



Education and Training Committee

Final Report

Inquiry into the Promotion of Mathematics and Science Education

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Inquiry into the Promotion of
Mathematics and Science Education

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Chair's Foreword

The economic prosperity of Victoria and Australia is highly dependent on our ability to develop scientists who can compete globally. Of equal importance is the need for Victorians to be mathematically and scientifically literate, to help empower us as citizens and skilled participants in a world increasingly dominated by technological innovation. To achieve these outcomes, mathematics and science education must be engaging and contemporary. Mathematics and science education must also be relevant to students' lives, promote deep conceptual understanding and embrace investigative inquiry and problem solving.

It is in this context that I am pleased to present the Education and Training Committee's report on the inquiry into the promotion of mathematics and science education. The Committee seeks to advance and promote mathematics and science education in Victoria, so that Victorian students can achieve a level of mathematics and science literacy that matches the best in the world by 2020. The Committee also seeks to increase participation in mathematics and science education and the pursuit of mathematics and science related careers for the advancement of Victoria's economic, social, cultural and environmental goals.

Victoria is fortunate that it already has an education system and teaching workforce that performs well by national and international standards. Victoria also has many centres of excellence that are successfully engaging students and teachers in the exciting new sciences. These include the Gene Technology Access Centre, the Victorian Space Science Education Centre and, Ecolinc, the new Science and Technology Innovations Centre at Bacchus Marsh. Furthermore, Victoria is home to cutting-edge science facilities, such as the Australian Synchrotron, that are at the forefront of science and innovation both here and overseas.

The Committee saw first-hand numerous innovative and exemplary practices being demonstrated in schools and various centres of excellence. Victoria has many dynamic teachers with deep, contemporary subject knowledge and conceptual understanding who are embracing the teaching of new sciences with energy and enthusiasm. It is these teachers who are demonstrating the greatest success in engaging Victorian students and helping them to achieve a high standard in mathematics and science.

Nevertheless, an overarching finding of this inquiry has been the considerable variability throughout mathematics and science education. Throughout Victoria there is variability in the levels of participation and achievement in mathematics and science subjects between different groups of students; variability in teacher quality; and variability in the

quality of science laboratories and equipment. The Committee also noted national inconsistencies within mathematics and science education.

The Committee has recommended a raft of strategies to improve mathematics and science education in Victoria. Crucially, professional development targeting primary teachers' confidence and familiarity in teaching science is required. For secondary science teachers, professional development should focus on staying abreast of new science and its applications, so that they can maintain student engagement in science. To ensure schools are at the leading edge of science education, new fields and applications of science need to feature prominently in our classrooms and, importantly, in our laboratories. Exploring the fundamentals of new sciences first-hand often requires new approaches in the laboratory and places new demands on equipment and facilities. As scientific investigation is at the heart of science education, the Committee recommends an equipment boost to both secondary and primary schools, and advocates schools sharing the more advanced contemporary and perhaps expensive equipment.

I wish to thank all those who participated in this inquiry. I especially thank the students and teachers who shared their insights with the Committee and who made particularly valuable contributions to our investigations. I would also like to thank the schools and science education facilities that welcomed the Committee during its investigations.

I thank the Committee Members for their dedication and hard work during this inquiry. Members of the Committee also wish to express sincere thanks to all staff that have assisted throughout this inquiry. I believe the improvements to mathematics and science education throughout Victoria, which will result from the implementation of the Committee's recommendations, are testament to the success of the all-party investigatory Committee system.

Steve Herbert MP
Chair

Contents

Membership of the Education and Training Committee	iii
Chair's Foreword	v
Executive Summary	xiii
Recommendations	xxi
List of Figures	xxvii
List of Abbreviations	xxxix

Chapter 1 Introduction

Vision for Mathematics and Science Education	1
– Functions of the Committee	
– Terms of Reference	
Inquiry Methodology	4
– Call for Submissions	
– Research Undertaken by the Committee	
– Conferences	
– Member's Study Tour	
Evidence to the Inquiry	6
Definitions	8
– Mathematics	
– Science	
– Enabling Sciences	

Chapter 2 Context for the Inquiry

Introduction	13
Industry Needs for Mathematics and Science Education.....	15
– Demand for Mathematics, Science and Technology Workers	
– Current Shortages in Supply of Mathematics, Science and Technology Workers	
Victorian Mathematics and Science Education Policy Setting	21
– Growing Victoria Together	
– Blueprint for Government Schools	
– Science, Technology and Innovation Initiative	
– School Innovation in Science	

– School Innovation in Teaching: Science, Maths and Technology	
– National Goals for Schooling	
National Policy	29
– Backing Australia’s Ability: Building our Future through Science and Innovation	
– Review of Teaching and Teacher Education	
– Prime Minister’s Science, Engineering and Innovation Council	
A Vision for a Future Mathematics and Science Education Policy for Victoria	33

Chapter 3 Curriculum Structure

Introduction	37
General Purpose of the Mathematics and Science Curricula	37
Curriculum Framework in Victoria.....	40
– The Victorian Essential Learning Standards	
– VELS Curriculum Planning Guidelines	
– The Curriculum and Standards Framework II	
– The Victorian Certificate of Education	
– Extension Studies	
– The Victorian Certificate of Applied Learning	
– Vocational Education and Training in Schools	
Mathematics Curriculum	50
– Mathematics and the Victorian Essential Learning Standards	
– Mathematics in the VCE	
– Foundation Mathematics Units 1 and 2	
– General Mathematics Units 1 and 2	
– Further Mathematics Units 3 and 4	
– Mathematical Methods and Mathematical Methods (CAS) Units 1 to 4	
– Specialist Mathematics Units 3 and 4	
– Senior Mathematics in Other Jurisdictions	
– VCAL Numeracy Requirements	
The Science Curriculum in Primary Schools.....	59
– Science and the Victorian Essential Learning Standards	
– Time Allocated to Science	
The Science Curriculum in Secondary Schools	62
– Biology	
– Chemistry	
– Physics	
– Psychology	
– Environmental Science	
– Agricultural and Horticultural Studies	

Senior Science Courses in Other Jurisdictions	67
– Science for Public Understanding	
– Science21	
– Multi-Strand Science	
– Engineering Studies	
– Expanding the Suite of Victorian Senior Science Courses	
Student Assessment.....	73
– Purpose of Assessment	
– Assessing More than Just the Facts and Figures	
– Reporting	

