme, should be freed from paperwork and other bureaucratic requirements that are not proven to lead to these results. Paperwork should be reduced as much as possible.
6. Learning materials should be provided and distributed on a massive scale; these should include basic packages of inexpensive materials, including library books for leisure reading.

CDE 2007

Current policy has resulted in highly variable language goals and teaching in primary schools

be added to instruction in the home language of learners. Additive bilingualism comes under pressure when schools serve multilingual communities. In addition, many African parents want their children to learn English as soon as possible. Current policy has resulted in highly variable language goals and teaching in primary schools, even in relatively homogeneous communities; considerable variation in understanding between the various actors in a school (parents, school governing body, principal and teachers); and gaps between stated policy and the practice of teachers in classrooms as they struggle to make themselves understood. The overall result is less than optimal learning. While the problem is most acute in primary schools, performance in the language of instruction and performance in SC maths are highly correlated. While much of the correlation is driven by a third factor – the general ability of learners – poor grasp of the language of instruction means that learners in maths classes are trying to understand a new language as well as new subject matter, with little chance of success.

Secondly, the teaching profession is highly unionised. In 2004 there were 362 042 educators in ordinary (non-special) schools.[6] There are four trade unions party to the Education Labour Relations Council: the South African Democratic Teachers Union (SADTU), the National Professional Teachers Association of South Africa (NAPTOSA), the Suid-Afrikaanse Onderwysunie (SAOU), and the National Teachers Union (NATU). Of these, SADTU is by far the biggest, claiming 230 000 members in November 2005.[7] In 2003, after years of negotiation, the department and the union agreed on an Integrated Quality Management System as the basis for evaluating schools and teachers. This is an elaborate

agreement. In 2004, schools were to begin advocacy and training towards establishing staff development teams and a school improvement programme, so as to ensure that teachers conduct selfevaluations, identify personal support groups, and develop personal growth plans. From this a school improvement plan must be developed in conjunction with district officials, and in-service training needs identified. Educators are observed by district officials for pay and Grade progression purposes. The staff development teams must keep records, and compile a report for whole school evaluation purposes. The whole cycle is meant to be repeated every year.

Given current district and provincial capacity, this system is very difficult to implement. It is not clear whether it is having any impact at all, and if so, in how many schools. (This is just one of many examples of initiatives or programmes that might work in Norway, California or Australia, but are highly impractical – and even fantastical – in South Africa.) In general, the Department of Education needs to engage strongly with the unions about improving maths and science teaching, with the expectation that the necessary co-operation will be forthcoming.

The Department of Education needs to engage strongly with the unions about improving maths and science teaching

The changing curriculum

At present, Grade 11 and 12 learners may choose whether or not to study maths and science. They must study at least six subjects, and they may study maths and science on the standard or higher grade. Learners who want be endorsed for university entrance must study four subjects at the higher grade. Neither maths nor science is compulsory for a SC.

In 2008 the SC will be replaced with the National Senior Certificate (NSC). Learners will work towards the NSC examination for three years – in Grades 10, 11 and 12. These grades will correspond to the senior secondary phase in the education system.

The introduction of the NSC has required a change in curriculum in Grade 10 from 2006 onwards, and in Grade 11 from 2007 onwards. Candidates for the NSC will have to study and write at least seven subjects, as follows:

- two official languages, at least one of which must be at the home language level;
- either maths or maths literacy;
- life orientation (to be assessed internally); and
- at least three other subjects.

The differentiation between HG and SG will disappear. Maths will be compulsory, in one form or the other, while science will remain an optional subject. To pass the NSC, a candidate will have to pass at least three subjects at 40 per cent (one of which is the home language) and the other three at 30 per cent. Candidates will have to obtain a mark of at least 30 per cent in maths or maths literacy. The same minimum mark will be required for science (if studied), provided the candidate in question scores at least 40 per cent in one of the two remaining elective subjects. The current system of differentiating between passes and passes with endorsement (the latter indicating suitability for entry into university) will fall away. It will therefore not be possible to say what level of performance in maths or maths literacy will be required for university entrance. The requirements will vary from university to university, and between different courses, as at present.

The change in curriculum will add close to 60 per cent to the mathematical instructional burden at senior secondary level over the next two years

MATHS, MATHS LITERACY AND SCIENCE: THE NEW (2008) CURRICULA[8]

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:

- mathematical process skills, such as making conjectures, proving assertions, and modelling situations;
- confident calculation, with and without calculators;
- manipulation of algebraic expressions;
- financial calculations;
- patterns and transformation of functions;
- two- and three-dimensional geometry and trigonometry;
- basic statistics and probability;
- differential calculus;
- sequences and series;
- solution of unseen mathematical problems;
- historical development of maths in various cultures; 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[9]

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:

Matter and materials (integrated); systems (chemistry); change (chemistry); mechanics (physics); waves, sound and light (physics); and electricity and magnetism (physics).

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The implications of these policy changes are considerable. In 2006, 63 per cent (or 330 513) of SC candidates chose to study maths, whereas virtually 100 per cent will be compelled to study maths or mathematical literacy for the NSC examination in 2008, amounting to more than half a million candidates. In other words, the change in curriculum will add close to 60 per cent to the mathematical instructional burden at senior secondary level over the next two years. Part of the solution may lie in larger maths/maths literacy classes, but the demand for maths teachers will increase significantly. It is unclear how the Department of Education will deal with this dramatic expansion in demand. It is also unclear what the distribution of candidates will be for the NSC between maths and maths literacy. The department reports that there is a 50:50 split in enrolments for maths and maths literacy

in the Grade 11 classes for 2007. However, much can change between enrolment in Grade 11 and completion of the NSC. (While it is not the purpose of this study to dwell on the wisdom and responsibility of changing an already stressed system in such a far-reaching way, the limited attention to the practical consequences of theoretically desirable policy changes is remarkable and worrying.)

The new science curriculum is demanding, and certainly more difficult than current SG science. The Department of Education believes it is at the same level as current HG science. So the new science dispensation may well have the opposite effect to the new maths dispensation: given its difficulty, the total number of learners choosing science as a subject for the NSC may well be smaller than learners currently studying both HG and SG science, and the level of teaching required will be also be higher.

In the course of its research, CDE has discovered considerable anxiety across the school system about the new maths and science curricula. Teachers and officials alike are worried about heavily loaded curricula; the standards for the NSC exams in maths, maths literacy and science; and teacher supply. In support of the new senior secondary curriculum, the Department of Education has developed subject assessment guidelines, learning programme guidelines, and work schedules as a means to assist teachers. The department has also conducted teacher training in new areas of the curriculum. Desirable, but more difficult to achieve, is continuous support for schools by subject advisors.

CDE has discovered considerable anxiety across the school system about the new maths and science curricula

TEACHER CONCERNS ABOUT THE NEW CURRICULUM

Staff at even the best-performing maths and science schools doubt their capacity to cover the new maths and science syllabi. Many schools appear to be opting for only two of the three new papers. The third paper is optional and contains the geometry syllabus, which might result in no geometry being taught to Grade 10–12 learners. Highly qualified teachers with many years of experience report being burnt out by their high workload and increasingly demotivated by administrative burdens, disillusionment with the education authories, poor discipline, and a lack of respect for teachers. They are also concerned about the declining level of education in feeder schools.

CDE 2007

Maths and science in primary schools

In 2000 South Africa participated in an assessment of reading and maths skills at Grade 6 level in countries in southern and East Africa.[10] As regards reading skills, 50 per cent of South African learners were only at Grade 4 level or lower. The corresponding figure for maths was 76 per cent. In two key areas, learners who were about to enter secondary education performed at least three Grade levels below the required standard.

South Africa scored particularly poorly in the Trends in International Maths and Science Studies (TIMSS) conducted in 1999 and 2003. Carried out by the International Association for the Evaluation of Educational Achievement (IEA), TIMMS is aimed at comparing the maths and science achievements of American students to those of students in other countries. TIMSS is conducted at the Grade 4 and 8 level, and data has been collected in 1995, 1999, and 2003. In 2003, South Africa came last of all 45 participating countries, which included five other African countries, namely Botswana, Tunisia, Egypt, Morocco and Ghana.[11] South Africa spends a bigger proportion of its national budget on education

than many of the other participating countries, and the TIMSS outcome therefore clearly illustrates the lower efficiency of the South African system. South Africa has withdrawn from the 2007 TIMSS tests.[12]

Early in 2007, the Department of Education announced that it would conduct a systemic evaluation of literacy and numeracy at Grade 3 and Grade 6 levels. CDE supports standardised testing (since there is no systematic way of assessing achievement without it), and hopes that the results will be put into the public domain for analysis and debate as soon as possible.

There have been many projects – primarily initiated by the private sector – aimed at improving maths, science and language teaching in schools, and many attempts to evaluate them. As part of this study, CDE, the Development Bank of Southern Africa, and a private foundation commissioned research aimed at establishing what could be learnt from some of these projects and their evaluations. This resulted in a review 13 of 20 evaluations of maths, science and language programmes implemented in primary schools between 1998 and 2006.

Teachers commonly fail to complete the curriculum of one Grade before learners are promoted to the next

The review identified the following enduring challenges that emanated from all the research reports about and evaluations of maths and language education:

- **Poor curriculum coverage:** Teachers commonly fail to complete the curriculum of one Grade before learners are promoted to the next. Often, not even half the curriculum is covered.
- **Slow curriculum pacing.** A major reason for teachers' failure to complete curricula is the slow pace of teaching and learning.
- **Failure to proceed to more abstract methods of solving problems.** Learners are often taught 'cumbersome and time-consuming' methods for solving simple problems. Learners at the end of the primary phase commonly try to divide 210 by three by counting out 210 sticks, grouping them in threes, and counting the groups without any knowledge of the relevant division algorithm.
- **Low cognitive demand of lessons:** As many as 90 per cent of maths and language lessons are conducted at lower than the correct Grade level.
- **Lack of conceptual progress in lessons:** Many teachers do not develop concepts or increase the level of demands during a lesson or even an entire school year.
- **Insufficient written work:** One study showed that Grade 10 learners surveyed over a 10-week period had, on average, completed just more than six written tasks.
- **Inadequate reading practice:** Several reports note that learners are not given enough opportunities to read during maths or language lessons. Where reading is taught, learners often chorus-read, and the teachers therefore do not identify weak readers.
- **Lack of feedback to learners:** Teachers often fail to comment on learners' performance. A common misconception is that learners are never wrong, and that they will eventually arrive at their own methods for solving problems through discussion and reflection. Answers are valued irrespective of whether they are correct or not.

As regards teacher development, the study found that:

- Teacher development should be based on a clearly defined set of teaching practices and associated content knowledge that the implementers expect the teachers to acquire.
- Developing teachers' content knowledge should be strongly emphasised.
- Teachers should be provided with clear assessment exemplars in the form of common tests.

The study paints a depressing picture of the impact of many projects. Some have seemingly resulted in major improvements, reflected in pre- and post-project test scores. However, these schools are coming off an extremely low base, and despite these apparent gains many learners still fail to pass Grade-appropriate tests used by evaluators.

The results therefore suggest that the returns on the investments in most of the country's largest intervention projects have been relatively low. It is estimated that three quarters of the country's secondary schools would be amenable only to direct and extensive government intervention,14 rather than smaller programmes funded by the private sector. Both the public and private sectors should be greatly concerned about this.

Teacher supply and demand

Most studies point to an impending shortage of teachers, although its exact magnitude and timing is a matter of debate

There is a lack of detailed data about teachers at South African schools. The data set out in this section has been obtained from a variety of sources, and often reflects different dates. However, an overall picture does emerge.

In 2006, the nine provincial departments of education employed 386 595 teachers; 19 407 of these taught in independent schools. Of teachers in public schools, 173 580 (51,1 per cent) were in primary schools, 111 865 (33,0 per cent) in secondary schools, and 53 988 (15,9 per cent) in combined schools. The teacher-to-learner ratio in public schools was 1:35.2. Two thirds of all teachers were women. In 2005, 53 per cent (186 832) of teachers had four or more years of post-SC training, 38 per cent (132 873) had three years, and 9 per cent (33 640) had less than three years.[15]

The annual attrition rate of teachers is between 5 and 6 per cent (19 000 to 20 000).[16] Two thirds of those who said they wanted to leave teaching were teaching in the technology, natural science, economics or management fields.[17] Teachers, especially those with a science and maths specialisation, are an attractive prospect for the private sector and for many wealthy countries. Adjusting official emigration data using receiving country statistics shows that between 800 and 1 000 teachers emigrated annually from 1999 to 2002, rising to 1 700 in 2003.[18]

Most studies point to an impending shortage of teachers, although its exact magnitude and timing is a matter of debate. There is a lack of fit between demand and supply, with an oversupply in some subject areas and an undersupply in others, and also imbalances in the deployment of teachers. Rural schools are particularly badly affected. Shortages are being experienced in scarce skills areas such as maths, science and technology; languages; arts; economics; and management sciences. Recent developments suggest that the projected shortage of maths teachers has already begun to manifest itself.

The number of student teachers has declined significantly over the past decade, except for 2006 and 2007. Nevertheless, only 6 000 new teachers were expected to graduate at the end of 2006. Our enquiries at universities indicate that there has been a particularly low enrolment of African student teachers (see Table 2). Fewer than 500 of the new teachers will be competent to teach African languages in the foundation phase. A new recruitment campaign by the Department of Education (the Fundza Lushaka Bursary Scheme) will be aimed at (a) learners in Grades 10–12 and school-leavers who have completed SC; (b) mature men and women eligible to enter teacher education and who may be unemployed or working in other occupations; and (c) students enrolled in appropriate degree programmes.

Too little is known about the current supply of qualified and experienced maths teachers

Table 2: Maths and science teaching graduates in 2006

	Maths	Physical science	Maths literacy	Biology
Nelson Mandela Metro University	9	6	13	9
North-West University	50	77		50
Rhodes University	2	4	5	
University of Cape Town	11	2		40*
University of Fort Hare	19**			
University of Johannesburg	8	6		
University of Limpopo	27	23	104	1
University of Pretoria	24	21		
University of Stellenbosch	29	16		
University of the Western Cape	3	2		
University of the Witwatersrand	45***	3		
Total	227	156	121	105

Source: Telephone calls by CDE to university graduate offices, May-June 2007.

