New Directions for Maths and Science

Encouraging Young Australians to study and teach Maths and Science

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Executive Summary

For Australia to succeed in a highly competitive global economy our children need to have a strong grasp of basic maths and science and encouragement to pursue careers in these areas. We are currently being left behind by other nations.

In our schools:

- Australia has a declining proportion of students who complete Year 12 studies in physics, biology and advanced mathematics.

We need more qualified teachers:

- nearly half of all senior physics teachers do not have a major in physics and around 25 per cent of senior chemistry teachers do not have a major in chemistry;
- 25 per cent of science teachers don't have a science qualification;
- around 25 per cent of maths teachers do not have a major in maths and nearly 10 per cent have not studied any maths at university; and
- around a third of all science teachers are aged over 50 years;

And at our universities,

- 0.4 per cent of Australian university students graduate with maths and statistics qualifications compared with an OECD average of around 1 per cent.

Labor will encourage the study of maths and science and offer incentives for graduates to take these skills into related occupations including the teaching profession by:

- reducing the HECS contribution for new maths and science students from the current annual student contribution rate of $7,118 to $3,998 from 1 January 2009 ($80.2 million over 4 years)
- paying 50 per cent of the HECS repayments of maths and science students as at 1 January 2009 who, upon graduation from university, engage in relevant maths and science occupations, particularly the teaching of maths and science.
- This HECS remission will be available for a period of up to five years from graduation and while the graduate continues working in a relevant maths or science occupation. ($30.8 million over four years)
- Labor will ensure that universities are not financially worse off as a result of this reduction in student contribution to the costs of a maths or science degree. This assistance to universities will be included in Labor’s higher education funding commitments to be announced in advance of the election.

Introduction

The foundations of a highly skilled workforce are increasingly laid in the maths and science classrooms of high schools and lecture halls of universities. For Australia to compete successfully in a highly competitive global economy, to ensure we seize new economic opportunities, our children need to have a strong grasp of basic maths and science.

Some of Australia's keenest competitors are making substantial investments in educating their future workforces and are giving priority to maths and science teaching. They recognise how crucial the basics of maths and science are to building a highly skilled workforce and a strong, advanced economy.

Australia currently lags behind many of our competitors in both the number of maths and science graduates and the quality of our maths and science education. A recent World Economic Forum annual report on global competitiveness ranked Australia's maths and science education 29th in the world[1].

If Australia is to become the most educated country and have the most skilled economy and best trained workforce in the world, we need a stronger foundation of maths and science learning in our schools and universities. To build that foundation, we must address the growing problem of the shortage of qualified maths and science graduates.

We need well trained teachers to give the next generation of students a strong command of maths and science. We also need to encourage more students to undertake tertiary maths and science study to build a stronger foundation of higher level skills in the workforce.

Federal Labor has already released a policy discussion paper: *The Australian economy needs an education revolution: New Directions Paper on the critical link between long term prosperity, productivity growth and human capital investment*. It argues that we cannot take current prosperity for granted. Not only is productivity growth beginning to slow, but resource prices are likely to unwind over the coming years, the ageing of the population will place significant pressure on public finances and reduce workforce participation, and the global marketplace is becoming increasingly competitive as China and India continue their transformation into economic superpowers.

If our children are to enjoy increases in their living standards that are comparable to those we have benefited from in recent years we must meet these challenges. We must do more than just maintain sound macroeconomic policies and open and competitive markets. We must lift Australia's rate of productivity growth. We must build a highly skilled workforce that can compete with the best of our competitors. Otherwise, we may simply become China's quarry and Japan's beach.

This policy builds on Labor's plan for a revolution in early childhood education - *New Directions for Early Childhood Education: Universal Access to Early Learning for Four Year Olds*. That document lays out a plan to give a universal right of access for all four year olds to fifteen hours a week of high quality early childhood education delivered by a qualified early childhood teacher.

This paper takes Labor's promise of an education revolution to its next stage - our schools and universities. It sets out a plan to encourage the study of maths and science in Australia and for graduates to take these skills into related occupations particularly the teaching of maths and science.