Chapter 4 Trends in Enrolments in Mathematics and Science

Introduction	81
Enrolments in VCE Mathematics Subjects.....	81
– Mathematics Enrolments by Gender	
– Mathematics Enrolments by Region	
– Mathematics Enrolments by Sector	
Enrolments in VCE Science Subjects	87
– Science Enrolments by Gender	
– Science Enrolments by Region	
– Science Enrolments by Sector	
Mathematics and Science Enrolments in Higher Education.....	93
Policy Implications of Current Enrolment Trends	96

Chapter 5 Trends in Student Achievement in Mathematics and Science

Introduction	99
National Numeracy Benchmarks	99
National Year 6 Science Assessment.....	103
Student Achievement in PISA.....	106
– Australia's Performance in Mathematics	
– Australia's Performance in Science	

Student Achievement in TIMSS	114
– Achievement in Mathematics – Year 4	
– Achievement in Mathematics – Year 8	
– Achievement in Science – Year 4	
– Achievement in Science – Year 8	
Policy Implications of Current Achievement Trends.....	122

Chapter 6 Participation and Achievement Differences between Students

Introduction	125
The Influence of Socioeconomic Status in Mathematics and Science Education	125
– Influence of Socioeconomic Status on Participation and Achievement in Mathematics and Science	
– Influence of Socioeconomic Status on Access to Enrichment Programs	
– Initiatives Aimed at Addressing Socioeconomic Inequities – Mentoring Programs	
The Influence of Gender Differences in Mathematics and Science Education	140
– Trends in Participation by Gender	
– Trends in Achievement by Gender	
– Gender Differences in Attitudes to Mathematics and Science	
The Influence of Geographical Differences in Mathematics and Science Education	146
– Differences in Participation and Achievement by Geographic Location	
– Initiatives Aimed at Addressing Geographic Inequities	
Summary of Findings and Policy Implications.....	155

Chapter 7 Engaging Students in Mathematics and Science

Introduction	159
The Learning Environment	160
– Primary School Mathematics	
– Secondary School Mathematics	
– Primary School Science	
– Secondary School Science	

Scientific Investigations, Laboratories and Equipment.....	176
– The Importance of Scientific Investigations	
– Science Laboratories and Equipment	
Mathematics and Science Enrichment Programs	187
– Excursions and Incursions	
– Education and Awareness Programs	
The Integration of Technology in the Classroom	193
The Integration of Business, Industry and Research Applications	197

Chapter 8 Teacher Supply and Demand

Profile of the Victorian Teaching Workforce.....	201
– Age Profile of the Teaching Workforce	
– Gender Profile of the Teaching Workforce	
Demand for Mathematics and Science Teachers	205
Attracting and Recruiting the Teaching Workforce.....	209
– Attractiveness of a Teaching Career	
– Teacher Salaries and Career Structures	
Teacher Education Places	215
– Allocation of Teacher Education Places	
– Student Contribution Charges	

Chapter 9 Teacher Quality

Introduction	221
Teacher Qualifications	221
Professional Standards.....	226
Professional Development Needs of the Current Teacher Workforce	229
– Primary School Teachers	
– Secondary School Teachers	
Current Delivery of Professional Development	235
– Challenges in Delivering Effective Professional Development	
– Professional Networks and the Sharing of Best Practice	
Compulsory Professional Development.....	243

Appendices

Appendix A	List of Written Submissions.....	245
Appendix B	List of Witnesses – Public Hearings and Briefings ...	249
Appendix C	List of Perth Meetings	263
Appendix D	Australian Bureau of Statistics: Socio-Economic Indexes for Areas (SEIFA) 2001	267
Appendix E	Mathematics and Science Education and Awareness Programs Examined by the Committee.....	273
Appendix F	Study Tour, Hon. Helen Buckingham MLC – List of International Meetings	277
Appendix G	Queensland Government Action Plan for Improving Mathematics and Science Education	281
Appendix H	South Australian Government Strategies for Mathematics and Science Education	283
Appendix I	Primary Connections 5Es Instructional Model	287
Appendix J	University Enrolments by Area of Study (2003)	289
Appendix K	PISA – Proficiency Levels in Mathematical Literacy for all Participating Countries (2003)	291
Appendix L	Centres of Excellence	293
Appendix M	University-to-School Mentoring Programs	303
Appendix N	Description of Mathematics and Science Education and Awareness Programs.....	307
Appendix O	Department of Education and Training 'Like School Group' Categories	323
Appendix P	Case Studies of Science Education and Awareness Programs Targeting Rural and Regional Communities.....	325

Bibliography	329

Executive Summary

Introduction

Mathematics and science education play a vital role in the development of individuals who are well equipped to function in a society underpinned by science and technology. Citizens of all ages must be able to acquire and use science and technology information to inform decisions about their day-to-day lives. Scientific literacy is also a key component informing both business and investment decisions and commercial and political debate within the community. Consequently, mathematical and scientific literacy are part of the necessary skill-set required by all Victorians. The first part of the Committee's vision for mathematics and science education is therefore for Victorian students to achieve a level of mathematical and scientific literacy that matches the best in the world by 2020.

High quality education outcomes in mathematics and science are also important in ensuring growth in new fields of science, technology and innovation. Growth in these fields is essential in achieving Victoria's economic, social, cultural and environmental goals. The second part of the Committee's vision is therefore to have a greater proportion of our highest achievers in mathematics and science pursuing these disciplines into senior secondary and university studies.

The Committee's inquiry found that Victoria is achieving some excellent outcomes in mathematics and science education. However, there is considerable variability in the quality of mathematics and science education and the outcomes for certain groups of students. Realisation of the Committee's vision therefore requires that all Victorian primary and secondary schools give a high priority to the teaching and learning of mathematics and science.

Context for the Inquiry

Over recent years, mathematics and science education have been given special policy attention at both the national and state level. Despite this, the Committee heard that many opportunities exist to improve the quality and status of mathematics and science education in Victoria. The Committee believes that the priorities for improvement include:

- Addressing the variability in the level of priority afforded science education within primary schools, together with variability in the level of knowledge and conceptual understanding of the mathematics and science disciplines among primary teachers.