** At Cape Town, this figure includes natural science, technology and biology*

*** At Fort Hare, the 19 honours graduates were qualified in both maths and science teaching.*

**** At Wits it was not possible to disaggregate graduates into subjects owing to varying combinations of subjects in different teacher's degrees.*

Earlier this year, CDE asked all the universities in the country how many of their graduates had obtained degrees at end 2006 allowing them to teach maths or physical science (see Table 2). The information received from those that did respond suggests a mean of about 34 maths and/or physical science teaching graduates per university. Extrapolating these figures to another five universities which did not respond suggests that the total number of potential new maths and/or science teachers emerging from the university system at the end of 2006 was about 545. How many of these will actually end up teaching in South African public schools is unknown, but it will certainly be a smaller number than those who had qualified. Some will join independent private schools, some will get non-teaching jobs in the private sector, and some will leave the country.

Data on maths and science teachers can also be found in a sample survey conducted by the Human Sciences Research Council (HSRC) in 2004.[19] Researchers studied 1 766 secondary schools, with 24 200 state-paid teachers. Findings include:

- There were 1 734 teachers trained in maths in the surveyed secondary schools – just under one per school on average, although in practice some schools had more than one and some had none at all. Of those, only 1 362 were actually teaching the subject.
- There were 2 192 teachers in secondary schools trained in science, of whom 1 490 were teaching science (taken to include not only physics and chemistry, but also general science, human and social science, environmental studies, computer studies, maritime studies, life sciences, and agricultural sciences).

The study contains no information about the numbers of teachers teaching maths and science who were not specialists in these fields. A study by the Education Foundation[20] has found that only 70 per cent of teachers teaching maths and science are specialised

in these subjects (ie, have been trained to teach them in at least a SC-plus-three level qualification). At the same time, educators who were qualified to teach maths and science spent only 44 per cent of their time teaching these subjects. This was because of time table problems and schools not allocating enough teaching periods to these subjects. Many maths and science teachers were therefore not efficiently deployed.

Another study of maths teachers in secondary schools in three provinces has found that about seven out of ten qualified maths teachers are actually teaching the subject (66 per cent in Gauteng, 69 per cent in North West, and 74 per cent in the Eastern Cape), pointing to an underutilised reserve of maths teachers in senior secondary schools.[21]

The government's statements about and responses to the supply of teachers are confusing. The Deputy Minister of Education, Enver Surty, alluded to a shortage of qualified maths and science teachers in mid-2004,[22] and again in late 2006.[23] More recently, the director-general of the Department of Education, Duncan Hindle, stated that while teacher bursaries had been reintroduced, 'there is a misconception that there is a shortage of teachers. Strictly speaking, this is not so: there is a shortage of teachers in certain subjects, and in certain parts of the country.'[24] At the time of writing, senior education officials were drawing attention to the fact that the schedule of 'scarce skills' of the Department of Home Affairs allows for the recruitment of 1 000 teachers in maths, science, or design and technology from outside South Africa's borders in 2007.[25] And on 3 August 2007 the Council of Education Ministers approved the recruitment of 1 500 teachers for mathematics and science in 2008.[26] Although the media statement on this is not clear, we assume this to imply at least some recruitment from overseas, although the timing or urgency of this recruitment is also not clear.

The content knowledge of many maths and science teachers is limited, severely so in many cases

The picture that emerges provides grounds for concern that:

- Too little analysis is available about teacher deployment and teacher utilisation.
- Too little analysis is available about the current supply of qualified and experienced maths teachers, their allocation, or the scale of the existing shortage.
- The school system may experience a substantial shortage of maths teachers in particular over the next few years.
- Official thinking on the subject is unclear.
- More analysis and new measures are needed to prevent a shortage of teachers from making the doubling goal impossible to achieve.

The quality of teachers and teaching

There is no system-wide information about the competence (as opposed to the formal qualifications) of maths and science teachers at senior secondary schools. Evidence from primary schools suggests, however, that the content knowledge of many maths and science teachers is limited, severely so in many cases.

In the study of the impact evaluations of educational initiatives referred to earlier,[27] the following common problems in maths, science and language teaching were identified: teacher failure to cover the syllabus; slow pace of learning and teaching; failure to cover abstract problem-solving; low cognitive demand in lessons; lack of conceptual progress; and insufficient written work and practice, with a lack of feedback on this.

As regards the in-service development of teachers, three findings emerged: teacher development should be based on content knowledge and teaching practices; content

knowledge should be more strongly emphasised; and teachers should be provided with examples of tests that could be used to assess learners' progress.

Overall, the evaluations were far from positive, with any progress generally being from a very low base. The evaluations demonstrated that the behavioural and attitudinal changes that occurred after the interventions to upgrade teacher skills did not necessarily lead to improved learning – even when the desired changes in teaching had been achieved. Dr Nick Taylor, chief executive of JET Education Services, has identified the basic reasons for the disappointing impact of these initiatives. Following extensive research, he has concluded that the vast majority (75 per cent) of South African schools are so weakened by a mix of educational backlogs, socioeconomic pressures, a lack of departmental support,

Many projects represented a poor return on the investments made

DO TEACHERS SPEND ENOUGH TIME ON TEACHING?

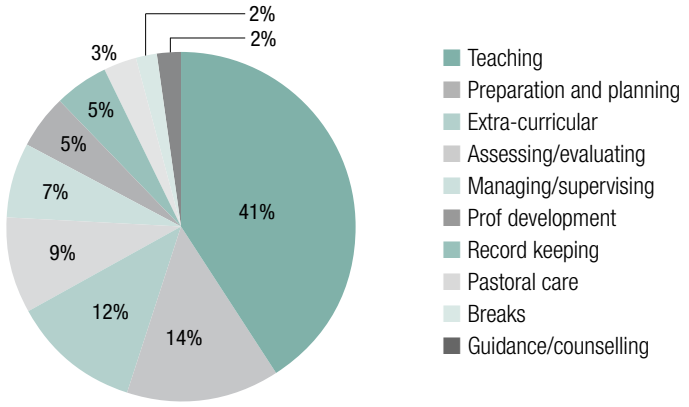
The following points have been drawn from a study commissioned by the Education Labour Relations Council, the primary industrial relations forum of the educational profession, published in 2005.[29]

- Teachers are expected to spend 1 720 hours a year on their various activities. This translates into a 43-hour working week during school terms.30 The formal school day is seven hours long, so educators are expected to work eight hours a week outside the formal school day. On top of that, they are expected to spend 80 hours a year on professional development outside formal school hours. Heads of department and teachers are expected to spend 85 per cent of the school day teaching, and the rest on preparation and planning, assessment, extramural activities, management and supervision, pastoral duties, guidance, and counselling and administration.
- Educators spend an average of 41 hours a week working during school terms. They spend only 41 per cent of this time on teaching, with a further 14 per cent devoted to planning and preparation; 14 per cent to assessment, evaluation, reports and record-keeping; 7 per cent to management and supervision; 5 per cent to professional development; 3 per cent to pastoral care; 2 per cent to guidance and counselling; and 2 per cent to breaks.
- This means that teachers spend an average of 16 hours a week (3,2 hours a day) on teaching out of an expected range of 22,5 to 27,5 hours. Teaching is crowded out by other activities. Hours taught on Fridays are particularly low.
- Conditions vary across schools. One teacher in each of ten schools was closely observed over a period of three days. The total length of the three school days varied from 1 155 minutes (6,4 hours a day) to 1 350 minutes (7,5 hours a day). The amount of time spent on teaching varied from 76 minutes to 708 minutes, with a median of 284 minutes (or 1,6 hours a day). Only four teachers used more than 50 per cent of their allocated instructional time for teaching.
- By contrast, breaks ranged from 16 minutes to 443 minutes, with a median of 173 minutes over three days or an hour a day. On top of that, lesson transition (learners or educators moving between classrooms at the start and end of lessons) ranged from 5 minutes to 151 minutes over three days, with a median of 56 minutes, or 19 minutes a day.
- Instructional time may be eroded because of school level organisational practices, teachers' management of assessment and reporting demands, and disruption of various kinds.
- History matters. Generally, educators in former white schools spent more time on teaching than educators in former African schools and new schools. Moreover, there is less erosion of classroom time in former white schools.

CDE 2007

and limited capacity that they are effectively beyond the reach of external interventions, no matter how well-intentioned or well-conceived these initiatives may be. He concludes that 'add-on' programmes will only make a difference once conditions in schools have been improved by meaningful system-wide reforms.[28] The projects studied represent a poor return on the investments made, and reinforce the need for the careful selection of schools in which to initiate or undertake projects. Data on teacher time on task provides additional grounds for concern (see box, facing page, and Figure 8 below).

Figure 8: Time spent by teachers on different activities



Source: Statistics derived from L Chisholm, U Hoadley, J Kivilu, H Brookes, C Prinsloo, A Kgobe, D Mosia, H Narsee and S Rule, Educator workload in South Africa, Pretoria: Human Sciences Research Council, 2006.

CDE 2007

Proficiency in the language of instruction is therefore the latent third partner in the maths–science nexus

Language

Statistical analysis during the first round of CDE's research pointed to a strong correlation between learners' performance in the language of maths instruction and their performance in maths itself. More detailed analysis in the second round has confirmed this finding.

Specifically, a pass in SC HG maths was associated with a mark of 70 per cent in the language of instruction, written as a second language. Proficiency in the language of instruction is therefore the latent third partner in the maths–science nexus.

Unfortunately, language is a vexed issue. Following the Soweto unrest of 1976, the Education and Training Act of 1979 established the right of parents to have a say in the choice of languages of learning and teaching for their children after the fourth year of schooling. In 1991, the government granted parent bodies the right to choose one of three options:[31]

1) English from Grade 1.
2) A transfer from home language to a first additional language as the language of learning and teaching in Grade 4.
3) A graduated transfer from home language to a first additional language as the language of learning and teaching during the first four years of schooling.

These options still inform much of what happens in South Africa's primary schools. A version of the third option seems to be best, taking into account the research findings[32] which

indicate the social and cognitive benefits for learners of learning in their home language in the early years of schooling and beyond.

Post-apartheid policy encourages schools to promote multilingualism in various ways, including using more than one language of learning and teaching, and the South African Schools Act emphasises the notion of additive multilingualism. Classroom-based research[33] has revealed the following uses of language in maths and science classes with learners whose home languages are neither English nor Afrikaans:

- Textbooks are often written in English and Afrikaans only. So are most curriculum and policy guideline documents, though some are written in learners' home languages.
- However, in the Foundation Phase, all textbooks and all curriculum statements are available in all 11 official languages.
- All forms of assessment are in English, though in some cases learners can respond to examination questions in their home languages.
- Teachers, if they are able to do so, tend to use both the learners' home language and English when teaching these subjects ('code-switching').
- In class discussions, learners tend to use their home language in group discussions, but will usually report back to the whole class in English. They may contribute and answer questions in the home language during whole class discussions.

A long-term programme of bilingual and multilingual maths and science textbooks should be introduced

CDE's commissioned research on the signficance of the language of learning and teaching[34] concludes with the following recommendations:

- The development of African languages should continue, so that they can become languages of learning and teaching in at least the foundation phase. Keeping track of the evolution of these languages is difficult, as is providing them with a maths and science vocabulary.
- Code switching in classrooms needs to be evaluated with a view to making this an effective teaching and learning strategy in multilingual contexts. The findings from such an evaluation need to be incorporated in the formal training of maths and science teachers
- A long-term programme of bilingual and multilingual maths and science textbooks should be introduced.

The real effort to introduce an appropriate language policy must be made at the primary school level. The issues at secondary school level are twofold:

- Maths and science teaching will be undermined if proficiency in the language of instruction is limited to those learners with a different home language.
- If the transition to secondary school involves immersion in a new culture for some learners, they should be given specific assistance to help them cope.

The Dinaledi programme

The Department of Education's premier initiative to improve maths and science results is known as Dinaledi. In 2001, 102 schools from all nine provinces were selected to receive specialised inputs in these subjects. The basic rationale for the initiative was to focus and concentrate resources, increase the participation of disadvantaged learners in maths and science, and introduce innovations in teaching and learning.

In 2006 the Minister of Education announced[35] that the number of Dinaledi schools would be increased to 400, and by August 2007 the number had increased to 490,[36] with a further increase to 529 schools expected at a later stage.[37] The criterion for inclusion was that the schools had to have achieved at least 35 SC maths passes by African candidates, either HG or SG. In Gauteng, the Western Cape and KwaZulu-Natal, some former 'white' schools which meet this criterion are now being included in the Dinaledi programme.[38]

The department is pursuing a target of doubling SC HG maths and science passes by end 2008, compared with those in 2004

In 2007 the department announced that the performance by Dinaledi schools had improved significantly.[39] According to the department's analysis of the 2006 results, Dinaledi schools comprised only 6,5 per cent of all schools, but contributed 34 per cent of African passes in HG maths and 31 per cent in HG science. However, in 2006:

- Only 30 per cent (120) of the 400 Dinaledi schools produced more than ten SC HG maths passes.[40] A further 26 per cent (103) produced between six and ten passes each, and 35 per cent (141) produced between one and five passes each.
- Nine per cent (36) of Dinaledi schools did not produce a single pass in HG maths.
- Only 45 per cent (180) produced more HG maths passes than in 2005.
- Sixteen per cent (65) produced the same number of passes, and 39 per cent (155) produced fewer.

This means that for 220 schools the Dinaledi programme has yet to have a positive impact on results. The department's view is that a longer-term perspective will be needed before Dinaledi can be pronounced a success or failure.

A detailed comparison of Dinaledi schools with schools of different historical origins reveals that former white schools (which no longer serve only white learners) still perform best (77 per cent pass rate for HG maths in 2004), followed by former Asian schools (74 per cent pass rate), and Dinaledi schools (59 per cent pass rate). The pass rate for HG maths in former coloured schools was 33 per cent, and the pass rate in other, mainly former African schools was 15 per cent.