[1] World Economic Forum Global Competitiveness Report 2006

Maths and Science are critical to a competitive, modern economy

The study and teaching of maths and science is essential to the future wellbeing of our nation, and for the international competitiveness of our economy.

Maths and science form the basis for much of our modern economic and commercial activities today:

> *They drive the data analysis, forecasting, modelling, decision-making, management design and technological principles that underpin every sector of enterprise. Their influence extends beyond science related disciplines to financial services, the humanities, arts and the social sciences.*[2]

It has been through science and maths that we have seen advances in a broad field of studies and applications. A near universal reliance on the internet is a direct result of advanced application of maths. So too is the encryption technology relied upon to make secure transactions over the internet, or our everyday reliance on electronic funds transfer, to the range of modern medical treatments we seek when we have a medical ailment, from an MRI to a CAT scan.

It has been through advanced applications of science and the quest to understand the nature of things that has led to such medical advances as penicillin, the cochlear hearing aid, and a greater understanding of the weather patterns that impact on our daily lives.

In this context, it is easy to see that a strong academic grounding in maths and science at their broadest levels are essential to the future of research, product and concept development and innovation by Government and business alike. It is also necessary if we are to adapt and respond to the changing nature of the challenges confronting our workforce into the future.

An absence of a strong base in these areas limits our capacity to solve complex problems, develop new technologies and innovate and adapt existing ones, and leaves us as a nation increasingly exposed and unprepared for the economic challenges of the future.

Alan Greenspan summarised this neatly in testimony before the United States House of Representatives Committee on Education and the Workforce in September, 2000:

> *…the proliferation of information technologies throughout the economy in recent years has likely accelerated [the] shift in the skill requirements of many occupations away from routine work and toward non-routine interactive and analytical tasks.*
>
> *…in today's economy, it is becoming evident that a significant upgrading or activation of underutilized intellectual skills will be necessary to effectively engage…newer technologies.*
>
> *Expanding the number of individuals prepared to use a greater proportion of their intellectual capacity means, among other things, that our elementary and secondary students must broaden their skills in mathematics and related sciences.*

There is nothing new in the need for a society and a workforce to respond to change. As our nation has advanced over the past century, we have adapted successfully to the shifting requirements of an evolving and changing workforce. As the structure of work

[2] *Mathematics and Statistics: Critical Skills for Australia's Future,* National Strategic Review of Mathematical Sciences Research in Australia, December 2006

has changed from agrarian and small scale manufacturing to assembly lines in factories and later through to the services industries, so too has the structure of education, with over time, a greater emphasis on high school education, which in the words of Greenspan talking in the United States context, enabled

> *…students to read manuals, manipulate numbers, and understand formulae. Students were accorded the skills necessary to staff the newly developing assembly lines in factories and the rapidly expanding transportation systems whose mechanical and automotive jobs required a widening array of cognitive skills.*

The international and economic pressures we face today are different to those faced by our predecessors a century ago or 50 years ago. Now, it is increasingly our understanding of maths and science that will determine our success or failure. That applies both individually, as workers in a modern economy, and as a nation, competing against the world.

Maths and Science in our School System

As a relatively small country, Australia has at times performed well against measures assessing maths and science comprehension at the lower and secondary school levels.

This was reflected in the 2003 OECD Programme for International Student Assessment (PISA) survey of 15-year-olds, which assessed students' understanding in reading, maths and science as well as their ability to apply that understanding to everyday situations.

The survey showed that Australia's overall results were above the OECD average in mathematical, scientific and reading literacy as well as problem solving. Four countries (Hong-Kong China, Finland, Korea and the Netherlands) performed significantly better than Australia in mathematical literacy, while three countries outperformed Australia in scientific literacy (Finland, Japan and Korea).[3]

However, other international benchmarking paints a less positive picture of Australia's educational outcomes in maths and science.