- Increasing the level of engagement of many secondary students in mathematics and science studies early in their secondary schooling, to ensure they continue to study these subjects and develop the high levels of mathematical and scientific literacy required for success in a broad range of trade and professional careers.
- Increasing the number of enrolments in the enabling science disciplines within senior secondary schools and universities.
- Better targeting mathematics and science education towards addressing skills shortages in the economy, through greater integration of business, industry and research applications into the school curriculum and improved career and subject advice to students.
- Addressing continued imbalances in the level of participation and achievement in mathematics and science between diverse groups of students.
- Addressing the emerging shortages of highly qualified mathematics and science teachers in some geographic locations.

The above priorities have been identified within a context of increasing industry demands for high levels of mathematical and scientific literacy across the workforce. There already exist long-standing skills shortages in many mathematics and science related trades and professions. As well, knowledge and conceptual understanding of mathematical and scientific concepts have become increasingly relevant to a diverse range of other professions.

The Victorian Government, together with its partners in the education community, is already implementing, and sometimes at the forefront of, innovative mathematics and science education programs and initiatives. However, the increasing necessity of mathematical and scientific literacy to allow for full participation in society means that a comprehensive, co-ordinated, mathematics and science education policy is essential.

The Committee believes that the Victorian Government should develop a strategic policy statement drawing together a comprehensive suite of existing and complementary mathematics and science education and awareness programs and initiatives. While recognising the importance of a defined central policy position, the Committee also recognises that parents, industry and the broader community need to be included in any new approach to further advancing the status and quality of mathematics and science education in Victoria.

Curriculum Structure

The Committee believes that the key priority of mathematics and science education should be to ensure that all Victorian students attain a high level of mathematical and scientific literacy. A secondary aim is to adequately prepare a substantial number of students for specialised studies and future careers in the enabling and new sciences.

Throughout the term of this inquiry, the school curriculum for Years Prep to Year 10 was undergoing significant change as the Victorian Essential Learning Standards (VELS) were developed, for progressive implementation from 2006. The VELS discipline strand contains detailed science and mathematics domains. Importantly, however, the VELS also contain a 'physical, personal and social learning' strand and, an 'interdisciplinary learning' strand that includes thinking processes such as inquiry, reasoning and problem solving, and creativity. The Committee sees the introduction of the VELS as an opportunity to significantly increase the presence of science in primary school classrooms. The interdisciplinary approach of the VELS is also important, as this is the context within which mathematics and science studies are most relevant.

The Committee has identified opportunities for the enhancement of the mathematics and science curriculum for senior secondary students. It identified the need for a more consistent approach to senior mathematics studies throughout Australia. The Committee also identified potential opportunities for the introduction of additional VCE science subjects. In particular, the Committee believes that there is scope to consider the inclusion of an applied engineering subject at VCE, as well as a new contemporary interdisciplinary science subject. The Committee believes that these subjects could appeal to students not already considering traditional science studies.

The Committee found that many issues associated with the curriculum are connected to student assessment considerations. Indeed, student assessment and reporting are often seen as drivers of the curriculum. It is therefore important that student assessment measure students' ability to apply their mathematics and science knowledge, rather than simply their ability to remember facts and formulas. The Committee also suggests that science be included in the Achievement Improvement Monitor, to promote the profile of science and provide increased data to facilitate better targeting of mathematics and science education programs and initiatives.

Trends in Enrolments in Mathematics and Science

The Committee found that over recent years there has been an increase in the proportion of secondary school students undertaking VCE mathematics subjects. Significantly, the substantial growth in VCE Further Mathematics has not been at the expense of enrolments in the more advanced mathematics subjects. This expansion of mathematics should be welcomed. Some growth has also been experienced in science enrolments although not as strong as the growth for mathematics subjects. Since 2000, Biology and Chemistry enrolments have increased, whereas enrolments in VCE Physics have remained steady.

A key concern among participants in this inquiry is the current level of enrolments in mathematics and science disciplines, especially in the enabling sciences (physics, chemistry and advanced mathematics). The Committee also heard concerns that an insufficient number of VCE graduates are pursuing mathematics and science related university and trade studies and careers. If Australia is to address current skills shortages in the economy and improve its innovative capacity and international competitiveness, current participation rates at secondary school and into further education and training need to increase substantially. The Committee therefore suggests that governments set benchmark targets for mathematics and science enrolments in secondary schools and universities and, ensure the allocation of sufficient funding and sufficient university places for these disciplines.

Trends in Student Achievement in Mathematics and Science

The Committee found that on the whole, Victorian primary and secondary students perform very well in mathematics and science, as compared with national and international achievement benchmarks. However, certain groups of students continue to achieve at a lower standard, as compared to the average for Victoria. The Committee also heard that there is significant scope for the performance of many of our best students to be raised, to match the best in the world. In seeking to raise the standards across the entire student cohort, the Committee suggests that the Victorian Government continue to monitor the performance of different jurisdictions against the key policies and programs being implemented in those jurisdictions. An analysis of different mathematics and science education and awareness programs should be undertaken to determine their comparative success in responding to the different needs of diverse groups of students.

Participation and Achievement Differences between Students

A significant focus of this inquiry was the broad range of performance among Victorian students in mathematics and science. While the Committee's terms of reference included gender issues in mathematics and science, the Committee found that other considerations, including socioeconomic status and geographic disadvantage, were of greater concern. The Committee heard that students in lower socioeconomic areas and in rural and regional Victoria often have lower participation and attainment levels in mathematics and science, compared with the average for Victoria. These students also often have less access than other students to a broad range of mathematics and science enrichment programs. As well, the Committee heard that to ensure that mathematics and science education remain gender inclusive, continued work is required.

The Committee found that in order to help address the effects of socioeconomic disadvantage in mathematics and science education, existing university-to-school mentoring programs could be better targeted. To address the specific needs of various groups of students, complementary mentoring models, including e-mentoring and mentoring involving industry, could also be developed. In addressing geographic disadvantage, the Committee believes that existing mathematics and science education and awareness programs need to be expanded. In particular, there are some interesting models operating in the United Kingdom and Queensland, which may be suited to the Victorian context.

Engaging Students in Mathematics and Science

Student engagement was one of the strongest themes to arise during the Committee's inquiry. The Committee heard that effective student engagement depends on students enjoying their studies in mathematics and science, being confident in their ability and recognising the relevance of these subjects to everyday life, now and in the future. The learning environment was identified as an important factor contributing to student engagement in both mathematics and science. The Committee also heard of the significant role that parents and families can play in supporting students' mathematics and science studies.