As noted earlier, the Department of Education is pursuing a target of doubling SC HG maths and science passes by end 2008, compared with those in 2004. To achieve this, it aims to increase input into the Dinaledi schools in 11 ways, including better teachers, more learning resources, and improved language capacity.[41] Exactly how many schools in the programme have received any or all of these different inputs and precisely when in the school year is not clear, and a matter of some concern. The department says it is keeping a record of schools which receive any or all of these various inputs. Anecdotal evidence from some high-performing Dinaledi schools suggests that few useful inputs have been received, and that no major changes have occurred at those schools since their inclusion in the programme. The Deputy Minister is encouraging all Dinaledi schools which have not received their package of inputs to contact the department so that the situation can be rectified.

UPDATE ON DINALEDI

In responding to a draft of this report, the Department of Education has provided useful new information about its current administration of the Dinaledi programme. It states that it keeps a record of support received by Dinaledi schools since 2005. This has been in the form of mathematics and physical science textbooks, scientific calculators, and computers in selected schools. The department concurs with CDE that the budget allocated for maths, science and technology is small compared with the needs of Dinaledi schools.

According to the department, the Dinaledi school project now also has a strong monitoring component. The department has assembled a monitoring team comprising senior officials and external members with experience in teaching maths and science, as well as in education research. In 2006 the monitoring team monitored 134 of the then 400 Dinaledi schools. This process allowed for the supply of relevant resources, and ensured that schools at risk could be identified and supported. The external members of the monitoring team have provided the department with an independent perspective on conditions in Dinaledi schools.

The department is encouraging private corporations to adopt Dinaledi schools, and has developed a framework document to guide the process. The department has put great store in this initiative; however, by August 2007 only seven companies had adopted Dinaledi schools.

The department has pointed out that, in terms of the constitutional allocation of powers, the selection of Dinaledi schools is a competence of provincial education departments in collaboration with the national department. It has acknowledged that procedures for adding or excluding schools are not being applied uniformly across provinces. Some provinces have delisted schools that have not significantly improved their output of maths and science learners, whereas others have retained schools with low HG enrolments.

CDE 2007

The precise impact of the Dinaledi programme is difficult to establish

The precise impact of the Dinaledi programme is difficult to establish. Although the number of HG maths passes at Dinaledi schools increased from 3 331 in 2004 to 3 815 in 2005 and 3 909 in 2006, the number of schools in the programme increased from 102 to 400 during this period. Additionally, there are weaknesses which need to be corrected to ensure that the planned outputs of the Dinaledi schools are fully realised.

According to the department, the Dinaledi budget is R4,5 million for the current financial year, and provincial departments have allocated additional funds to Dinaledi schools. However, the state budget for Dinaledi is still inadequate, and few departmental staff are allocated specifically to the programme, and how provinces are dealing with budgetary or staff allocations is unclear. Procedures for adding promising schools or excluding those that fail to perform are not clearly defined, and seem to differ from province to province. The competence levels of teachers in maths and science in each school are not known. Co-ordination of inputs between the department and the private sector is not optimal.

An important new maths and science teacher upgrade programme – aimed at improving their content knowledge – is being piloted in Dinaledi schools. A total of 2 400 teachers (three in maths and three in science) in each of the 400 Dinaledi schools in 2006 is meant to receive training. Teachers are being placed in one of three categories:

- **master trainers**, who are high-performing and successful teachers with at least five years' experience;
- **mentor teachers**, who are well-performing teachers with at least three years' experience; and
- **Teachers in need of upgrade**.

Master trainers are meant to train other teachers, focusing on their content knowledge in particular. Mentor teachers will support teachers in need of upgrade through structured and monitored activities such as group work, workshops, and other collaborative activities. Each teacher being upgraded will be assessed on a portfolio of evidence, examinations, tests and other classroom-based assignments throughout the programme.

By February 2007, 80 master teachers had received further training.[42] The programme in Gauteng has reportedly been delayed owing to lack of budgetary allocations as well as a reluctance among some teachers to accept appointments as master teachers, as this would involve too much additional work over weekends on top of their already heavy teaching loads.[43] However, according to the department, seven maths and six physical sciences teachers attended a master teachers' training session in Gauteng in September 2006.

As noted later, a private foundation[44] is financing a training programme to improve the proficiency of English teachers in four provinces. This was due to be piloted in 20 Dinaledi schools each in Limpopo and KwaZulu-Natal in 2007, and rolled out to Gauteng and the Western Cape in 2008. The department reports that it will also make the resource material available to other Dinaledi schools that are not participating in the programme.

Most HG maths and science passes continue to be produced in historically advantaged schools

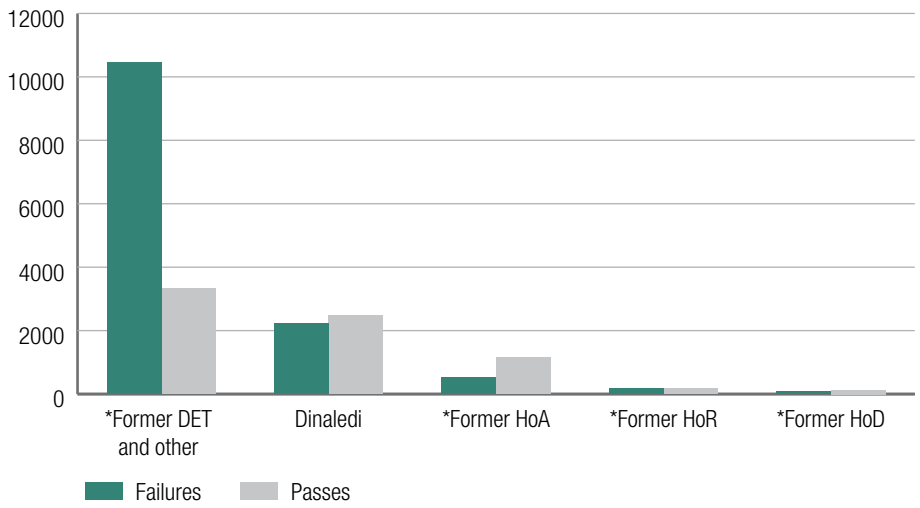
Performing schools at risk

Most HG maths and science passes continue to be produced in historically advantaged schools. In 2004, just 617 (10 per cent) of secondary schools – mainly ex-House of Assembly (HoA) schools – produced 58 per cent of HG maths passes (13 736 candidates, of whom 1 147 were African), and 51 per cent of HG science passes (13 447 candidates, of whom 1 298 were African). If former House of Delegates (HoD) schools are included, these figures rise to 69 per cent of passes (16 269) for HG maths, and 62 per cent of passes (16 313) for HG science. Pass rates among African candidates for HG maths were highest (68 per cent pass rate) in former HoA schools, followed by former HoD schools (59 per cent), Dinaledi schools (53 per cent), former House of Representatives (HoR) schools (49 per cent), and all other schools (24 per cent pass rate).

The image, derived from the apartheid years, of white or Model C (former HoA) schools with airy classrooms, a full range of audio-visual aids, libraries, trees, lush playing fields, and swimming pools coexisting with squalid and overcrowded schools in African townships without electricity, books, or other amenities persists strongly in contemporary South Africa. Disparities certainly continue to exist; it has already been noted that progress in dealing with physical backlogs is unnecessarily slow.

However, learner-to-educator ratios in well-resourced schools have also begun to rise, and, given the post-apartheid pro-poor funding formula, these schools have also experienced a drop in the allocation of recurrent non-teaching funds. In general, and incorrectly, they are regarded as being as affluent as the communities immediately surrounding them, even if they have admitted a large number of learners from poorer communities. In 2004, 19 per cent of SC candidates in ex-HoA and HoD schools were African; the proportion is much higher in some schools, and has certainly grown over the past three years. In 2004, in 74 (12 per cent) of the 617 former HoA schools, 50 per cent or more of SC candidates were African. In a further 16 (3 per cent), between 40 per cent and 50 per cent of candidates were African. The corresponding figures for former HoD schools were 47 (30 per cent) and 16 (10 per cent).

Figure 9: Passes and failures by African learners in SC HG maths, 2004



** Excluding Dinaledi schools in these categories.*
Source: Statistics derived from Department of Education, Senior Certificae Examination Results, 2004.

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Some high-performing maths and science schools are coming under considerable financial pressure

In 2004 the Minister of Education, Naledi Pandor, stated in parliament that schools with poor learners who were unable to pay school fees would be compensated.[45] According to CDE's research, by 2005 this promise had not materialised in any of 12 top-performing schools in Gauteng and Mpumalanga. According to one principal of a township school, the last time he had received compensation for non-fee-paying learners was in 1992.[46]

Some high-performing maths and science schools are coming under considerable financial pressure. It has been pointed out that 'excellent fee-paying state schools occupy a unique, fragile niche in the South African education system. They operate as public–private partnerships. Government puts in teachers' salaries and a subsidy for maintenance. Parents pay for additional teachers, top up salaries above state levels, and cover costs, from textbooks to new buildings.'[47] For many – if not most – such schools, this is a considerable and growing burden.

There are additional sources of stress:

- Secondary schools often experience a considerable inflow into Grade 8 of poorly prepared learners from low-quality primary schools. This either slows down learning in Grade 8, or requires extra catch-up classes.
- Learners from poor communities often have other needs which, if not met, will impact on their learning. Some schools have had to introduce feeding schemes, and some learners have urgent counselling needs.
- Some internal assessment practices mandated by the Department of Education require a significant proportion of teachers' time, and may well fail the Crouch-Patel test of contributing to learning.
- Where the stresses are great, school discipline may deteriorate sharply, with adverse effects on learning outcomes.
- There are unnecessary constraints on what school governing bodies may do.

HIGH-PERFORMING SCHOOLS AT RISK

In 2005, CDE commissioned in-depth research at 12 schools which had achieved high scores in its maths and science performance index for 2004, to document the extent to which their continuing educational success was threatened.

All these schools were found to have appropriately qualified maths and science teachers. However, they had not received any high-quality in-service teacher training from the Department of Education. A few of the teachers had attended courses provided by universities in Johannesburg and Pretoria.

On the basis of interviews with teachers and principals, the schools were categorised as follows:

1. **Good performers, some threatened by textbook shortages**:

   Northcliff High School, Mondeor High School, Hoër Tegniese Skool Witbank, Springs Boys' High School, Kenneth Masekela Secondary School, Hoërskool Randburg, Leshata Secondary School, Thomas Mofolo Secondary School.

2. **Improving performers threatened by poor resources (teaching space, textbooks)**:

   Springs Secondary School, Phillip Ndimande Secondary School.

3. **Good performers threatened by poor discipline, distance from community served, low levels of community involvement**:

   Witbank High School, Waverley Girls' High School.

The research showed that high performance in maths and science can only be maintained if:

- fully qualified maths and science teachers are motivated to remain employed at these schools;
- school principals are trained to manage and maintain strict discipline in their schools;
- the administrative load on teachers is reduced to enable them to spend more time on teaching;
- there are enough classrooms and science laboratories in which teaching can take place;
- each school is provided with a science laboratory assistant;
- schools are provided with sufficient equipment and material for science teaching;
- each school is supplied with sufficient maths and science textbooks for the enrolled learners;
- teachers are provided with regular in-service training, especially on syllabus content; and
- schools are compensated for all learners who are exempted from paying school fees.

CDE 2007

Developed maths and science schools also need to be identified and helped to maintain their high maths and science outputs

Clearly, it would be counterproductive if the good performance of ex-HoA and HoD schools in maths and science were to decline even as performance in the Dinaledi schools improved. Many of them have become so fragile that this is a real possibility.

The key point here is that the Dinaledi programme is too narrow in its selection of schools requiring support. Developed maths and science schools also need to be identified and helped to maintain their high maths and science outputs. Properly handled, these schools can become an increasingly valuable resource for African learners as well as others.

Summary of key findings

1. Having achieved impressive advances in the quantity of education, **South Africa urgently needs to turn attention to its quality**. Nowhere is this more pressing than in maths and science. Low output from secondary education is hindering economic growth and making black economic empowerment goals hard to achieve.

2. **Improvements in quality have to be achieved quickly, and this requires active management of focused initiatives**. Improvements needed to support maths and science education include clearer communication of goals to teachers, large-scale investment in the assessment of learners, highly specific in-service training, development of tightly programmed year-long learning plans, and the timely provision of learning material.

3. **The new NSC**, which will be written for the first time in 2008, **is changing the landscape of senior secondary maths and science**. The requirement that all senior secondary learners study either maths or maths literacy will increase the demand for maths teachers. Close monitoring of outcomes during the first few years of the new system will be essential.

4. **Maths and science teaching in most of South Africa's primary schools is woefully inadequate**. A poor foundation limits what can be achieved in secondary schools. Doubling output is possible by interventions at the secondary level alone, but moving beyond that will require attention to conditions in primary schools.

5. **There is far too little publicly available information on the demand for, supply of, and use of maths and science teachers, but there are grounds for concern that supply constraints could make the doubling goal impossible to achieve**. CDE welcomes the new framework for teacher training. However, skills shortages in both maths and science make it imperative for a proper database of all teachers to be established, together with a plan to meet the demand that will arise with the changes in maths education from 2008 onwards. Placing enough teachers in each of the relevant schools – again starting with Dinaledi – is essential if we are to achieve our doubling ambitions as the first step in wider and deeper system reform.

6. From what we do know about the training of new teachers, and the demand for an increased supply of good and well-qualified maths teachers to improve output from the schooling system, it is quite clear that **South Africa needs to supplement its teaching corps from outside the country**. A plan for the recruitment of teachers from abroad needs to be urgently developed, and discussed with teachers' unions. It must then be implemented speedily and effectively.

7. **Teachers' content knowledge and time on task are also matters of considerable concern**. One of the clear differences between South Africa and countries – often poorer than ours – that are performing better in maths and science concerns the amount of time spent actually teaching the syllabus. The lack of clear guidelines to teachers on what to teach by which quarter of the school year could become a more important and troubling issue with the full-scale introduction of the new curriculum in 2008.

8. **Accountability in the schooling system as a whole is a key missing factor**. It is hard to see significant improvements in quality without the introduction of effective responsibility for results and consequences for a lack of performance by schools or teachers.

9. **Competence in the language of instruction is a key element for success in maths and science**. Therefore, steps should be taken to improve the language competence of maths and science teachers in Dinaledi schools.