The International Association for the Evaluation of Educational Achievement's 2002 *International Mathematics and Science Study* (TIMSS) demonstrate this. This surveyed student achievement in maths and science for Year 4 and Year 8 students. The 2002 results showed that the performance of Australian children remained statistically similar to their 1994/95 test results, in marked contrast to a number of competitor countries, which had made substantial improvements over the same period and raised their position against that of Australia.[4] Between 1994/95 and 2002, the performance of Australian children fell against our international competitors in the following areas:

- Year 4 maths: our ranking dropped from seventh to 14th;
- Year 4 science: our ranking dropped from third to eighth;

[3] OECD (2003), *Learning for Tomorrow's World: First Results from PISA 2003*
[4] Australian Council for Educational Research (2002), *Highlights from TIMSS from Australia's Perspective*

- Year 8 maths: our ranking dropped from ninth to tenth; and
- Year 8 science: our ranking dropped from fifth to ninth.

As Chart 1 shows, TIMSS found that Australian Year 8 students performed poorly compared with the top five countries reaching the top two benchmarks, identified as

- High – students can apply their understanding and knowledge in a wide variety of relatively complex situations; and
- Advanced – students can organise information, make generalisations, solve non-routine problems, and draw and justify conclusions from data.

Chart 1: Comparison of the percentage of Australian Year 8 students reaching the TIMSS international benchmarks

Source: The National Strategic Review of Mathematical Sciences Research in Australia, 2006: 53

These results illustrate a broader malaise when it comes to the study of maths and science in our schools. By standing still in our educational attainment in maths and science, we are falling behind our international competitors.

This was most recently illustrated in the World Economic Forum's annual report on global competitiveness, which showed that Australia's maths and science education ranking overall is now 29th in the world, behind nations like Singapore, France, India, the Czech Republic and even Tunisia.

Table 1: Quality of maths and science education, top 30 countries

Rank	Country/Economy	Rank	Country/Economy	Rank	Country/Economy
1	Singapore	11	Romania	21	Slovak Republic
2	Finland	12	Malaysia	22	Canada
3	Belgium	13	Hungary	23	Korea
4	Switzerland	14	Japan	24	Serbia and Montenegro
5	France	15	Netherlands	25	New Zealand
6	Hong Kong	16	Ireland	26	Lithuania
7	India	17	Israel	27	Austria
8	Czech Republic	18	Estonia	28	Indonesia
9	Tunisia	19	Barbados	**29**	**Australia**
10	Taiwan, China	20	Denmark	30	Cyprus

Source: World Economic Forum *Global Competitiveness Report 2006*

**Respondents were asked about maths and science education in their country's schools (1.0 = lag far behind most other countries, 7.0 = are among the best in the world)*

This trend isn't isolated to just the lower levels of schooling. As Table 2 shows, the *December 2006 National Strategic Review of Mathematical Sciences Research In Australia* identified that the proportion of year twelve students participating in advanced and intermediate maths also declined between 1995 and 2004.

Table 2: National Participation by Year 12 students: advanced and intermediate mathematics, 1995 and 2004

Advanced mathematics students, as a percentage of Year 12

	NSW	VIC	QLD	WA	SA	TAS	ACT	NT	(AUS)
1995	18.9	11.4	12.6	12.6	11.8	4.6	12.2	5.8	(14.1)
2004	15.0	12.6	8.4	8.2	9.1	5.5	11.9	3.2	(11.7)

Intermediate mathematics students, as a percentage of Year 12

	NSW	VIC	QLD	WA	SA	TAS	ACT	NT	(AUS)
1995	30.0	24.4	33.7	18.8	23.6	15.3	27.6	9.7	(27.2)
2004	20.1	24.2	31.7	13.4	16.0	14.3	28.0	9.9	(22.6)

Source: The National Strategic Review of Mathematical Sciences Research in Australia, 2006: 54