The importance of investigative approaches in science education and even mathematics was consistently emphasised by students, teachers and other participants throughout the inquiry. Investigative approaches include various forms of practical work, including demonstrations, experiments, fieldwork and open investigations. The Committee heard, however, that the frequency and quality of science investigations varies

considerably throughout Victorian schools. The Committee found that exemplary scientific practices and investigations take place in many primary and secondary schools. However, the Committee also heard that the level of quality and availability of scientific equipment, and the design and facilities in some school laboratories hinders achievement of best practice in some schools. The Committee has therefore called upon the Victorian Government, as part of a strategic statement for mathematics and science education, to develop a five-year plan for science laboratories and equipment in primary and secondary schools.

The Committee heard that the large variety of mathematics and science education and awareness programs can assist in engaging students in these subjects. These include excursions, incursions, competitions and awards programs and extended scientific research/project enrichment activities. The Committee found that not all schools, teachers or families make the best use of these programs. Therefore, the Committee considers that a centralised, online resource describing the various opportunities and how to participate would be beneficial.

The Committee heard how the application by the business, industry and research sectors of mathematics and science could be better integrated into the curriculum. The integration of such applications into schools and learning communities could play a role in addressing two key goals of government: raising levels of scientific literacy across the community; and addressing skills shortages in the economy. The Committee heard that the business, industry and research sectors can be directly involved in mathematics and science education, going into schools and learning communities with their own mathematics and science education programs, or through partnership programs. These sectors can also play an indirect role in mathematics and science education, by becoming involved, for example, in curriculum development and teacher professional development. The Committee believes that the links between business, industry and research, and mathematics and science education need to be strengthened.

Teacher Supply and Demand

The Committee heard that the current level of demand for primary school teachers in Victoria is being met but that there are emerging difficulties in meeting the demand for specialised mathematics and science teachers, particularly in some hard-to-staff locations. The Committee has therefore recommended that the Victorian Government consider offering additional incentives to attract postgraduate entrants into teaching in the mathematics and science disciplines.

The Committee found that the two most significant barriers to meeting future demand for mathematics and science teachers rest with the higher education system. The Committee is concerned that the current system for allocating teacher education places is not fully effective in

ensuring a sufficient number of places are allocated between primary and secondary teaching, and across secondary teaching disciplines. The Committee also believes that in working towards a more balanced subject mix among new teacher graduates, the Commonwealth Government will also need to review student contribution charges (formerly HECS), which currently act as a disincentive for students considering a career as a secondary mathematics or science teacher. Specifically, the Committee believes that debt arising from university studies should be equalised where mathematics and science graduates subsequently enter the secondary teaching workforce.

Teacher Quality

The Committee noted that following the establishment of the Victorian Institute of Teaching, the standards and professionalism within the teacher workforce have risen steadily over recent years. There has been significant work undertaken by the Institute in defining standards for the accreditation of teacher education and for the registration of new teachers entering the system. This will result in ongoing improvements in teacher quality over coming years. The Committee notes that the Australian Association of Mathematics Teachers and the Australian Science Teachers Association have each developed professional standards for teaching excellence in their respective disciplines.

Teacher quality was the subject of much evidence to this inquiry. The Committee heard evidence about many innovative programs and practices for the effective teaching and learning of mathematics and science in Victoria. The Committee also notes that professional development initiatives implemented by the Victorian Government, including Schools Innovation in Science and Principles of Learning and Teaching, have been influential in the development of initiatives nationwide. However, the Committee notes that some variability exists in the capacity of teachers to effectively engage students in mathematics and science education.

The main concerns relating to primary school teachers were the level of variability of knowledge and conceptual understanding of mathematics and science, together with teacher confidence in delivering engaging mathematics and science lessons. It was seen as crucial for primary teachers to not only set in place the knowledge foundations for continued studies in mathematics and science but, to also engender in students a passion and understanding for the significance of these subjects in modern society. For secondary teachers, the main issues focused on effective teaching strategies, making sure mathematics and science are relevant and engaging in the context of students' own lives, and that industry and other real world applications are integrated into the curriculum. The need for teachers to remain up-to-date with the rapidly advancing body of knowledge in areas of new science was also identified as a challenge.

The Committee heard of the varying levels of participation in teacher professional development throughout Victoria. The size of the teacher workforce, together with the difficulties associated with having teachers undertake professional development during school hours, represent considerable challenges for schools and employing authorities in meeting the needs for teacher professional development. These challenges are exacerbated for many teachers in rural and regional Victoria. The Committee heard, however, that professional networks and forums for sharing of best practice within local learning communities are often some of the best mechanisms for effective teacher professional learning.

The Committee also noted that teacher professional development is often voluntary and that teachers place varying levels of priority on this activity. In seeking to increase standards, the Committee believes that the teaching profession should move towards a system of compulsory professional development, as is the case in other professions. The professional standards developed by various subject associations represent a useful tool in devising a model of compulsory professional development. The Committee believes that a points-based system could be implemented, which recognises a broad range of valuable professional learning. This includes attainment of formal qualifications, attendance at conferences and workshops, participation in school-based or industry research, involvement in curriculum development initiatives and participation in professional learning networks.

Recommendations

Chapter 2 Context for the Inquiry

Recommendation 2.1 (page 36): That the Victorian Government define the future direction for mathematics and science education in Victoria, through a strategic statement outlining:

- the purpose of and goals for mathematics and science education in Victorian schools;
- principles for curriculum and assessment development and implementation;
- strategies for increasing engagement and participation in mathematics and science education, training and employment pathways;
- strategies for intervention for lower achieving students and for raising achievement among the entire student cohort;
- strategies for improving the quality of teaching in mathematics and science; and
- strategies and programs for an enhanced role for industry in mathematics and science education.

Chapter 3 Curriculum Structure

Recommendation 3.1 (page 58): That the Victorian Government raise with the Ministerial Council on Education, Employment, Training and Youth Affairs, in consultation with the industry, business and research sectors, the need for national consistency in the content and naming of senior mathematics subjects.

Recommendation 3.2 (page 73): That the Department of Education and Training, in partnership with the Victorian Curriculum and Assessment Authority and other relevant stakeholders reconsider the existing suite of VCE science courses and investigate the merits of introducing:

- a contemporary general science and science communication subject; and
- an applied or engineering-based science subject.

Recommendation 3.3 (page 78): That the Department of Education and Training revise existing summative assessment tools to ensure they measure and promote student understanding and students' ability to apply their mathematics and science knowledge.