10. **The Dinaledi project has a major contribution to make in accelerating improvement in maths and science. However, the project needs more components and substantial development:** a signficant budget, appropriate professional and administrative staff; an expanded definition of how a school qualifies to be part of the programme; a sound and continuously updated database of all schools involved; procedures for adding new schools; and clear rules for excluding schools from the programme if their output of HG maths and science passes does not increase substantially.

11. **The capacity of current high-performing schools to continue producing good maths and science results cannot be taken for granted**. Some of these schools are at risk, and need attention.

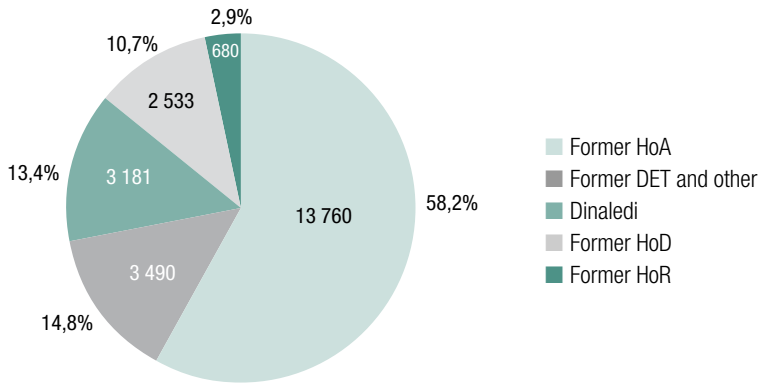
12. **The government and key components of the private sector are still a long way from aligning their efforts in this field**. This results in wastage of resources and a proliferation of initiatives that are too small to have a bearing on the problem. A maths and science education forum involving public and private leaders and implementers could play a vital role in helping the country to focus all its resources to maximum effect. The private sector especially needs to refocus its efforts on changes to the system that can have multiplier effects, rather than single, isolated projects.

13. In all the areas researched it is clear that **ad hoc, stand-alone initiatives will not succeed. Systemic and systematic change is needed**.

14. A number of interlocking factors account for the inadequate output of maths and science output from the senior secondary school system. These range from the need for a greater 'skills agenda' orientation in school education to an insufficient supply of teachers with both high levels of content knowledge and a determination to teach the curriculum fully and well, to the demands of a changing curriculum, and pressures on high-performing schools. The government's Dinaledi programme is a start, but it has weaknesses. The build-up of HG maths passes in them has been slow in relation to the doubling target. In 2004 the Dinaledi schools produced 3 331 HG maths passes, in 2005 they produced 3 815, and in 2006 they produced 3 903. **The current Dinaledi programme alone cannot be expected to produce anything near a doubling of South Africa's HG maths and science passes**.

It is clear that ad hoc, stand-alone initiatives will not succeed. Systemic and systematic change is needed

Figure 10: Distribution of HG maths passes by school type, 2004



Note: Dinaledi schools have been excluded from other categories.
Source: Derived from Department of Education, Senior Certificate Examination Results, 2004.

CDE 2007

‘DOUBLING FOR GROWTH’: CDE’S RECOMMENDATIONS

It is clear there are multiple constraints on improving SC maths and science results, and that only a bold, system-wide, and well-resourced initiative that creates appropriate incentives has a chance of surmounting them. The current Dinaledi programme is too narrowly focused to achieve the results expected of it, and it is very poorly resourced, giving it little capacity to help the targeted schools. It does not provide teachers and schools with adequate incentives, and also does not secure their accountability in turn.

The proposed system would mean that the number of Dinaledi schools would increase threefold over the present level

Until now, well-performing schools have been implicitly divided into two groups:

- former coloured, Asian and white schools; and
- Dinaledi schools, defined as such by the level of African learner performance in maths and science (35 SC passes).

The distinction is becoming increasingly unclear and unhelpful, for the following reasons:

- Changing school demography complicates the situation. Thus some former coloured, Asian and white schools now qualify to be Dinaledi schools since they produce the requisite number of maths and science passes by African learners.
- Some former coloured, Asian and white schools perform poorly in maths and science, and could well help to achieve the doubling target with appropriate inputs.
- Some schools that have performed well historically are at risk of deteriorating, and need attention.
- The increase required for doubling SC maths and science passes in the medium term cannot only come from African learners. Improvements must come from white, coloured and Asian learners as well.

Accordingly, we propose that the Dinaledi system be restructured in the following way.

All senior secondary schools – ie, all schools offering candidates for the SC – should be classified into one of three categories:

- Schools conforming to criteria for high performance in maths and science. All these schools should become **full Dinaledi schools**.
- Schools conforming to the current Dinaledi performance criteria. Some of these schools should be chosen to become **candidate Dinaledi schools**.
- Schools that do not conform to the current Dinaledi criteria. They will be excluded from the Dinaledi programme.

Initially, about 400 candidate Dinaledi schools should be chosen from the second category. As soon as possible thereafter, the number should be increased to 600 by inviting applications from other schools in that category. Over time (say, three years), candidate Dinaledi schools should be required to achieve full Dinaledi status, or move out of the programme. Either development would open up vacancies for new schools to become candidate Dinaledi schools. The proposed system would mean that the number of Dinaledi schools would increase threefold over the present level.

PROPOSED CRITERIA FOR FULL AND CANDIDATE DINALEDI SCHOOLS

As noted in the text, we propose that all schools be grouped into one of three categories in respect of maths and science: full Dinaledi schools; candidate Dinaledi schools; and schools not eligible to participate in the Dinaledi programme. The criteria for selection should be as follows:

Full Dinaledi schools: A minimum of 20 passes in HG maths; 40 passes in HG maths and science, with a minimum of 10 in HG maths; or HG passes by 15 per cent of SC candidates. On the basis of the 2006 results, 570 out of 6 264 secondary schools would qualify to become full Dinaledi schools.

Candidate Dinaledi schools: A minimum of 35 passes in SG and HG maths and science (the present Dinaledi criterion). On the basis of the 2006 SC results, 1 653 secondary schools meet this criterion, while not meeting the criterion for full Dinaledi schools. For capacity reasons, it will not be possible to immediately accommodate all these schools within the candidate Dinaledi programme. We therefore believe the candidate programme should start with the existing Dinaledi schools. Once capacity has been built up, and the programme is running successfully in terms of all the objectives proposed in this report, we believe a window should be opened to receive applications for new membership. As an intermediate but not initial goal, we recommend that the number of candidate Dinaledi schools be fixed at 600.

If these criteria are adopted, 1 170 schools (570 full Dinaledi schools and 600 candidate Dinaledi schools, or 19 per cent of all secondary schools) would participate in developing the Dinaledi programme.

CDE 2007

'Doubling for Growth' should be a national project, with its own budget and staff

The proposed criteria for qualifying as a full or candidate Dinaledi school – and the number of schools that would qualify if these criteria are adopted– are set out in the box above.

This system would require considerable administrative capacity and funding. Minimally funded or staffed gestures will not work.

CDE therefore proposes a package of recommendations that will – in time – achieve the national goal of doubling SC HG maths and science passes. 'Doubling for Growth' should be a national project, with its own budget and staff, and sufficient autonomy to run an effective national programme.

The doubling programme would be only the first step in changing the nature and quality of our schooling system. The sooner we take this step, the sooner we will be able to move on to another doubling, and then to reforming other aspects of the system that desperately need attention. More detailed recommendations follow below.

1. Teachers

In recent years, there may have been enough or even a small surplus of teachers with specialised maths and science qualifications, but not all such teachers are suitable for producing SC HG maths and science passes, and not all of them are teaching these subjects. Moreover, the new senior secondary curriculum will greatly increase the demand for maths teachers. Therefore, we urgently need an audit of maths, science and language teachers in all schools essential to reaching the doubling goal.

At the very least, maths and science teachers should be able to pass a HG SC paper in their subject with very high marks, and upgrade their skills to cope with the new NSC curriculum.

Heads of department should have several years' experience of successful teaching. Maths and science teachers who cannot meet these criteria should be deployed on tasks other than teaching maths and science in Grades 10, 11 and 12.

Provincial departments of education need to have information about the effectiveness of maths and science teachers in senior secondary schools, and need to have a diagnostic system so that they can offer support to teachers who need it. Given the lack of such information, it is impossible to tell for certain how much poor content knowledge among senior secondary teachers contributes to poor learner performance. We do have evidence that this is a serious problem in primary schools. In subjects where logical structure is paramount, the problem is likely to be acute in the majority of secondary schools. We cannot achieve our doubling goal or adequately assist Dinaledi schools without much more information on the capabilities of our maths and science teachers. This problem has recently been successfully tackled in Peru (see box below).

Provincial departments of education need to have information about the effectiveness of maths and science teachers in senior secondary schools

TESTING TEACHERS' COMPETENCE IN PERU[48]

Peru has done relatively well at getting children into school: more than 90 per cent of children complete primary schooling, and two thirds complete secondary schooling, a better record than in richer Argentina and Mexico. The problem is that Peruvians do not learn much in the classroom. In a 43-country international test in 2000, Peru came last, well behind even the other Latin American participants.

In December 2006 the education ministry announced that all teachers would have to take a proficiency exam. Union leaders, most of whom belong to radical Marxist parties, had long rejected teacher evaluation. They got hold of the exam paper and posted it on their website. According to the minister of education, José Chang, this was 'the most serious mistake' in the union's history, resulting in the public losing 'what little confidence it still had in the union'.

The ministry rewrote the exam paper and required the country's 250 000 teachers to complete it in January 2007. Four out of five of them did, in defiance of the union's boycott. Almost half of those who sat for the exam were unable to solve elementary maths questions, and a third failed a reading comprehension test.

CDE 2007

The Department of Education began implementing a new framework for teacher training in 2006. The preferred qualification for all teachers is a four-year Bachelor of Education degree, followed by a one-year post-graduate diploma – also after other approved first degrees. A new three-year diploma is being considered. Conversion programmes enabling serving teachers to move into scarce learning areas, subjects or phases (groups of grades) will be offered.

CDE welcomes this new framework. However, contrary to the official preference for the four-year Bachelor of Education degree, we believe senior secondary teachers in maths and science should have a degree with relevant major(s) plus a year's post-graduate training in order to gain a proper grasp of subject content.

The Department of Education has allocated R220 million to a four-year incentive programme to improve the skills of maths, science and technology teachers in Dinaledi

schools.[49] Teachers will be trained and mentored, and assessed via examinations, tests, and classroom-based assignments. Teachers, mentors and master teachers are given cash incentives to participate. While there seems to be some delay in rolling it out, CDE also welcomes this programme.

Continuous modelling of the supply of maths and science teachers is required. This in turn requires a database of teachers, containing information on the schools in which they are working, the levels at which they are employed, how they are being utilised, their qualifications and training, where they qualified, and where they were first employed. Some, but not all, of this information is collected in the Annual Schools Survey. All this will help the education authorities to identify current and future shortages.

The Department of Education should produce a concrete plan for massively increasing the supply and effective allocation of maths and science teachers to senior secondary schools

The supply of maths and science teachers is under considerable and growing pressure. There is an existing and generally acknowledged shortage of effective maths and science teachers, and the new NSC curricula in maths and mathematical literacy in particular will require far more teachers. A high proportion of existing teachers will find it even more difficult to teach the new maths curriculum, and, according to our research, the vast majority have not received any or adequate training to do so despite the fact that the new curriculum has already been introduced in Grades 10 and 11. Moreover, the proposed expansion of the Dinaledi programme will place even greater demands on the quantity and quality of maths and science teachers.

Both the department's framework for teacher training as well as the government's Joint Initiative on Priority Skills Acquisition (JIPSA) identify shortages of maths and science teachers as obstacles to improving South Africa's pool of skilled people, but the government had still not produced a practical plan, with concrete targets and deadlines, outlining how the country intends to eliminate this shortage.

The Department of Education should produce and make public a concrete plan with clear goals and time frames for massively increasing the supply and effective allocation of maths and science teachers to senior secondary schools.

Every effort should be made to train more maths and science teachers, and retrain existing ones, but this will take time. What should we do in the meantime? The optimal response is to acknowledge that we need to import some maths and science teachers. It is perfectly feasible to do this. Botswana has successfully imported Indian maths and science teachers. CDE and the Department of Education already have evidence of excellent pass rates (97–100 per cent) in SC HG maths achieved by two schools in Limpopo in 2006 where Indian teachers have been employed. And there is anecdotal evidence of increasing numbers of qualified Zimbabwean teachers filtering into South African schools. As noted earlier, the quota system for foreign skills of the Department of Home Affairs provides for the recruitment of 1 000 foreign teachers in 2007, but none have been recruited thus far.

Our research shows clearly that South African teachers spend far too little time actually teaching their subjects. In many schools, this is caused by a lack of basic organisation, and the situation could be significantly improved if periods were clearly demarcated, announced by a bell, and teachers were required to be in front of their classes for all the assigned lessons. It is also evident that extra-curricular activities such as sport and choir festivals impinge on teaching time instead of being attended to outside teaching hours. Moreover, an elaborate assessment system is occupying teachers during teaching hours. The appropriate norms are clear enough, but they need to be enforced. No school that

does not observe these principles can hope to become a high-performing maths and science school.

An adequate supply of good teachers is a *sine qua non* for reaching the doubling goal. Without an audit of existing teachers, we cannot tell how many effective teachers we have, how many we need, how many we need to upgrade, and how many we need to import, and by when.

MATHS AND SCIENCE TEACHERS: CO-OPERATION WITH INDIA?

In 2006 the governments of India and South Africa signed a memorandum of understanding on co-operation in the fields of governance, administration and other areas. It is valid for three years, and will be automatically renewed for a further three years unless either government specifically wants to terminate it. Among other things, the memorandum envisages the secondment of public officials of one country to the other, and mentorship and exchange programmes to facilitate skills transfers.

In the education sector, numerous areas of co-operation have been identified. These include field visits to education districts in South Africa by a joint team of Indian and South African officials to scope the skills requirements and gaps. The Indian government will also help to develop a framework for evaluating South African maths and science teachers, in order to identify the gaps and the training programmes needed to address them. It will also help the South African education authorities to evaluate their maths and science curricula. This framework could be extended to bring Indian teachers to South Africa on a short-term or longer-term basis. Other government departments such as Home Affairs, Labour and Foreign Affairs will need to be involved in this initiative.