The situation is similarly bleak when it comes to science. For example, the Department of Education, Science and Training in its 2003 report *Australia's Teachers: Australia's Future - Advancing Innovation, Science, Technology and Mathematics* found that Australia has a declining proportion of students who complete Year twelve studies in physics, biology and advanced maths.[5] In addition, between 1980 and 2002, the proportion of Year 12 students taking chemistry or physics nearly halved, while the percentage of Year 12 students taking higher level maths (advanced and intermediate level) fell from 41 per cent in 1995 to 34 per cent in 2004.[6]

According to the *National Report on Schooling in Australia, 2005*, of those students studying for Year 12, a diminishing number, around 40,000 fewer students were enrolled in tertiary accredited science subjects in 2005 compared to 2000.[7]

[5] Department of Education, Science and Training (2003) *Australia's Teachers: Australia's Future - Advancing Innovation, Science, Technology and Mathematics*
[6] *National Strategic Review of Mathematical Sciences Research in Australia*, December 2006
[7] *National Report on Schooling in Australia 2005, Appendix 1; National Report on Schooling in Australia 2000, Appendix 1*

Quality Teaching Standards in Maths and Science

Part of the solution to improving maths and science education is to help ensure that students are taught by teachers with expertise in their subject areas. Research shows that having a highly qualified teacher in the classroom is one of, if not the most important factor in academic success.

This isn't the reality for many Australian school students studying maths and science today.

A 2003 review by the Department of Education, Science and Training identified a number of areas of national concern including:

- a declining proportion of students who complete Year 12 studies in physics, chemistry, biology and advanced maths;
- insufficient numbers of highly trained teachers in science, technology and maths;
- uncertainty among primary school teachers about how best to teach science, accompanied by primary teachers' relatively low levels of interest and academic attainment in science and maths; and
- teaching which does too little to stimulate curiosity, problem solving, depth of understanding and continued interest in learning among students, or to encourage them to undertake advanced study in science and maths at school and beyond.[8]

The qualifications and the level of educational attainment in the study of maths and the sciences present major institutional problems for our schools.

The Australian Council of Deans of Science surveyed nearly 10 per cent of all science teachers in Australia for its survey report, *Who's Teaching Science?,* released in 2005. The Council found that:

- more than 42 per cent of Year 11 and Year 12 physics teachers do not have a major in physics (having passed at least two units at third year university level), while 25 per cent had not studied physics beyond first year university;
- around 25 per cent of senior chemistry teachers do not have a major in chemistry;
- a relatively high proportion of teachers at the Year 7 and Year 8 levels have no university science background, identified as the most crucial years for students deciding whether or not they like science;
- around a third of all science teachers are aged over 50 years;
- more than a third of schools surveyed report difficulties filling physics and chemistry positions; and

[8] Department of Education, Science and Training (2003) *Australia's Teachers: Australia's Future - Advancing Innovation, Science, Technology and Mathematics*

- retaining teachers is difficult, with around half of science teachers starting out in their careers unsure if they will continue.

Crucially, the report found that more than 25 per cent of respondents did not hold a science qualification.

The situation in relation to maths teaching is just as alarming. A 2006 study by the Australian Council of Deans of Science, *The Preparation of Mathematics Teachers in Australia*, found that:

- 8 per cent of maths teachers had not studied any maths at university;
- around 20 per cent of maths teachers had not studied maths beyond first year university, including 23 per cent of junior school teachers;
- around 25 per cent of maths teachers did not have a major in maths, including 17 per cent of teachers of intermediate and advanced senior school maths;
- many maths teachers had studied no maths teaching methods whatsoever, including around 30 per cent of those who taught only at the junior or middle school level; and
- teachers under the age of 30 were significantly less likely than their older colleagues to hold a maths major or to have studied maths teaching methods.

These facts are having an adverse impact on the retention of quality maths and science teachers in our schools.

According to a 2003 Department of Education, Science and Training report, *Attracting and retaining teachers of science, technology and mathematics*, retaining quality educators remains a central issue to the teaching of maths and science in our schools. Factors affecting teachers' decisions to leave the profession include a lack of qualifications in science and maths and a lack of educational resources and relevant support.[9]

Chief amongst these, according to industry groups such as the Business Council of Australia, is developing the skills of high school teachers in maths and science. With an ageing society and a generation of schoolteachers leaving the teaching profession over the next decade, the need to build these skills for our existing and future schoolteachers is essential.