Recommendation 3.4 (page 79): That the Victorian Government include as part of the Achievement Improvement Monitor, the assessment of achievement and progression of students in science.

Chapter 4 Trends in Enrolments in Mathematics and Science

Recommendation 4.1 (page 97): That the Victorian Government undertake an analysis of enrolment trends against forecast future workforce requirements and develop benchmark targets for Year 12 enrolments in the enabling science subjects (physics, chemistry and advanced mathematics).

Recommendation 4.2 (page 97): That through the Ministerial Council on Education, Employment, Training and Youth Affairs, the Victorian Government work with the Commonwealth Government and other State and Territory Governments to ensure the funding and allocation of university places in mathematics and science related disciplines are sufficient to meet future industry and community needs.

Chapter 5 Trends in Student Achievement in Mathematics and Science

Recommendation 5.1 (page 123): That the Victorian Government undertake an analysis of the comparative success of interstate and international mathematics and science education and awareness programs in engaging and assisting students from diverse backgrounds.

Chapter 6 Participation and Achievement Differences between Students

Recommendation 6.1 (page 157): That the Victorian Government develop strategies aimed at improving the participation and performance of students from lower socioeconomic backgrounds in the enabling sciences (physics, chemistry and advanced mathematics) to that of the overall student cohort.

Recommendation 6.2 (page 157): That the Victorian Government work with university-to-school mentoring programs to ensure they are better targeted towards achieving improvements in mathematics and science attainment levels, especially within schools:

- that are located in areas of relative socioeconomic disadvantage;
- that perform lower in national and/or international benchmarking studies;
- that have lower levels of educational attainment; and/or
- that have student groups that traditionally have lower levels of educational attainment, including students in rural communities, Indigenous students and students from some language backgrounds other than English.

Recommendation 6.3 (page 157): That the Victorian Government review the specific needs of rural and regional students in gaining equitable access to a range of mathematics and science education, awareness and enrichment programs and devise strategies to overcome geographic disadvantage in mathematics and science education.

Recommendation 6.4 (page 158): That the Victorian Government develop additional strategies to ensure that the mathematics and science curriculum and its implementation are gender inclusive. Particular areas of focus should include the use of gender inclusive content, language and role models within the curriculum and integration of learning technologies that respond to gender needs.

Recommendation 6.5 (page 158): That the Victorian Government trial an e-mentoring program involving the industry, business and research sectors to complement existing mentoring programs.

Chapter 7 Engaging Students in Mathematics and Science

Recommendation 7.1 (page 175): That the Victorian Government pursue through the Ministerial Council on Education, Employment, Training and Youth Affairs, the development of a nationwide curriculum and teacher professional development initiative for secondary schools.

Recommendation 7.2 (page 175): That the Victorian Government pursue strategies to improve the quality of advice to young people and their parents to ensure that those pursuing vocational pathways undertake appropriate mathematics and science studies.

Recommendation 7.3 (page 187): That the Department of Education and Training, as part of a strategic statement for mathematics and science education (refer recommendation 2.1) develop a five-year plan for science laboratories and equipment in primary and secondary schools. The strategic plan should include:

- best practice guidelines for the design of laboratory facilities;
- best practice guidelines for the delivery of the school science curriculum within occupational health and safety and duty of care requirements;
- partnership strategies to facilitate appropriate sharing of science facilities and equipment;
- strategies to facilitate industry support for the provision of some specialised laboratory equipment; and
- strategies for ensuring students in rural and regional Victoria and in areas of socioeconomic disadvantage can access appropriate facilities and experiences.

Recommendation 7.4 (page 187): That the Victorian Government fund a science 'equipment boost' for primary and secondary schools to encourage greater innovation, scientific practice and experimentation as part of the consolidation of the Victorian Essential Learning Standards in Victorian schools.

Recommendation 7.5 (page 192): That the Department of Education and Training develop and maintain an online resource detailing mathematics and science related excursions, incursions, competitions and award programs and other enrichment activities that are available to Victorian students.

Recommendation 7.6 (page 200): That the Department of Innovation, Industry and Regional Development, in conjunction with the Department of Education and Training, host a triennial conference involving high-level representatives of the business, industry, research and education sectors. The conferences should focus on:

- showcasing recent advancements in the application of mathematics and science within the economy; and
- developing approaches for the effective integration of these applications into schools and learning communities.

Chapter 8 Teacher Supply and Demand

Recommendation 8.1 (page 215): That the Victorian Government consider offering additional incentives to attract postgraduate entrants into teaching in the mathematics and science disciplines.

Recommendation 8.2 (page 217): That the Victorian Government pursue through the Ministerial Council on Education, Employment, Training and Youth Affairs, strategies that result in sufficient teacher education places being allocated within priority disciplines such as mathematics and science.

Recommendation 8.3 (page 220): That the Victorian Government pursue through the Ministerial Council on Education, Employment, Training and Youth Affairs a review of student contribution charges, which currently act as a disincentive to qualification as a secondary mathematics or science teacher.

Chapter 9 Teacher Quality

Recommendation 9.1 (page 244): That the Victorian Institute of Teaching consider and develop an appropriate model of mandated professional development for Victorian teachers, particularly mathematics and science teachers, whose disciplines face rapid advancement.

List of Figures

Figures

Figure 2.1	Skills Shortages – Australia and Victoria (Professions) (2005).....	18
Figure 2.2	Skills Shortages – Australia and Victoria (Trades) (2005)	20
Figure 2.3	National Goals for Schooling in the Twenty-First Century	28
Figure 2.4	Australia's Teachers: Australia's Future Priorities for Action	32
Figure 3.1	VELS Curriculum Planning Framework.....	42
Figure 3.2	VELS Curriculum Planning Guidelines.....	46
Figure 3.3	Comparison of Interstate Mathematics Courses by Relative Difficulty (2004 to 2005).....	57
Figure 3.4	Suite of Senior Science Courses throughout Australia (2006).....	68
Figure 4.1	Percentages of Year 12 Students Enrolling in VCE Unit 4 Mathematics (2000 to 2004)	82
Figure 4.2	Percentages of Year 12 Students (Males) Enrolling in VCE Unit 4 Mathematics (2000 to 2004) ..	82
Figure 4.3	Percentages of Year 12 Students (Females) Enrolling in VCE Unit 4 Mathematics (2000 to 2004) ..	83
Figure 4.4	Percentages of Year 12 Students Enrolling in VCE Unit 4 Mathematics by Region (Metropolitan) (2004).....	84
Figure 4.5	Percentages of Year 12 Students Enrolling in VCE Unit 4 Mathematics by Region (Non-Metropolitan) (2004)	85
Figure 4.6	Percentages of Year 12 Students Enrolling in VCE Unit 4 Mathematics by Sector (2004).....	86
Figure 4.7	Percentages of Year 12 Students Enrolling in VCE Unit 4 Science (2000 to 2004).....	87
Figure 4.8	Percentages of Year 12 Students (Males) Enrolling in VCE Unit 4 Science (2000 to 2004).....	89
Figure 4.9	Percentages of Year 12 Students (Females) Enrolling in VCE Unit 4 Science (2000 to 2004).....	89