The key is to act urgently, and as a first step take advantage of the pre-approved work permits for foreign maths and science teachers. What progress if any has been made in this area since the signing of the memorandum is hard to ascertain. Every year that we delay affects the number of learners who could be getting a decent maths education, and thus the platform for a range of new opportunities for them and their families

CDE 2007

Language development, career guidance, cultural support and – where necessary – boarding facilities should also be provided

2. Identifying learner talent across the country

The Dinaledi strategy is important but not sufficient for achieving the doubling goal. It needs to be complemented by identifying good maths and science learners in schools that are ill-equipped to develop these aptitudes, and are not part of the Dinaledi programme. In terms of our proposals, more than 80 per cent of secondary schools (about 5 000) would not qualify for full or candidate Dinaledi status, and most of them would probably not become Dinaledi schools in the near future. In these schools, fewer than one per cent of SC candidates pass SC HG maths.

We therefore repeat our call for a national voluntary aptitude test at the end of Grade 7 so that all learners with an aptitude for science and maths can be identified and placed in appropriate schools. Every learner and every parent should know that there are effective avenues for identifying and developing an aptitude for maths and science. Such a system will not only improve the maths pass rate, but will also expand the pool of potential passes. Without such a scheme it is hard to see how we will achieve our doubling goal, and especially how we will ensure that more and more Africans achieve the standard of maths, science and language they need to gain university admission.

CDE's research shows that developing these learners will require more than just a change of school. Language development, career guidance, cultural support and – where necessary – boarding facilities should also be provided. The experiences of Sekolo sa Borokgo, LEAP, and the Alexandra Education Committee confirm the importance of these add-ons (see box, next page). The challenge will be how to replicate such initiatives on a much larger scale throughout the country.

At the end of Grade 7, all learners who wish to do so should undergo a maths aptitude test, aimed at identifying those capable of passing NSC maths. A suitable benchmark score should be established, and a register kept of those who reach or surpass it. While any Grade 7 learner should be able to take the test, the learners at whom it is aimed are those with a reasonable chance of achieving the benchmark score and who may need assistance in gaining access to good maths tuition at the secondary level. Any learner on the register should be able to obtain, if he or she needs it:

At the end of Grade 7, all learners should have the opportunity to take a maths aptitude test, aimed at identifying those capable of passing NSC maths

- assistance with placement at a school producing HG maths passes or their equivalent under the NSC;
- boarding fees or an allowance for subsistence and accommodation at or near such a school, if the learner cannot live at home;
- a travel allowance, if the learner has to commute to the school; and
- assistance with other needs essential to successful secondary school study.

Such a system would be difficult to administer, and take time to establish. It would have to be well-resourced, and taken to scale within five years.

An aptitude test plus bursary scheme would have several desirable incentive effects. It would be to the credit of primary schools if their Grade 7 learners performed well in the aptitude test, and some additional coaching of promising learners by those schools might result. Moreover, bursaries would heighten competition to gain admission to full Dinaledi schools. Communities that have traditionally supplied these schools with learners might well, as a defensive measure, encourage those learners to increase their efforts in primary schools. Other secondary schools might also be motivated to improve their efforts and thereby qualify as Dinaledi schools.

These learners should be transferred at the end of Grade 7, so that they have a full opportunity to catch up and participate fully in the school in which they are placed. However, under certain circumstances such learners might be transferred successfully at later stages as well.

(In responding to this report, the department stated that it intended to introduce a system for assessing the literary and numeracy of all learners in Grades 3 and 6, starting in 2007. This is meant to provide a basis for strengthening their numeracy and reading and writing skills.)

3. Language

English is the chosen language of learning and teaching at the majority of secondary schools attended by African learners. This reflects the social and economic power of English and the aspirations of school communities rather than the language proficiency of learners. Such learners generally have little exposure to English outside the classroom, apart from television. Many do not achieve the threshold level of English language profi-

The transition from SC to the NSC will move the goalposts in senior secondary maths and science

SUCCESSFUL INITIATIVES FOR TALENTED LEARNERS

Placing talented learners in enabling contexts is having good results. Three examples follow:

Sekolo sa Borokgo, an independent school in Johannesburg, raises bursaries for talented learners, mainly black, from township or rural schools. It specialises in English first language, maths and science. It achieved a 96,2 per cent pass rate in the 2006 SC exams. Teachers attribute this success rate to seven 40-minute periods a week for both maths and science, including a double period for each; daily homework checked at the start of each lesson; a culture of discipline and accountability; and the creation of awareness of career opportunities. Non-bursary holders pay R600 a month for 10 months, and R700 a year for textbooks.

LEAP school in Cape Town teaches learners identified mainly by teachers at schools in Langa and other townships. They are initially identified for possible selection on the basis of energy and enthusiasm, rather than past academic achievements. They are invited to a winter camp where, through participation in a variety of activities, they are assessed on the basis of factors such as their educational foundations and their ability to co-operate in group settings. LEAP learners pay an annual school fee of R200, which is paid over to his/her school of origin. Eighty learners are admitted each year, 40 from three primary schools and 40 from two secondary schools. LEAP learners are given access to facilities and resources at Diocesan College (Bishops). Ten of the 15 SC candidates in 2004 (LEAP's first year) were placed in tertiary institutions. The school day is long and intensive; learners are helped to catch up on basic numeracy, and are given strong emotional support and life orientation lessons.

The **Alexandra Education Committee** in Johannesburg funds bursaries enabling primary school learners to attend high-performing secondary schools. In 2006, most of the 130 bursary holders attended Highlands North Boys' High School or Waverley Girls' High School. The bursaries cover school fees, transport, uniforms, textbooks, stationery, and lunch for those who need it. Bursars are selected on the basis of tests in English language competence, learning skills, maths, and an interview. Potential bursary holders attend a Saturday school during Grade 7 for an hour of English and an hour of maths. In 2005 all the bursary holders passed their SC exams, half with endorsement. In 2004 and 2005, 36 per cent of candidates studied HG maths, and 80 per cent passed; 54 per cent studied HG science, and 100 per cent passed.

The challenge is how to implement these sorts of initiatives at significant scale so as to make a real numerical impact on the schooling system.

CDE 2007

ciency to engage effectively with learning across the curriculum, and particularly in maths and science.

A new pilot programme funded by the Zenex Foundation and supported by the Department of Education will offer a two-year training course in language teaching to 80 selected Dinaledi schools spread across four provinces (20 schools per province). The programme began in KwaZulu-Natal and Limpopo in 2007, and is meant to start in Gauteng and Western Cape schools in 2008.[51] It will provide teachers with a highly structured learning programme for Grades 10 and 11. The programme will emphasise reading and writing in the classroom, with time set aside for independent reading. The subject content will include a theoretical understanding of second language learning, a basic overview of grammar and how it works, knowledge of literature genres, and knowledge of how to write in them.

Training programmes such as these are essential for complementing the training of maths and science teachers. It should be accompanied by incentives similar to those in the

maths and science teacher training programme. The 2007–8 programme in the first two provinces should be carefully evaluated from the outset, and if it proves to be successful it should be rolled out to all other Dinaledi schools (and then others) as soon as possible.

4. The transition from Senior Certificate to National Senior Certificate

The transition from the SC to the NSC will move the goalposts in senior secondary maths and science, and it will be important to relate them to one another so that progress towards the doubling target can be measured.

It may be that a pass in SC HG maths will be equivalent to a mark of 40 per cent or better in NSC maths, and that a pass in SC HG science will be equivalent to a mark of 40 per cent in NSC science. Umalusi – the body that moderates the SC – should pay special attention to this issue when it moderates the results of the first NSC exam in 2008. The Department of Education reports that discussions between it and Umalusi on this topic are under way.

Besides this, the department should communicate more effectively with secondary schools and the public about the new NSC exams in maths and science. Such communication should cover the numbers of learners studying each subject in Grades 10, 11 and 12, the lessons learnt from the standardised testing of senior secondary learners, the format of the NSC examinations, and the importance of maths to those wishing to enter higher education. This would alleviate unnecessary anxiety, and would give the department an opportunity to spell out its goals and strategies to schools, learners and parents. Universities and technikons should simultaneously publicise their entry requirements under the new NSC.

The department reports that the implementation of the National Curriculum Statement has required it to communicate regularly with schools and other stakeholders to ensure a common understanding of the new curriculum. It has done so by means of circulars, interprovincial meetings, and communication with professional associations such as the South African Principals' Association and the School Governing Bodies Association. The department has developed exemplar examination papers for Grade 10 in 2006 and Grade 11 in 2007. Grade 12 exemplars will be available for schools in the fourth quarter of 2007.

Schools and teachers are concerned and uncertain about the new curriculum. Issues include the length of the new syllabus, competence to teach all its aspects, and the lack of guidance about which parts of the curriculum to emphasise or leave out if need arises. The department may need to stipulate which parts of the syllabus should be completed at what stages in the school year. It reports that it is aware of some of these concerns. In response, it has developed appropriate supporting documents to guide teachers, including work schedules and subject assessment guidelines. These documents are intended to provide clarity and bring stability to curriculum implementation.

5. Schools and a new 'school contract'

If the 'Doubling for Growth' project is to succeed, all the key participants need to be clear on their roles and responsibilities and the resources available to them for meeting their targets. Each Dinaledi school should enter into a contract with the education authorities which spells out its rights and duties in relation to the programme. These contracts should

Each Dinaledi school should enter into a contract with the education authorities which spells out its rights and duties in relation to the Dinaledi programme

clarify the school's entitlements and obligations, spell out annual targets, and also spell out the accountability of each party in respect of reaching these goals.

For the amended Dinaledi scheme to work, there are two overriding prerequisites:

- schools need to want to become and remain Dinaledi schools; and
- the government needs to introduce and maintain an effective programme of support and communication with all role players.

The government needs to introduce and maintain an effective programme of support and communication with all role players

Dinaledi school entitlements

Full or candidate Dinaledi schools should be entitled to the following support:

- An assessment of school infrastructure affecting the teaching of maths and science, with a construction programme designed to bring facilities up to an adequate level within two years.
- An immediate assessment of teaching capacities, with a teacher upgrade programme (where necessary or desirable), and a reassessment at the end of it.
- An assessment of teachers of the language of instruction, with a teacher upgrade programme (where necessary or desirable), and reassessment at the end of it.
- The immediate employment of at least two maths and two science teachers with proven content knowledge and teaching experience, and assistance with rapid recruitment when vacancies occur.
- The timely provision of consumables and durables essential to the teaching of maths and science, eg textbooks, calculators, and chemicals.
- A training programme for school governing boards in the objectives of the Dinaledi programme, and how they could help to achieve them.
- A training programme for teacher counsellors aimed at enabling them to provide learners studying maths and science with information about the career opportunities open to them, and encouraging all learners with the necessary ability to study maths and science.

(The department has indicated that it is already implementing some of these items to varying degrees.)

Dinaledi school obligations

The obligations of full or candidate Dinaledi schools should be:

- To agree on and review annually with the department targets for enrolments in maths and science in Grades 10, 11 and 12, as well as targets for SC results – ie, outputs. This should take the form of a contract between the school and the department which embodies the obligations, entitlements, and rules of participation associated with Dinaledi membership.
- To participate in an immediate maths, science and language teacher audit and to deploy only teachers of proven ability in teaching these subjects in the senior secondary phase.
- To participate in a support programme if targets are not achieved. Poor performance after the support programme will lead to being dropped from the Dinaledi programme.
- To provide counselling for learners deciding on their SC subjects.
- To provide at least 20 per cent more teaching time in maths, science and language of instruction than the minima set out in departmental policies.

And additionally, for full Dinaledi schools:

- To accept learners talented in maths who would not otherwise go to a Dinaledi school, and support them with any supplementary tuition they may need. An additional contract should be signed specifying the sources of funds for subsistence, accommodation, transport, and special support teaching.
- To share their resources and expertise with neighbouring schools which are either candidate Dinaledi schools or not yet part of the Dinaledi project.

Well-resourced Dinaledi schools will require little from the Dinaledi budget. They may need no infrastructure or teacher upgrades. And what they do require would be justified by the 'Doubling for Growth' objective. Moreover, they would incur the full set of obligations. Less well-resourced schools are likely to need better infrastructure, more teacher training, and a greater supply of durables.

Lastly, good performance should be recognised (see box below).

Effective implementation of the Dinaledi project will require far more state capacity than exists at the moment

REWARDING PERFORMANCE

At present, schools which achieve more than 100 SC HG maths passes a year are recognised as members of the '100 Club' established by the Minister of Education in 2006, and each 100 Club school is provided with a R50 000 reward.[52] Consideration should also be given to the formation of a '50-plus Club' for schools that produce between 50 and 99 HG maths passes, and also to a 'High Pass Club' for schools in which HG maths passes exceed 30 per cent of all candidates but which do not qualify for the 100 or 50 clubs.

On the basis of the 2006 SC results, 12 schools would qualify for the 100 Club, 91 schools for a 50 Club, and 94 schools for a High Pass Club.

The four schools with the highest number of SC HG maths passes in 2006 were all in the Pretoria/Tshwane area; they were Hoërskool Waterkloof (196 passes), Pretoria Boys' High School (173); Hoërskool Eldoraigne (121); and Hoërskool Garsfontein (117). The fifth was Stellenberg High School (114) in the Western Cape. Previously disadvantaged schools which achieved close to a 100 per cent pass rate of more than 20 candidates were Makgetse High School in North West, Nyanga Senior Secondary School in the Eastern Cape, and Khanyisa High School in Limpopo.