Maths and Science in our Universities

The difficulties affecting our schools are having a significant impact on the study of maths and science across our universities.

And in the study of mathematical sciences, around 0.4 per cent of Australian university students graduate with maths and statistics qualifications compared with an OECD average of around 1 per cent.[10]

This is unsurprising given that the December 2006 review, *Mathematics and Statistics: Critical Skills for Australia's future* found that the situation confronting the study of maths at university is inadequate and at risk of falling further behind.[11]

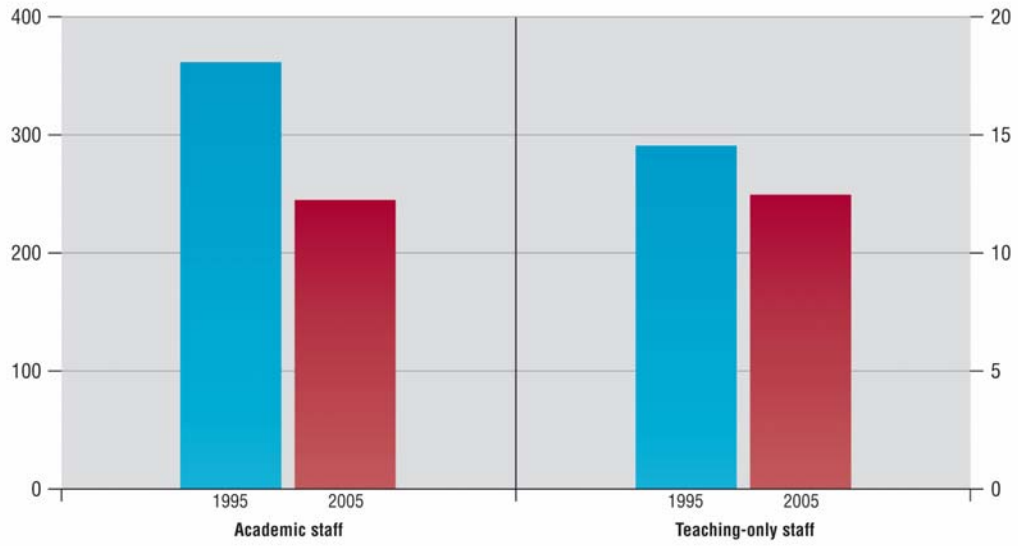
[9] Department of Education, Science and Training (2003) *Australia's Teachers: Australia's Future - Advancing Innovation, Science, Technology and Mathematics*
[10] OECD (2003) *Education at a Glance 2003*

This study found that there is a circular relationship between the education levels achieved at high school and at university and vice versa. It found that the declining number of Year 12 students taking higher-level maths is

> *…limiting the level of training that can be supplied in undergraduate degree programs such as commerce, education, engineering and science….*[12]

It also found that over the past decade mathematical science departments in the Group of Eight research Universities alone have lost almost a third of their permanent academic staff, while maths departments at a number of other Universities have disappeared altogether.

Chart 2: Staff in mathematical sciences departments in the Group of Eight Universities, 1995 and 2005



Source: The National Strategic Review of Mathematical Sciences Research in Australia, 2006: 36

In this environment, it is not uncommon for specialist mathematical and statistical subjects to be taught by non-specialists.[13]

These factors are impacting negatively on the attractiveness of undertaking university study in both maths and in science.

In 2005, less than 60,000 of the more than 500,000 students enrolled at our nation's universities were enrolled to study maths and the sciences. Of those, there are only around 250 students graduating each year with honours or higher-level qualifications.[14]

In an international marketplace that increasingly puts a premium on a country's intellectual resources, we must reverse this trend. Labor believes that maths and science education must be given the highest priority in all education systems and in every school and university.