Figure 4.10	Percentages of Year 12 Students Enrolling in VCE Unit 4 Science by Region (Metropolitan) (2004)	90
Figure 4.11	Percentages of Year 12 Students Enrolling in VCE Unit 4 Science by Region (Non-Metropolitan) (2004)	91
Figure 4.12	Percentages of Year 12 Students Enrolling in VCE Unit 4 Science by Sector (2004)	92
Figure 4.13	Award Course Completions for All Domestic Students by State and Broad Science Related Field of Education (2003)	93
Figure 4.14	University Completions by Field of Study (%) (2003)	94
Figure 5.1	Percentage of Year 3 Students Achieving the Numeracy Benchmark by State and Territory (2003)	100
Figure 5.2	Percentage of Year 5 Students Achieving the Numeracy Benchmark by State and Territory (2003)	101
Figure 5.3	Percentage of Year 7 Students Achieving the Numeracy Benchmark by State and Territory (2003)	102
Figure 5.4	Percentage of Students at or above Scientific Literacy Proficiency Levels by State and Territory (2003)	105
Figure 5.5	Student Performance in Overall Mathematical Literacy for all Countries (2003)	108
Figure 5.6	Proficiency Levels on the Overall Mathematical Literacy and the Mathematics Subscales (Australia) (2003)	109
Figure 5.7	Proficiency Levels on the Overall Mathematical Literacy for Australian States (2003)	110
Figure 5.8	Student Performance in Overall Scientific Literacy for all Countries (2003)	112
Figure 5.9	Multiple Comparisons of Overall Scientific Literacy Performance by Jurisdiction (2003)	113
Figure 5.10	Proportion of Year 4 Students Reaching International Mathematics Benchmarks (2002)	115
Figure 5.11	Proportion of Year 8 Students Reaching International Mathematics Benchmarks (2002)	117

Figure 5.12	Proportion of Year 4 Students Reaching International Science Benchmarks (2002)	119
Figure 5.13	Proportion of Year 8 Students Reaching International Science Benchmarks (2002)	121
Figure 6.1	Percentage of Year 12 Students Studying Science by Socioeconomic Status (2001)	126
Figure 6.2	Index of Relative Socio-Economic Advantage/Disadvantage by School Sector (%) (2001)	130
Figure 6.3	Profile of Schools Participating in Mathematics and Science Enrichment Programs by School Sector (%) (2003 to 2005).....	131
Figure 6.4	Profile of Schools Visiting Melbourne-based Science Facilities by School Sector (%) (2003 to 2005).....	132
Figure 6.5	Profile of Schools Receiving Science Outreach Programs by School Sector (%) (2002 to 2005).....	133
Figure 6.6	Profile of Schools Visiting Melbourne-based Science Facilities by Region (%) (2003 to 2005)	149
Figure 6.7	Profile of Schools Participating in Mathematics or Science Enrichment Programs by Region (%) (2003 to 2005).....	149
Figure 6.8	Profile of Schools Participating in Mathematics or Science Outreach Programs by Region (%) (2003 to 2005).....	150
Figure 8.1	Employment of (FTE) Teachers in Victoria (2003)	201
Figure 8.2	Proportion of Victorian Government School Teachers by Age Group (2003).....	202
Figure 8.3	Government Secondary Schools Experiencing Difficulty Recruiting Mathematics Teachers by Local Government Areas (2002 to 2004)	207
Figure 8.4	The Most Important Motivations for Becoming a Teacher (Australia) (2002)	210
Figure 8.5	Comparison of the Student Contribution Charge to Qualify as a Secondary Teacher (2006).....	218

List of Abbreviations

AAMT	Australian Association of Mathematics Teachers
ABS	Australian Bureau of Statistics
ACE	Adult Community Education
ACER	Australian Council for Educational Research
ACFE	Adult, Community and Further Education
ACU	Australian Catholic University
AIM	Achievement Improvement Monitor
AIP	Australian Institute of Physics
AMC	Australian Mathematics Competition
AMOP	Australian Mathematical Olympiad Program
AMSI	Australian Mathematical Sciences Institute
AMT	Australian Mathematics Trust
AMTA	Australian Mathematics Teachers Association
ANU	Australian National University
ASISTM	Australian School Innovation in Science, Technology and Mathematics
ASTA	Australian Science Teachers Association
BISTMT	Boosting Innovation, Science, Technology and Mathematics Teaching
CAS	Computer Algebra Systems
CECV	Catholic Education Commission of Victoria
CGS	Commonwealth Grant Scheme
CREST	CREativity in Science and Technology
CSF	Curriculum Standards Framework
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSIRO SEC	CSIRO Science Education Centre

DE&T	Department of Education and Training
DEST	Department of Education, Science and Training
DEWR	Department of Employment and Workplace Relations
DIIRD	Department of Innovation, Industry and Regional Development
ENTER	Equivalent National Tertiary Entrance Ranking
EYNP	Early Years Numeracy Program
FTE	Full-time Equivalent
GCE	General Certificate of Education (UK)
GTAC	Gene Technology Access Centre
HECS	Higher Education Contribution Scheme
ICE-EM	International Centre of Excellence for Education in Mathematics
ICT	Information and Communications Technology
IEA	International Association for the Evaluation of Educational Achievement
IMO	International Mathematical Olympiad
IMYMS	Improving Middle Years Mathematics and Science
KLA	Key Learning Area
KPM	Key Performance Measure
LLEN	Local Learning and Employment Network
MAV	Mathematical Association of Victoria
MCEETYA	Ministerial Council on Education, Employment, Training and Youth Affairs
MERGA	Mathematics Education and Research Group of Australasia
MTQ	Mathematics Talent Quest
MYPRAD	Middle Years Pedagogy Research and Development
NEiTA	National Excellence in Teaching Awards