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6. New capacity in the Department of Education

Effective implementation of the Dinaledi project will require far more state capacity than exists at the moment. This will have to be divided appropriately between the national and provincial departments, and should include:

- The appointment of a chief executive officer or director for the doubling project, including Dinaledi. The appointee should be a very senior person, experienced in running largescale programmes, and should be subject to stringent performance requirements.
- The establishment of comprehensive, detailed, and transparent national and provincial Dinaledi budgets.
- Officials who will be able to inform each school about exactly what it can expect and who will be responsible to ensure that they get it; and who will be in a position to fast-

track all senior appointments (principals, deputies, and maths and science teachers) for Dinaledi schools.
- Staffing up with senior people with experience in running large projects.
- Immediately engaging in the crucial process of negotiating and signing contracts with Dinaledi schools. This is the key communication and accountability step in the project, and will lay the foundation for the effective implementation of the entire programme.
- The creation of a maths and science 'hotline', whose functions should include:
  - enabling schools to rapidly locate new teachers, and import them from other countries where necessary;
  - the recruitment of new principals;
  - a support service to principals to deal with issues such as the delivery of textbooks or calculators, and the payment of fees for needy learners; and
  - the needs of bursary holders, including information about where to take the aptitude test and when it will be conducted.

  For such a 'hotline' to work well, it will have to operate in terms of strict standards. For example, any query should be answered within 24 hours, and results achieved within five working days.
- The expansion of the already existing departmental database of Dinaledi schools (full and candidate), to deal with infrastructure; the employment of teachers in maths, science, and the language of instruction; assessment and training; consumable and durable supplies; learner enrolments for maths and science in Grades 10, 11 and 12; past SC results; and agreements about targets. If kept up to date, the accumulating information could be expected to yield an early warning when targets are in danger.
- The ability to provide information from the database.
- The development and administration of an annual aptitude test available at centres across the country in order to locate talented learners, and awarding and administering bursaries for such learners to attend high-performing maths and science schools.
- Effective communication nationally about the importance of doubling maths and science output and the way in which this doubling project will be implemented; and what various groups – parents, learners, teachers, school managements and governing boards, and national and provincial officials – can do to help reach this goal.
- An annual progress report to parliament.
- An ability to engage strategically with private funders and NGOs, and to participate effectively in the proposed Maths and Science Education Forum (see below).

For such a 'hotline' to work well, it will have to operate in terms of strict standards

7. State funding

In order to improve the quantity and quality of maths and science passes along the lines discussed thus far, more state funding will be needed, and funding priorities changed. At least the following will require funding:

In each Dinaledi school (full and candidate)

- Bringing infrastructure and equipment up to the standards required for effective maths and science teaching
- Ensuring that a full complement of maths, science and language teachers is maintained. This should include a set of procedures for the rapid recruitment of foreign teachers.
- Training school management and school governing boards in effective participation in the Dinaledi programme, including reporting of needs and progress.

FUNDING CDE'S RECOMMENDATIONS: THE DETAILS

The state education budget has three components: the capital budget, the salaries and wages budget, and the non-personnel recurrent budget. These funds flow from the national department to the provinces, in line with the allocations of educational functions set out in the constitution.

A study completed more than a decade ago by the Urban Foundation concluded that there was virtually no correlation between need and the national and provincial schools capital programme. Despite three rounds of the School Register of Needs, there are no indications that this situation has improved significantly since then. The Department of Education should provide clear guidelines for minimum acceptable infrastructure in schools, and start a programme to eliminate those deficits where they exist, starting with Dinaledi schools, going on to other secondary schools, and then to primary schools. This would require an increase in school capital expenditure for a few years, but in a context where the government intends to spend more than R400 billion on infrastructure in a short period, this is eminently feasible. The constraint is not money, but the ability to design and implement such a programme.

Our proposals have no implications for the overall salaries and wages budget. The introduction of compulsory maths/maths literacy means there is a need for more maths teachers, but this will be accompanied by a need for fewer teachers in other subjects. (As maths or maths literacy is now compulsory, they will necessarily crowd out other subjects, and the department should monitor the implications of this for teacher deployment.) If Dinaledi schools are to succeed, their teaching complements will have to be closely monitored, and gaps filled quickly.

The non-personnel recurrent budget is allocated according to a pro-poor formula. This should be left alone. Two additional expenditure items should be created. The first should be a fund to finance augmented capacity at the national and provincial level and to provide a rapid response to Dinaledi school needs.

The second should finance an annual voluntary national test to be taken in the last quarter of Grade 7 by learners with an aptitude for maths and science. High-scoring learners not otherwise able to go on to a developed or a Dinaledi school should then be considered for bursaries to enable them to do so. A bursary fund should be created to cover school fees, board and lodging (where necessary), learner support material, and uniforms. Within five years, the need may rise to 12 000 new bursaries a year. Assuming a linear rise from 2 000 bursaries in the first year, this would imply 35 000 bursaries in year five. At an average cost of R20 000, this would imply a commitment of R700 million in that year, and R1,2 billion once the system has been working for a number of years.

Bursary awards	
Year 1	2 000
Year 2	4 500
Year 3	7 000
Year 4	9 500
Year 5	12 000
Total (Years 1 to 5)	35 000

All bursary holders will still be in the system in year five.

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Nationally

- A special fund to run nationwide aptitude tests for learners (particularly in areas where there are few if any good maths and science schools), provide bursaries for high-potential learners to full Dinaledi schools, and also provide the support programmes such bursary holders will need to succeed.
- A national audit of South Africa's teaching capacity in maths and science.
- A programme for importing qualified and experienced teachers from India and elsewhere, to supplement the local corps of maths and science teachers.
- An effective national ' hotline' for schools participating in the doubling project.

The most important element likely to slow down economic growth is the absence of high-level skills

8. The private sector

The government has indicated the importance of maths and science for the Accelerated and Shared Growth Initiative for South Africa (AsgiSA) and JIPSA initiatives. It has correctly recognised improving our performance in these areas as essential to achieving higher levels of shared economic growth.

The private sector has a close interest in improving maths and science education. The most important element likely to slow down economic growth is the absence of high-level skills. In a modern, technology-based economy, many of the high-level skills in the private sector are based on maths or science, as well as associated language skills. The private sector could hardly have a more direct interest in funding initiatives outside its own business operations.

In April 2006 the Minister of Education convened a meeting of private sector representatives and other stakeholders to inform them about the government's maths and science initiatives, and ask them for their support. Such support is starting to pick up, but the department hopes for a greater effort by the private sector. In CDE's view, the condition for greater support is a clear definition of appropriate roles and contributions. Since the Minister and department are open to private–public partnerships to an unprecedented degree, this is an appropriate time to forge such strategic partnerships (see box, facing page).

This is not to say that the private sector is not already involved in improving maths and science education. CDE has identified scores of national, regional and local private sector initiatives and, literally, hundreds of projects. However (as shown by extensive research for the 2004 report, and repeated in the research for the present one), it is clear that business and donor funding of maths and science education programmes has hitherto not had a significant impact on the education system as a whole. The independent assessment (mentioned earlier in this report) of the impact of 23 of the largest programmes[53] found that despite some changes in management and classroom practices in the schools concerned, very few of the interventions had a lasting impact on the quality of the schooling system, or on school performance in maths and science.

In order to maximise the return on its investment, the private sector should now focus on improving the entire system rather than engaging in small-scale, low-impact interventions which are often unsustainable and operate in isolation from other initiatives. Successful experimentation with innovative systematic programmes is likely to motivate policy changes aimed at achieving significant increases in the numbers of HG passes in maths and science.

QUESTIONS THE PRIVATE SECTOR SHOULD ASK ABOUT ANY PROPOSED INITIATIVE IN MATHS AND SCIENCE EDUCATION

The big questions

1. Where do you want South Africa's maths, science and language teaching to be in five to ten years' time? What can your companies' (limited) resources do to help the country get there?
2. What should the government do to fund maths and science schooling? Within this framework, how can private funds help to make a difference?
3. How can private money play a catalytic role in improving South Africa's maths and science schooling system?
4. How can private money play a 'risk or venture capital' role? In other words, how can private money be used to test new ways of doing things?
5. Will your proposal help the 'Doubling for Growth' initiative? And if so, in what way exactly?

More detailed questions

6. Do we know the facts about the SC maths and science output of the relevant schools?
7. Are the relevant schools Dinaledi schools? If so, what support have they received from the government under the Dinaledi programme? Do they have adequately staffed maths and science departments? Are there serious infrastructural deficits? More generally, is the government discharging its responsibilities adequately, or is it not? If not, is it reasonable that the private sector should discharge them instead?
8. If the schools are not Dinaledi schools, is there a chance of success?
9. Is the region in question growing economically? This will improve incentives for better supply of secondary education and for better demand among learners as they come to understand that new opportunities await them.
10. Is the school in question small or big, growing or declining ? In a country experiencing rapid urbanisation, this is a vital issue.
11. Is there an opportunity for an innovative experiment which may lead the way towards better techniques of education? And if the private sector funds it, will the state take it to scale?
12. Does the intervention include an assessment of its effects?
13. Will the project impact on systemic change?

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The private sector should now focus on improving the entire system rather than engaging in small-scale, low-impact interventions

Specifically, private companies, foundations and collective business organisations should consider the findings of this report and its implications for current expenditure on maths and science schooling projects. They should particularly think seriously about moving away from the following:

- Undifferentiated interventions in maths and science teaching in particular schools or groups of schools. These have not been very successful because too many conditions, such as school management, quality of teachers, or socioeconomic circumstances are uncontrolled. Selecting the right schools is vital – a factor which is often overlooked. Focusing on need alone without taking capacity into account will only result in wasted effort.

- Piecemeal donations of science equipment and other hardware to particular schools or groups of schools, unless these are Dinaledi schools and unless there is good reason why private and not state resources should be mobilised for this purpose.
- Bursary schemes, unless the bursaries are (a) awarded strictly on the basis of maths and science talent, (b) awarded on the basis of need, (c) are for places in Dinaledi schools, and (d) provide for the integration of learners in their new schools, including provision for catch-up in maths, science, and language of instruction.

Rather, new private sector and donor funding should encompass the following initiatives:

The composition of the forum should be negotiated by key public and private interests

A maths and science forum

- The creation of a forum on maths and science education (see recommendation 9 below, and CDE's 2004 recommendations). Doubling maths and science passes will be difficult, and the country and public and private sectors need to:
  - learn as we move deeper into this new initiative; and
  - share insights and experiences across the country.
- 'Doubling for Growth' is a national objective, and the forum can help to ensure that this challenging but vital set of objectives involves interests and capacities across South African society, public and private, not only an already stretched Department of Education.
- The composition of this forum should be negotiated by key public and private interests. The key is to make it focused and effective. It should not be a decision-making body or a negotiating forum, but a place for sharing insights about obstacles encountered and progress made.
- It should have a secretariat, funded and staffed by the private sector. The forum's roles could include integrating public, private and international initiatives to improve the maths and science output of the schooling system and increase the numbers of qualified maths and science educators; developing the aptitude test to identify learners with potential; provide schools with incentives to participate in maths and science programmes; and monitor and evaluate all the initiatives needed to double HG maths and science output.

Other initiatives

Under the rubric of this forum and the public–private partnership it embodies, the private sector could additionally provide resources for:

- Improving and analysing the quantitative database of all developments in maths and science education at the secondary school level. It is such additional (and expensive) analysis that has enabled CDE to provide the detailed school-by-school information that has not been available before.
- Regional pilots of the aptitude test to be voluntarily taken by learners at the end of Grade 7, following which learners with high potential would be selected to attend Dinaledi or private schools. The private sector could initially provide bursaries to learners selected through the standardised tests, and supply resources to schools that accept these additional students. Private sector funding should be supplemented by the current allocation to each learner in a state school, which should 'follow the learner' to a good school. The aim is to make this programme a national initiative. Ideally, it should be funded by the state as part of its education budget. We are proposing that initially – if necessary – private sector funding could kick-start a demonstration

project, which if successful needs to be taken up by the national department and taken to scale.
- A 'learning by doing' monitoring and evaluation of the Dinaledi programme and associated initiatives aimed at improving the output of the schooling system with respect to maths and science.
- Funding very specific capital development in the interests of maths and science education, such as building new hostels to enable full Dinaledi schools to accommodate learners with bursaries.
- Providing full Dinaledi schools with funding to help them share their resources and expertise with candidate or aspirant candidate Dinaledi schools. or assisting cities or towns which want support to implement locally based 'Doubling for Growth' coalitions of schools, companies, and local governments (see later).
- Recognising performance by providing awards for schools which perform well in maths and science, as has already been done by one large corporation.
- Encouraging innovation and encouraging private schools to share their resources with other, less well-endowed schools.
- Other initiatives to be identified by the forum.

The country can learn a great deal about how to achieve its doubling objective by breaking down the national target into local or regional doubling targets

NEW PRIVATE SECTOR INITIATIVE

A major South African corporation has established two new trusts aimed at improving the pass rates in maths and science in South African schools.

Founded by Anglo American South Africa, but independently managed, the Epoch and Optima Trusts will disburse about R40 million a year for this purpose for three to five years.

Their managers hope to support as many as 50 public schools each year that show creative and effective ways of sustaining and improving good performance in HG maths. The schools themselves will identify the form of assistance which they believe will have the greatest impact on their individual circumstances.

The formation of the trusts was announced in March this year. At the time, Cynthia Carroll, chief executive of Anglo American PLC, was quoted as saying that the country's weak maths and science results 'may be the single most constraining factor on its long-term economic growth prospects'.

CDE 2007

9. Pilot projects and regional experiments

The 'Doubling for Growth' initiative can usefully experiment with mobilising energy, capacity and commitment outside the traditional parts of the schooling system.

On the basis of our regional research in three different parts of South Africa, urban and rural, we suggest that:

- The country can learn a great deal about how to achieve its doubling objective by breaking down the national target into local or regional doubling targets, and mobilising local communities to play a greater role in achieving results.
- Achieving the doubling target is not just a job for the Department of Education alone. Many other stakeholders can be enrolled to help it and the country achieve the results we need. Regional programmes can be an effective way of doing this.

- Regional experiments could be an ideal area for private sector funding. However, this has to be done on the following terms:
  - It needs to be part of a positive public–private partnership to test a decentralised approach that mobilises local communities and stakeholders.
  - The experiments need to be designed in such a way that proper monitoring and evaluation of the regional initiative can help the country learn by doing, and spread the ideas and lessons from these experiments to other communities.
  - Private funding must involve a commitment from the state that if these experiments are useful, government funding will be available to implement them at scale.