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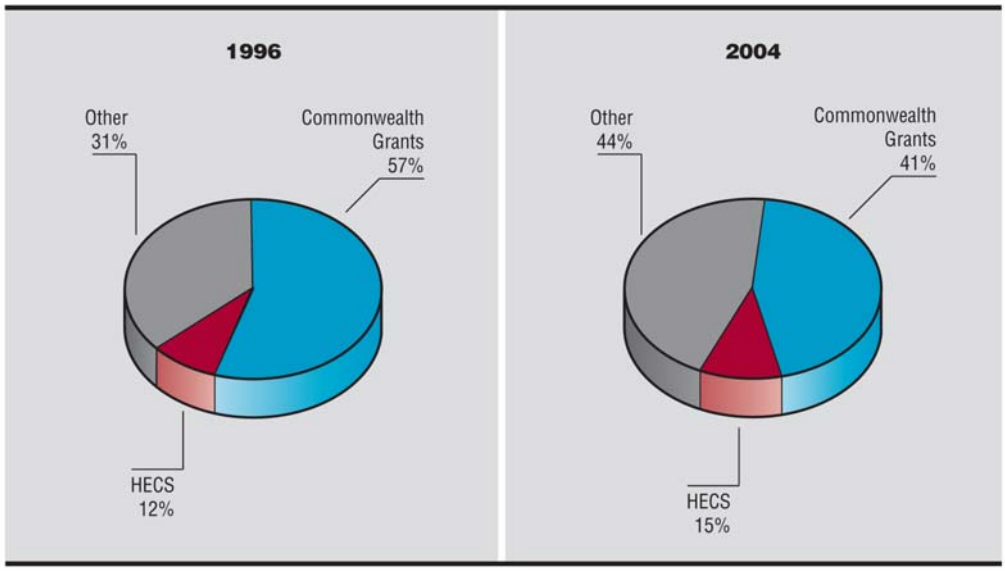
[11] *National Strategic Review of Mathematical Sciences Research in Australia*, December 2006: 8-9
[12] *National Strategic Review of Mathematical Sciences Research in Australia*, December 2006:9
[13] Peter Haggstrom, *Maths slump adds up to a national crisis*, AFR, 17 January 2007
[14] *National Strategic Review of Mathematical Sciences Research in Australia*, December 2006: 27

HECS Fees for Maths and Science

As a part of the Howard Government's 2003 changes to higher education, it allowed universities to increase the level of student contributions to their university degree by up to 25 per cent. All but three of the nation's public universities have now passed on at least some of this increase to university students, with 30 passing on the full 25 per cent increase to students in 2006. This has shifted the cost burden of university education further onto students and their families.[15]

Chart 3: University revenue by source



Source: Australian Vice Chancellors' Committee, 2005

To set this 25 per cent price cap, the Government drew up a schedule of maximum permissible student contributions. National Priority courses, such as nursing and teaching, were quarantined from HECS rate rises. The schedule of fees for the maximum student contribution covered four HECS bands, divided into the 12 university course clusters.

[15] Answer to Question on Notice, No.E087_07

Table 3: Maximum student contribution amounts

The following table shows the maximum student contribution amounts for a equivalent full-time student load place that may be charged for units of study in 2007.

	Funding cluster	*Maximum student contribution amount*
1	Law	$8,333
2	Accounting, Administration, Economics, Commerce	$7,118
3	Humanities	$4,996
4	Mathematics, Statistics	$7,118
5	Behavioural Science, Social Studies	$4,996
6	Computing, Built Environment, Health	$7,118
7	Foreign Languages, Visual and Performing Arts	$4,996
8	Engineering, Science, Surveying	$7,118
9	Dentistry, Medicine, Veterinary Science	$8,333
10	Agriculture	$7,118
11	Education	$3,998
12	Nursing	$3,998

Note: These rates apply to Commonwealth supported students who are not covered by the transitional arrangements in the *Higher Education Support (Transitional Provisions and Consequential Amendments) Act 2003* and the *Transitional Arrangements for Students Guidelines* issued under that Act.

Maths and science students now contribute $7,118 per year to their university education. In contrast, teaching and nursing student contributions are capped at the lowest level of $3,998 per year.