NIAS	National Innovation Awareness Strategy
NMTQ	National Mathematics Talent Quest
OECD	Organisation for Economic Co-operation and Development
OHS	Occupational Health and Safety
PEEL	Program for Enhancing Effective Learning
PISA	Programme for International Student Assessment
PMSEIC	Prime Minister's Science, Engineering and Innovation Council
PoLT	Principles of Learning and Teaching
PTRA	Physics Teaching Resource Agents (US)
QUT	Queensland University of Technology
SEIFA	Socio-Economic Indexes for Areas
SINE	Success in Early Numeracy Education
SIS	School Innovation in Science
SIT	School Innovation in Teaching
SMET	Science, Mathematics, Engineering and Technology
SRS	Student Research Scheme
STAR	Science Technology Awareness Raising
STAV	Science Teachers' Association of Victoria
STI	Science, Technology and Innovation
STNI	State Territory Nominated Independent
STS	Science Talent Search
TAFE	Technical and Further Education
TIMSS	Trends in International Mathematics and Science Study
TQELT	Teacher Quality and Educational Leadership Taskforce
VCAA	Victorian Curriculum and Assessment Authority

VCAL	Victorian Certificate of Applied Learning
VCE	Victorian Certificate of Education
VELS	Victorian Essential Learning Standards
VET	Vocational Education and Training
VICS	Victorian Institute for Chemical Sciences
VIT	Victorian Institute of Teaching
VQA	Victorian Qualifications Authority
VSIC	Victorian Schools Innovation Commission

1. Introduction

Vision for Mathematics and Science Education

The Education and Training Committee's vision for mathematics and science education is:

for Victorian students to achieve a level of mathematical and scientific literacy that matches the best in the world by 2020 and to increase the proportion of our highest achievers pursuing these disciplines for the advancement of Victoria's economic, social, cultural and environmental goals.

Mathematics and science education plays a crucial role in the development of individuals equipped to function in a society underpinned by science and technology. Citizens must be able to acquire and use science and technology information to inform their day-to-day decision making. This includes decisions about the consumer items they purchase, foods they eat, medical treatments they require and a range of other issues including approaches to the environment, infrastructure, energy supply and occupational health and safety. Scientific literacy is also a key component informing business and investment decisions and allowing community and political debate regarding the use of emerging science and technologies within our community. Mathematics and science skills are therefore part of a broader skill set that can assist young people in further education, participation in home and life activities and obtaining employment.¹ Significantly, students with a mathematics and science background in Year 12 have been found to be more likely to enter higher education than other Year 12 students.²

High quality educational outcomes in mathematics and science are also important in ensuring growth in new industry fields of science, technology and innovation. Of particular importance is the growth in the innovation economy sectors such as advanced manufacturing and processing (including automotive, aerospace and food), biotechnology, nanotechnology, financial services, design, logistical supply, information and communications technology (ICT) and research and

¹ Australian Bureau of Statistics 2005, *Australian Social Trends*, 'Education and Training: School students mathematics and science literacy', Canberra, (Catalogue 410.0).

² S. Lamb & K. Ball 1999, 'Curriculum and Careers: The education and labour market consequences of Year 12 subject choice', *Longitudinal Surveys of Australian Youth Research Report No. 12*, ACER, Camberwell, cited in ABS, *Australian Social Trends*, 'Education and Training: School students mathematics and science literacy', Canberra, (Catalogue 410.0).

development based knowledge generation and commercialisation. Developing, for the future, the technical expertise in these areas will ensure that Victoria remains nationally and internationally competitive and that it continues to attract high quality investment to the State. Effective mathematics and science education in all school sectors constitutes the first stage in the development of the highly skilled and talented workforce required by Victoria's rapidly expanding innovation economy.

The Committee found that Victoria is achieving some excellent mathematics and science education outcomes. The Committee heard that the science curriculum is interesting and engaging for many students. It also heard that the teaching workforce is generally highly skilled and motivated and demonstrating excellent teaching practice in the classroom. However, exceptions to this are obvious and there is a clear need for greater consistency in mathematics and science education, if Victoria is to achieve its goals.

The Committee's inquiry identified a need for increased participation and higher standards in mathematics and science education in schools, as well as increased participation in these disciplines within universities. Increased levels of participation will contribute to the development of a future generation with the high levels of mathematical and scientific literacy required to engage as a constructive, concerned and reflective citizen. The Committee also found a need for an increased proportion of the highest mathematics and science achievers to actively pursue mathematics and science knowledge, learning and debate to ensure the future economic, environmental, social and cultural development of the State.

It is within this context that the Committee developed its vision for mathematics and science education; to help give purpose, direction and drive to mathematics and science education in Victoria.

Functions of the Committee

The Education and Training Committee comprises seven Members of Parliament, with five drawn from the Legislative Assembly and two from the Legislative Council. Mr Steve Herbert MP chairs the Committee.

The Education and Training Committee is constituted under the *Parliamentary Committees Act 2003*. The Committee's specific function under the Act is to:

Inquire into, consider and report to the Parliament on any proposal, matter or thing concerned with education or training if the Committee is required or permitted so to do by or under the Act.

Terms of Reference

On 27 July 2004, the Education and Training Committee received a reference to inquire into, consider and report on opportunities to promote maths and science in Victorian education. Specifically, the Committee was requested to:

- Determine which factors will support high quality teaching and learning of mathematics and science including teaching method and environment, subject knowledge, pedagogy and teaching expertise.
- Examine national and international trends and report on innovative initiatives that promote the teaching and learning of maths and science.
- Determine how best practice in teaching of maths and science can be shared among schools and other education communities and identify other opportunities for cross government action.
- Determine how new business, industry and research applications of mathematics and science can be integrated into schools and learning communities.
- Examine the potential for greater cross-sectoral links between industry, tertiary and training institutions and schools in the promotion of mathematics and science education.
- Examine gender issues in the teaching and learning of mathematics and science education.
- Considers ways of promoting greater interest by suitably qualified people to undertake mathematics and/or science teaching careers.

The Committee advertised for submissions in October 2004 and commenced work on the inquiry in March 2005. In August 2005, a request was made to revise the reporting date from September 2005 until February 2006.