Our studies in Kimberley and Springs suggest the potential for innovative local initiatives for doubling the maths and science HG pass rates. There are encouraging opportunities for the formation of public–private partnerships to achieve and exceed this goal in local areas.

In Kimberley, we detected an enthusiastic response to a suggestion about the establishment of a city-wide forum

Regional initiatives can create the networks for co-operation among schools and for the identification of learners with aptitude. They can also provide a defined arena on which to focus attention, and speed up the doubling process.

Kimberley

Kimberley is the provincial capital of the Northern Cape and is situated in the Frances Baard District Municipality, 472 kilometres south west of Johannesburg.

Total population	324 814	**Language**			
African	196 591	Setswana			142 171
Coloured	88 054	Afrikaans			137 936
White	38 373	isiXhosa			17 005
Indian/Asian	1 796	English			16 088
Total labour force	79 340	**Institutions being attended by 4–24 year olds**			
Employed	46 412	None	24 479	Pre-school	2 902
Unemployed	32 928	School	50 536	College	1 392
Not economically active	54 218	Technikons	392	University	181
		Adult education	95	Other	151

Source: Statistics South Africa. http://www.statssa.gov.za

In Kimberley, we detected an enthusiastic response to a suggestion that local role players should establish a forum for co-ordinating efforts to improve the quality of maths and science education, and increase the number of SC HG maths and science passes.[54] Accordingly, we propose that a Science and Maths Education Committee of Kimberley (SMECK) be established. It should be independent of the regional educational bureaucracy and the political pressures that affect government structures. SMECK should comprise representatives of local business, the Northern Cape Department of Education, the National Institute for Higher Education (NIHE), the Sol Plaatje Local Municipal Council, local government, and current and potential funders and employers of maths and science graduates.

SMECK should be tasked initially with an analysis of the maths and science performance of Kimberley's 19 secondary schools over the past five years. On the basis of recent enrolment and success in maths and science, four schools could be categorised as top performers (Hoërskool Noord-Kaap, Hoërskool Diamantveld, Kimberley Girls High and Hoër Tegniese Skool Kimberley). The others are performing poorly, even in SG maths, and interventions will have to be carefully tailored and sustained if they are to have a lasting effect.

Categorisation will assist in determining the best options for intervention and investment. Details of all past and existing interventions or initiatives in maths and science education should then be compiled. Thereafter, SMECK should liaise with stakeholders about all existing and proposed initiatives and interventions. These should include teacher development, career counselling, and the identification and placing of talented learners in schools with the capacity to develop these talents.

The ongoing functions of the committee should include:

- co-ordinating the implementation of initiatives to eliminate duplication or contradiction;
- identifying the most appropriate initiatives for each stakeholder;
- monitoring and evaluating the progress and effectiveness of initiatives;
- identifying and receiving requests from potential beneficiaries for assistance;
- playing an advocacy role to promote maths and science;
- identifying and advertising opportunities to work and study in fields involving maths and science, including bursaries, learnerships, and job opportunities; and
- spearheading a 'grow your own timber' campaign for Kimberley that will identify, support, and facilitate the training and later employment of talented and motivated learners in maths and science.

In Springs, private and government stakeholders are unanimous in recognising the need and potential for intervention and innovation to increase the pass rates in HG maths and science

Municipal service centres and a 'maths café' could be utilised to distribute information about careers that make use of the subject. Information or puzzles (such as Sudoku) could be made available to generate interest. Businesses could help to produce and distribute information about careers, learnerships, bursaries and job opportunities. Local media can showcase role models, and promote general interest in maths and science. Local branches of national maths and science teacher organisations can help teachers act as resources for one another's development, with assistance and support from the NIHE, the Northern Cape Department of Education, teacher unions, and NGOs.

Springs

Ekurhuleni is one the country's major metropolitan areas, situated immediately east of Johannesburg. It comprises several sizeable towns, including Springs, on its eastern periphery.

Total population			2 480 260	**Language**			
African	1 891 452	Asian	39 664	isiZulu	754 411	Sesotho	278 398
White	482 080	Coloured	67 064	Afrikaans	321 103	English	277 950
				Sepedi	282 641	isiXhosa	213 389
				Institutions being attended by 4–24 year olds			
Total labour force			127 7059	None	299 982	Pre-school	33 177
Employed			761 048	School	495 459	College	22 568
Unemployed			516 011	Technikons	7 923	University	10 002
Not economically active			514 444	Adult education	1 956	Other	2 194

Source: Statistics South Africa. http://www.statssa.gov.za

Private and government stakeholders in Springs interviewed by CDE researchers are unanimous in recognising the need and potential for intervention and innovation to increase the pass rates in HG maths and science.[55] Building on this, we propose a practical programme to improve maths and science performance in Springs schools by (i) building on the potential within the school system, and (ii) increasing the involvement of the

private sector and NGOs in school education. The specific objectives of the programme should be to:

- respond to the external environment by changing negative perceptions of maths and science and of teaching as a career;
- address the poor management and administration of schools by means of greater involvement by school governing bodies and the local business community;
- improve the English language skills and subject knowledge maths and science teachers;
- advocate a higher level of participation in maths and science by promoting awareness of the importance of these subjects for learner's future careers, assessing learners for maths and science talent, providing bursaries to high-performing schools, and rewarding good performance; and
- offer homework support facilities at schools.

At poorly performing schools, the emphasis should be on changing negative perceptions of maths and science

The programme should initially run over five years and could be co-ordinated by an office located in the Gauteng Department of Education, with the active participation of the Springs Chamber of Commerce. A steering committee could determine priorities, and ensure implementation. Monitoring and evaluating the programme would be essential in order to ensure its optimal implementation, and allow its course to be modified when necessary.

Private sector funders could be encouraged to shift their support to the programme. This would entail:

- Institutional support for a public–private partnership to double the number of HG maths and science passes over five years.
- Support to individual schools that are performing well and/or improving, or to schools aspiring to join the specialised maths and science programme.
- Support for a teacher development programme based on credible international models.
- Support for programmes to identify learners with maths and science potential by means of an assessment in Grade 7.
- Financial support for learners with potential to travel to or board at high-performing maths and science schools.
- Provision of financial and other incentives to the best-performing teachers and learners.
- Financial support for maintaining and updating the CDE database of individual and school performance with respect to maths and science, as a tool for monitoring progress.

If a school decides to participate in the programme, it should identify a 'champion' to represent it on the steering committee. Differential implementation of the programme at each category of schools will be required. On the basis of recent SC maths and science participation and results, the 14 secondary schools in Springs are categorised as:

- **High-performing schools** (20 or more candidates and a pass rate > 80%): Hoërskool Johan Jurgens, Springs Boys High School, Springs Girls High School.
- **Schools with potential** (fewer than 20 candidates and a pass rate > 60%): Kenneth Masekela Secondary School, Laban Motlhabi Comprehensive School, Phulong Secondary School, Springs Muslim School, Springs Secondary School, Tlakula Secondary School, Zimisele Secondary School.

- **Poorly performing schools** (fewer than 20 candidates and a pass rate < 60%): Eureka High School, Hoër Tegniese Skool Springs, Lefa-Ifa Secondary School, Nkumbulo Secondary School.

At poorly performing schools, the emphasis should be on changing negative perceptions of maths and science; identifying learners with potential, and transferring them to better schools; and upgrading these schools to the 'schools with potential' category if sufficient improvement occurs.

At schools with potential, maths and science prefects should be appointed to assist with classes, serve as role models, and engage with Ekurhuleni East Technical College to include maths and science teachers in the college's 'success workshops'. Representatives of local business communities could address Grade 9 learners about their subject choices. Other steps could include the reduction of additional maths and science classes as existing lesson periods become properly utilised; the recruitment of student teachers to provide assistance as part of their community service; the organisation of school maths and science competitions; afternoon homework sessions at school; the provision of bursaries for maths and science teaching candidates by local business; rewards for top maths and science students; and management training for principals.

The forum should have a relationship with ASGISA and JIPSA, but should be a distinct, more specialist operation

At high-performing schools, the programme should emphasise partnerships with schools with potential (exchanges of teachers, learners and resources); maths and science competitions; and the rewarding of top-performing learners and teachers.

As the Kimberley and Springs case studies show, local communities will organise and interact in different ways to achieve the doubling goal, and this will make it possible to test a range of approaches, partnerships and initiatives so as to see what works best in which circumstances.

10. The Maths and Science Education Forum

In 2004, CDE recommended the creation of a national task force with responsibility for the whole system of maths, science, and language education. More recent consultation indicates that a forum for maths and science education would be a more appropriate institutional format. Different levels of government (national and provincial), business, and NGOs could participate in the forum. Its key function would be the exchange of information, insights and debate, in the interests of doubling maths and science output at the SC level. The forum would need a secretariat to organise meetings and act as a repository of information, a role which CDE is willing to play. It should play an important role in monitoring and evaluation, which should take place primarily at the national level. Analytical work already done by CDE can be fed into the process. The forum should have a relationship with AsgiSA and JIPSA, but should be a distinct, more specialist operation.

An essential part of a programme leading to sustained improvement in maths and science schooling is monitoring and evaluation, and this should be reported on regularly to the forum. Monitoring refers to the collection of information and its recording in an intelligible and consistent framework. Evaluation refers to an analysis of the information collected with a view to answering policy and implementation questions.

All schools should be eligible for Dinaledi membership

INFORMATION NEEDED BY THE PROPOSED FORUM

Data on individual performance by SC candidates. This information usually becomes available some months after each examination, and is available to a restricted range of users.

- Data on standardised tests in maths and science in Grades 10, 11 and 12 in Dinaledi schools.
- The collection of such data has begun, but is not far advanced. Neither these data nor analysis derived from them is generally available.
- Data on physical infrastructure, resources and support material for maths and science, teachers and learners in Dinaledi schools. Questionnaires collecting this information have been circulated, but it is not known whether the information has been collated and analysed.
- Data collected from provincial education departments, district offices, school principals and teachers in terms of the National Strategy for Learner Attainment. Again, questionnaires collecting this information have been circulated, but it is not known whether the information has been collated and analysed.
- Data on teachers, linked to schools. When CDE sought this information, it was available for only three provinces.
- In the first instance, it is the responsibility of the Department of Education to collate and analyse this information. The department should use outside consultants if this is necessary for timely and thorough analysis. The results of analysis should be widely and effectively communicated among all parties concerned with the doubling of maths and science output.

CDE 2007

The full forum should meet perhaps twice a year, with participation at the highest levels from the public and private sector. Technical committees and task groups could then work on selected problems on a more continuous basis, and report back to the forum as appropriate.

Summary of recommendations

A summary follows of CDE's recommendations for achieving the proposed 'Doubling for Growth' target – ie, doubling the number of SC HG maths and science passes as soon as possible.

Doubling maths and science output for economic growth

- All schools should be eligible for Dinaledi membership. Dinaledi schools should be divided into full and candidate members. Criteria for full membership should be 20 HG maths passes; 40 HG maths and science passes, with a minimum of ten HG maths passes; or HG maths passes by 15 per cent of all SC candidates. The criterion for becoming a candidate Dinaledi school should be a minimum of 35 passes in SG and HG maths and science (the present Dinaledi criterion). Initially, 600 candidate Dinaledi schools should be chosen. Over time, they should either become full Dinaledi schools or leave the programme, making space for others. Similarly, full Dinaledi schools should move out the programme if they do not maintain their results over a reasonable period.

Teachers

- The supply of maths and science teachers should be continuously monitored and modelled.
- A plan to supply teachers for the introduction of compulsory maths or maths literacy in the new NSC is needed.
- Teacher upgrades, which pay particular attention to content knowledge, should be expedited. This must be coupled with assessments of teacher knowledge.
- An energetic campaign to recruit a large number of qualified teachers from India and elsewhere should be launched. The national maths and science teacher audit which should be undertaken simultaneously will provide guidelines on how best to allocate teachers for the 2008 school year.
- Ways must be found of dramatically increasing teacher time on teaching task.
- The accountability of schools and teachers must be greatly strengthened.

Ways must be found of dramatically increasing teacher time on teaching task

Identifying learner talent

- At the end of Grade 7, all learners should be invited to write a test for measuring their aptitude in maths. Those with potential to achieve a SC HG maths pass should be helped to gain access to secondary schools where their aptitude can be developed effectively.
- Such learners should be placed at a good maths school, provided with boarding fees or an allowance for subsistence and accommodation if necessary, a travel allowance if necessary, and assistance with other essential needs. This will include effective counselling on adapting to a new and often different environment.

Language

- Since proficiency in the language of instruction is key to success in maths and science, attention should be paid to upgrading the relevant language teachers in at least all Dinaledi schools.

The transition to the NSC

- Ways must be found of comparing performances in the current SG and HG maths and science SC exams to the new maths, maths literacy, and science NSC exams.
- The Department of Education needs to improve its communication with various role players in maths and science education on progress made in teaching and examining the new curriculum.

Schools and the school contract

- The education authorities and Dinaledi schools should enter into contracts that spell out the rights and duties of each party in respect of the Dinaledi programme.
- Priority should be given to ensuring that Dinaledi schools have the infrastructure, teachers, equipment and consumables needed for the effective teaching of maths, science and the language of instruction. Capacity should be created at the national and provincial levels to give effect to this priority.

- Teachers, school managers, and school governing bodies should be trained to ensure that (a) teachers have adequate content knowledge; (b) they fully understand the requirements of the new NSC curriculum; and (c) school managers and governing bodies understand the maths and science doubling objective, and know how to participate fully in the Dinaledi programme.
- In return for more tangible benefits under the programme, Dinaledi schools should (a) commit themselves to achieving certain performance targets, and report regularly on progress made towards achieving them; (b) counsel learners so that all those capable of taking maths (rather than maths literacy) are strongly encouraged to do so; and (c), in the case of full Dinaledi schools, accept a negotiated number of talented learners from other areas into Grade 8 (and possibly other Grades).

The private sector should not attempt to perform the functions of the state

State capacity

- State capacity should be radically increased, thus enabling it to efficiently run the Dinaledi programme. This capacity should include the ability to respond speedily to school needs, especially in respect of teachers, infrastructure, equipment and consumables, as well as the needs of bursary holders. The Department of Education must establish and maintain a database of Dinaledi schools. It must be able to administer an aptitude test for talented learners across the country, and administer a bursary programme for them.