The student contribution rate paid by maths and science students puts them at a distinct financial disadvantage when compared with those studying education, nursing, behavioural sciences, foreign languages, visual and performing arts, and the humanities.

This contributes to the decisions taken by students as to which courses they study at university. Some students considering taking up the study of maths or science at university are influenced by the level of debt they will accrue upon graduation compared to their counterparts undertaking studies in other disciplines.

Debt levels may also influence the career decisions taken by those university students who do undertake studies in maths and science.

The Howard Government received expert advice in October 2003 from a study commissioned by then Education Minister, Dr Brendan Nelson that stated:

> *At a time when expertise in science, technology and mathematics is in high demand, and when Australia needs to produce more high calibre teachers of science, technology and mathematics, it is imperative to send a clear signal that the teaching of science, technology and mathematics matters* ***by taking steps to ensure that teachers of these discipline areas do not pay more HECS than other teachers.***

Labor will send a message that the study of maths and science is important to our national capacity as is the teaching of maths and science.

Maths and Science: A New Direction for Australia

> *Our hopes for delivering and maintaining a well-skilled country must be linked to rebuilding the infrastructure of the mathematical and other enabling skills through our education system.*
>
> Peter Taylor, CEO, Engineers Australia

Labor knows that education is essential to our national economy, and that maths and science are important keys needed to ensure our future productivity and prosperity.

We no longer have enough trained scientists or mathematicians entering the workforce.[16] This is particularly so for the teaching profession where growing shortages of appropriately qualified school teachers in maths and science are impacting on the overall educational attainment levels of our primary and secondary students, in turn crippling our ability as a nation to respond to economic and technology challenges of the future.

We must reverse this trend.

We need to encourage the study of maths and science at Australian universities by our best and brightest students. And we need to encourage those students who graduate from these disciplines to make their careers in these fields.

Labor will encourage students to study science and maths in our universities and encourage them upon graduation to go into science and maths occupations, particularly the teaching of maths and science.

Reducing the HECS burden on Maths and Science Students

Currently, some students who are considering studying maths and science are deterred by the size of the HECS debt they would accrue compared to their counterparts in other disciplines.

Labor will reduce the HECS contributions new maths and science students are required to pay for their maths and science degrees from the current annual student contribution rate of $7,118 to $3,998 a year.

This $3,120 reduction per year will apply to new maths and science students from 1 January 2009.

At a cost of $80.2 million over four years, this reform is designed to provide a significant incentive for students to undertake studies in these areas of critical economic importance.

In addition, Labor will pay 50 per cent of the HECS repayments of maths and science students as at 1 January 2009 who, upon graduation from university, engage in relevant maths and science occupations such as the teaching of maths and science.

This HECS remission will be available for a period of up to five years from graduation and while the graduate continues working in a relevant maths or science occupation at a cost of $30.8 million over four years.

Labor will also ensure that Universities are not financially worse off as a result of this reduction in student contribution to the costs of a maths or science degree. This

[16] *National Strategic Review of Mathematical Sciences Research in Australia*, December 2006

assistance to universities will be included in Labor's higher education funding commitments to be announced in advance of the election.

The implementation of this policy may be brought forward to apply from 1 January 2008, if the timing of the 2007 Federal Election permits.

This action will help encourage young Australian school leavers to become new maths and science university students. It says to them that their nation believes that the study of maths and science at a high level at university is a priority. As a consequence, a financial obstacle will be taken out of the path of those studying maths and science and those wishing to teach maths and science.

Further Measures

Labor's commitment to encouraging the study and teaching of maths and science will see Labor consider a range of further measures including:

- providing additional funding for maths and science university courses;
- increasing the number of maths and science places at Australian universities;
- funding a maths and science careers awareness program;
- working to enhance the skills of current maths and science teachers;
- encouraging suitably qualified professionals to make a career change to maths and science teaching; and
- establishing programs to interest young Australians in science as a career.

Labor will consult widely over coming months with relevant stakeholders on the merits of these further measures.

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