State funding

- State funding will need to be reallocated or increased in order to support the doubling programme.
- This should include the Dinaledi programme which needs a proper budget and staff to ensure that Dinaledi schools have the teachers, infrastructure, textbooks, calculators, and other items they need to deliver the required results.
- The state should provide funding for upgrading school infrastructure needed for maths and science teaching.
- It should establish a special fund to fund nationwide aptitude tests for learners in Grade 7, and provide bursaries for high-potential learners identified in tests, thus enabling them to attend Dinaledi schools.

The private sector

- The private sector should participate in and help fund the proposed Maths and Science Education Forum, including a secretariat which would maintain and update a database on maths and science in secondary schools, and keep abreast of all monitoring and evaluation of policy changes.
- The private sector should take the lead in regional experiments in the upgrading of maths and science. Identified opportunities exist in Kimberley and Springs.
- The private sector should not attempt to perform the functions of the state. Rather, private sector actors should ask themselves a series of questions designed to test whether their initiatives are appropriate.

Concluding remarks

The target of achieving 50 000 HG maths passes (or their equivalent under the new curriculum) a year needs to be achieved as quickly as possible. It can be done if all learners who are capable of passing HG maths or the new mathematics examination enter for it (see box below).

THE DEMANDS OF DOUBLING

Doubling will not be easy, The following table uses HG maths passes in the 2006 SC exam as a basis for setting performance goals for various proposed categories of schools. These goals are demanding and will need to be addressed on an incremental basis; therefore, they exceed the first round of targets which should be set.

Category	Number	2006	Target
Full Dinaledi			
Top	197	9 360	9 850
Other	373	7 817	13 055
Candidate Dinaledi	600		10 500
Other eligible schools	1 053	6 182	7 371
Non-eligible schools	4 041	2 269	2 269
Bursary students			8 000
Total	6 264	25 628	51 045

Note: Top schools achieve at least 50 SC HG maths passes, or 30 per cent of all candidates achieve HG maths passes.

The goal has been set at 50 passes per school for top schools, 35 per school for other full Dinaledi schools, 17.5 per school for candidate Dinaledi schools, seven per school for non-Dinaledi schools that qualify for candidate status, and static for non-Dinaledi schools that do not qualify for candidate status. It has been assumed that 80 per cent of bursary holders will pass HG maths. These bursary holders would be additional learners at full Dinaledi schools who will need additional support to help them make the transition, and do as well as they can.

CDE 2007

Achieving these goals will require a broad-based initiative involving substantially more state funding

Achieving these goals will require a broad-based initiative involving substantially more state funding. Important though these contributions may be, it will not suffice for the public sector to concentrate solely or mainly on the current Dinaledi approach, or for the private sector to focus on the existing mix of projects and the Independent Schools Association of Southern Africa's bursary scheme. On present form, we are likely – at best – to achieve 30 000 HG maths passes out of the target of 50 000 set by the Department of Education for 2008. What is required is:

- An overall strategy with clear and achievable targets, and commensurate budgets and experienced management.
- A mechanism – our proposed forum – where the combined interests and expertise of public and private sectors can be brought to bear.

There is widespread agreement that we urgently need to double the HG maths and science output from our schools. However, experience with Dinaledi since its establishment in

2001 and the fact that, from 2005 to 2006, the HG maths output dropped instead of increasing shows just how complex this challenge is, and how difficult it will be to achieve this goal. We believe it will require a ring-fenced project with its own budget and staff; a package of defined interventions at different levels; excellent communication of the doubling project; a clear, well-communicated system of ongoing inclusion in the Dinaledi project; and a mechanism of accountability that will define the criteria for the exclusion of schools from the Dinaledi programme because of a lack of performance. CDE believes that:

- **We have to look across the whole school system to achieve the doubling target**, and we propose a system of categorising schools for inclusion in the Dinaledi project that can make a contribution.
- **We have to expand the pool of potential SC HG maths candidates** by looking outside the current performing and Dinaledi schools. We propose the use of aptitude assessments in order to identify learners with the talent and potential to perform well in maths and science.
- **We have to have effective teachers operating in functioning schools to make this all happen**. At present we don't know which maths teachers can actually teach maths. Formal qualifications are far from being an infallible guide. Endless upgrading programmes are not working, and given past experience there is no reason to expect that they will work in the future. We have to find a way of testing the current teacher corps so as to assess exactly where we have maths teaching skills, and where these need to be supplemented. A possible first step is to say that this is a prerequisite for becoming a Dinaledi school. The benefits of becoming a Dinaledi school and a maths teacher in such a school must function as an incentive to push for an effective testing process in these schools at least. It is only on this basis that we will know how many Dinaledi schools have two excellent maths teachers, and how many do not. Once we know, remedial remedies for the school and the teachers can begin. The school must immediately acquire the maths teaching expertise it needs, if necessary (which is more than likely) from a programme of importing maths and science and language teachers. The teachers who are not up to scratch can be counselled and, depending on their results, either sent on training courses, redeployed to another subject or level of teaching and perhaps another school, or taken out of teaching altogether.

We have to expand the pool of potential SC HG maths candidates by looking outside the current performing and Dinaledi schools

To reach the doubling target within a few years will be difficult. This is demonstrated by the government's experience with Dinaledi since 2001. The target of doubling can only be met if all the role players and experts in the public and private sectors pull together, and we propose a national forum to facilitate this.

Most important, we strongly recommend that 'Doubling for Growth' becomes a self-standing national project with increased power and responsibility for its implementation at the national level. In order to run such a large multi-million rand and complex programme of innovation, intervention and monitoring it is essential that executive capacity with extensive management experience is appointed to head this programme. We are attracted to the effectiveness – universally acknowledged – and operational autonomy of the South African Revenue Service as a model for serious consideration by the Minister of Education.

Our contribution is to place a package of concrete and achievable suggestions on the table. Meeting the goal of doubling the number of matriculants achieving the required standards in maths, science and language is essential for many other national goals. This could be a platform for a dramatic increase in the number of African graduates with the

skills to participate in BEE, play larger roles in the South African economy, and strengthen the capacity of the South African state. What could be more important at this stage of our development?

We recognise that most primary and secondary schools need attention. Therefore, we need to point out that our proposals are meant to be a first step in a much broader and longer-term process. It may seem unfair to start with maths and science and language at secondary schools, but this is the most practical starting point, and will rapidly benefit national economic growth and South African society more generally. If we can achieve results in this area, we can start to build the capacity to move deeper into the schooling system as a whole.

CDE believes that improving maths and science in senior secondary schools presents a unique opportunity to influence the whole education system. The scale of the intervention is large enough to make a real difference in several ways, but small enough to be understood by all stakeholders, the implementation closely monitored, and the results visible to all. About 1 200 schools should be directly affected. Yet the impact on economic reality, the lives of many young people, and the morale of all those participating will be enormous, if the programme succeeds.

Improving maths and science in senior secondary schools presents a unique opportunity to influence the whole education system

There will, of course, be difficulties in implementation, and some tough negotiations with stakeholders not immediately convinced of the value of the programme, such as teachers' unions over assessments of current capacity and the recruiting of teachers abroad.

Nevertheless, CDE firmly believes that its research, the attitudes of scores of stakeholders interviewed, the willingness of the private sector to get involved, and the stand taken by the Minister of Education point to the success of a bold and co-ordinated programme to improve the quantity and quality of maths and science education.

CDE calls on all concerned parties to give immediate and earnest attention to this report.

Appendix A

Research reports commissioned by CDE

Du Toit, Jacques & Willi Faling, Practical programme to double the number of Senior Certificate Maths and Science passes in Springs over the next five years, 2006.

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Taylor, Nick, Doubling the output of Higher Grade maths matriculants in public schools: a framework, 2006.

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Webb, Paul and Viv England, Practical programme to double the number of Senior Certificate maths and science passes in O R Tambo District (Eastern Cape) over the following five year period, 2006.

Zietsman-Thomas, Aletta, Jim Thomas and Lydia Ntepe, Excellence in maths and science education at 12 top schools in Gauteng and Mpumalanga, 2006.

Appendix B

CDE's 2004 recommendations, and the response

RECOMMENDATION	IMPLEMENTATION
1. Double the number of SC HG maths and science passes within five years.	'These [education policy changes] include eliminating fees for the poorest quintile of primary schools, targeting 529 schools to double the Maths and Science graduate output to 50 000 by 2008, and re-equipping and financing the Further Education and Training Colleges.' – President Thabo Mbeki, State of the Nation Address, Joint Sitting of Parliament, 3 February 2006
2. Mobilise the concerns of important stakeholders in maths and science education into a national programme. National and provincial government, the private sector, foreign governments and donor bodies, international agencies, the independent schooling system, tertiary education, the scientific research community, educators, learners and parents should all be involved in the development of a systematic, country-wide initiative aimed at ensuring a common understanding of the nature of the challenge we face and mobilising commitment to a common strategic set of interventions.	No systematic mobilisation of concerns among stakeholders has occurred. Business and other donors are being asked to contribute to the needs of schools included in the Dinaledi programme. Meetings in April and October 2006[56] were presented with a list of particular needs, including 'adopting' schools in order to promote accountability.
3. Increase the supply of qualified maths and science educators. All educators qualified to teach maths and science but who are employed to teach other subjects should be persuaded and allocated to teach maths and science. This should be complemented by a distinctive programme to attract new and retain existing maths and science educators by means of private sector-funded or other incentives. All maths and science educators should be provided with steady incremental in-service training on content knowledge and teaching skills, using the expertise available in tertiary institutions.	Bursaries have been offered to teaching students in Limpopo. The Minister of Education has encouraged non-practising maths and science teachers to re-enter the profession, and the department is offering incentives of R20 000 to teachers who complete a comprehensive course on syllabus content.[58] The 2007 education budget contains R700 million for bursaries for student teachers over the next three years; the first R120 million has been allocated to the Fundza Lushaka bursary programme, and will fund the studies of 3 000 student teachers.[59]
4. Build on the potential in the school system. The role of all high-performing maths and science schools should be expanded to accommodate additional talented learners either in situ or in their neighbourhood. These schools should be provided with programmes to improve school management, language and maths and science subject content knowledge, linked to incentives.	The Minister of Education has appointed a ministerial committee to study 'schools that work'. It has been tasked with conducting research in successful secondary schools in order to determine which factors enable some schools to achieve good results in the SC examinations while others in seemingly similar circumstances do not.[60]

RECOMMENDATION	IMPLEMENTATION
5. 'No child left behind': Provide mechanisms for learners and parents, wherever they live, to take advantage of new educational opportunities. Stimulate greater demand by parents, learners, educators and principals for quality maths and science education. There should be an annual national maths and science aptitude test for Grade 9 learners, success in which makes a learner eligible for financial support to attend a high-performing maths and science school. It should be implemented experimentally to streamline its effectiveness and optimise private sector and other resources.	Nil
6. All maths and science education initiatives should include language components. All maths and science educational activities should be closely linked with improved language education, especially English, given the nature of global economic development. The approach and steps required should be developed by a National Task Force (see recommendation 10).	Pilot programme initiated and funded by a private foundation, and implemented with departmental support.
7. The Dinaledi programme should be reconceptualised, restructured and expanded.	The number of schools increased from 102 to 400 in 2006 and 490 in 2007, with 27 from the first phase having been removed from the programme. Selection criteria were changed for Dinaledi II.
8. Review all other educational policies for their effect on maths and science. Maths and science schooling is the top educational priority. Where general education policies and financing priorities are (unintentionally) having a negative impact on maths and science education, these should be modified.	Nil
9. The private sector and NGOs should review the support they have given to maths and science education at secondary and tertiary education levels, with a view to achieving greater synergy in their own efforts and between their efforts and other stakeholders with the proposed new national thrust. The private sector should shift its focus from small-scale research and programme implementation to institutional support for a new public–private partnership to double the number of HG passes in five years. Support should be targeted at individual schools that are performing well or improving; an educator development programme based on credible international models; assessments of Grade 9 learners for maths and science aptitude; financial support for learners with potential who need to travel to or board at well-performing maths and science schools; financial and other incentives to the best performing educators and learners; financial support for maintaining and updating the CDE database on individual and school performance in maths and science as a tool for monitoring progress; and extension of corporate bursary programmes with a tighter focus on potential maths and science educators.	This is being increasingly encouraged by the Department of Education and bodies such as the Independent Schools Association of SA. A few leading companies have started to reassess their support in this field.

RECOMMENDATION	IMPLEMENTATION
10. International aid agencies and foreign national donors should forge links with a new national initiative, and develop synergies between themselves and other stakeholders in the effective use of resources. Since 1994, the financial contributions to South African education by international aid agencies and foreign national donors have far exceeded those of local businesses and other donors. The continued support of these foreign agencies will be essential for the success of any maths and science programme. We believe this is a good moment for international aid agencies and foreign national donors to commit additional resources and target their support at the proposed national initiative and integrated programme of action.	Not known.
11. The Cabinet should establish a National Task Force as the vehicle to focus and direct a national partnership to change maths and science schooling dramatically. A public-private partnership in the form of a National Task Force (NTF) will facilitate greater focus than would the sum of its components. A broadly based institution with responsibility for the whole system of maths, science, and language education would harmonise and amplify interventions. It would have two primary goals: • Doubling the number of school-leavers with a higher Grade pass in maths, physical science, or both within 5 years; AND • Doubling the number of adequately qualified and trained educators in these subjects within the same period.	Nil

Endnotes

1 For example, there are acute shortages of suitable candidates for engineering and accountancy qualifications. In March 2007, only 3,1 per cent of the 25 902 members of the SA Institute of Chartered Accountants were African, and only 8 per cent of the 1 674 passes in the SAICA public practice exam were achieved by Africans. Chantyl Mulder (SAICA) reports difficulty in finding sufficient African recipients for its Thuthuka bursary programme for undergraduate study in accountancy. Personal communication, 11 July 2007.

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CDE believes that improving maths and science in senior secondary schools presents a unique opportunity to influence the whole education system. The scale of the intervention is large enough to make a real difference in several ways, but small enough to be understood by all stakeholders, the implementation closely monitored, and the results visible to all.

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