Inquiry Methodology

Call for Submissions

In October 2004, the Committee advertised the terms of reference for this inquiry in *The Age* and the *Herald Sun*, both in the early general news section and the education specific lift-out of each paper. Further advertisements were placed in *The Age* and *Herald Sun* in June 2005, as well as in the Victorian Department of Education and Training's *Education Times*, all Leader newspapers (covering metropolitan regions) and the Mighty V Network of newspapers, which includes the *Albury Wodonga Border Mail*, *Ballarat Courier*, *Bendigo Advertiser*, *Geelong Advertiser*, *La Trobe Valley Express*, *Shepparton News*, *Mildura Sunraysia Daily* and the *Warrnambool Standard*.

Additionally, over 300 targeted stakeholders and experts were invited to make submissions to the inquiry.

Seventy written submissions were received by the Committee from a wide range of stakeholders (refer Appendix A). These included the Victorian Government, teacher education providers, primary and secondary schools, the vocational education and training (VET) sector, mathematics and science associations, special interest groups and current teachers, including some previous winners of the BHP Billiton Science Awards or the National Excellence in Teaching Awards. In addition, the Committee collected a large volume of supplementary material from around Victoria, interstate and overseas, including detailed data, past research and published reports, curriculum documents, academic papers and other materials.

Research Undertaken by the Committee

Prior to commencing formal hearings the Committee was briefed on the context surrounding mathematics and science education by the Minister for Education and Training, the Hon. Lynne Kosky, as well as senior officers within the Department of Education and Training and the Department of Innovation, Industry and Regional Development.

An extensive series of formal hearings and site visits took place during the period April 2005 – August 2005 (refer Appendix B). Nearly 230 witnesses gave evidence to the inquiry. In addition to the public hearings conducted in Melbourne, school and industry forums were conducted at Balwyn High School, Bendigo Town Hall, Montmorency Secondary College, Templestowe College, Parkdale Secondary College and Shepparton Science and Technology Centre. Additional informal consultations with teachers and students took place at Eaglehawk Primary School, Eltham High School, McGuire College, Mt Eliza Primary School, Kangaroo Flat Secondary College and St Helena Secondary College. The Committee also visited the Gene Technology

Access Centre, Melbourne CSIRO Science Education Centre, Australian Synchrotron Project, Scienceworks Museum and the Bendigo Science and Discovery Centre. During its interstate investigations, the Committee conducted meetings with recognised authorities in the areas of mathematics and science education and visited Lynwood Senior High School, Kent Street Senior High School and SciTech in Perth (refer Appendix C).

In addition to the above Committee activity, staff of the Committee met with Department of Education and Training regional science co-ordinators at Nunawading Primary School and academics at La Trobe University (Bendigo). They also attended the Science Talent Search (La Trobe University, Bundoora), Questacon Science Circus (Mt Eliza Primary School) and Questacon public traveling exhibition (Geelong).

In order to gain a comprehensive understanding of the accessibility of various mathematics and science education and awareness programs throughout Victoria, the Committee also undertook original data analysis. The Committee's analysis involved two key stages.

The first stage involved categorising Victorian schools along a variety of dimensions. These included school type (primary, secondary and primary/secondary), school sector (government, Catholic and independent), location (postcode and Department of Education and Training region) and, for government schools, their Department of Education and Training 'Like School Group' category. For schools offering the Victorian Certificate of Education (VCE), indicators of academic performance published by the Victorian Curriculum and Assessment Authority were also linked to each school. These indicators included the proportion of successful VCE completions, mean study score, proportion of study scores of 40+ and the proportion of students applying to university. Each school's postcode was also linked to the Australian Bureau of Statistics Socio Economic Indexes for Areas (SEIFA) 2001 (refer Appendix D).

The second stage involved identifying schools that had participated in a broad range of mathematics and science education and awareness programs over recent years. A list of programs for which data was obtained is contained at Appendix E. By entering this information into the schools database created in stage one of the analysis it was possible to profile schools that accessed a large number of programs against a broad range of variables. The results of this analysis are largely contained in Chapter 6.

Conferences

In July 2005, representatives of the Committee attended the *Australian Science Teachers Association 54th Conference* at the University of Melbourne (4–7 July) and the *Mathematics Education Research Group of Australasia (MERGA) Conference* at RMIT University (7–9 July). In November 2005, representatives of the Committee attended the *Science Teachers Association of Victoria Conference*, held at La Trobe University, Bundoora (24–25 July).

Member's Study Tour

During June and July 2005, Committee member, the Hon. Helen Buckingham MLC, undertook a study tour that investigated mathematics and science initiatives in England, Scotland and France. The study included meetings with key authorities within the government and higher education sectors (refer Appendix F).

A detailed written report is available from the Parliamentary Library. An oral presentation of the key points arising from the meetings was presented to the Committee.

Evidence to the Inquiry

Realisation of the Committee's vision for mathematics and science education requires that these subjects are given a high priority in all primary and secondary schools in each education system throughout Victoria. In conducting this inquiry, the Committee has considered a wide range of factors that support high quality teaching and learning of mathematics and science. These included:

- students and student engagement and how these issues differ among different student cohorts and change as students move through the education system;
- school systems and structures, including school design and classrooms and laboratories;
- partners in mathematics and science education, including parents, industry, community and professional associations;
- special considerations for rural and regional delivery; and
- teacher education, professional development and career structures.

Central to addressing many of the above issues is the need to consider mathematics and science education as independent disciplines. While

the complementary nature of these two subjects results in some similarities in issues examined by the Committee, there were also many issues specifically relevant to either mathematics or science, as well as many that were specific to either the primary or secondary school sector. Teaching and learning in mathematics and science are very different pedagogically and are organised and funded separately in most schools.

One of the arguments supporting the need to consider the mathematics and science disciplines separately is the ongoing expansion in the role of mathematics in many branches of knowledge other than science and engineering. Traditionally, there has been a considerable amount of quantitative work required in both physics and chemistry. The Australian Mathematical Sciences Institute further argued that some other sciences, including biology and environmental science, are also becoming highly mathematical.³ However, as noted by a number of stakeholders, we now also have many non-science disciplines that are increasingly reliant on sound understanding of mathematical concepts and skills. These include, for example, econometrics, demography, epidemiology, market research, financial mathematics, operations research and forecasting.

It should be noted that mathematics is not only a foundation subject for future studies and participation in society, but also a cumulative discipline. This means that if learning of core concepts is interrupted or disrupted at any stage, it can be very difficult for a student to adequately grasp successive topics. The Committee heard of many examples of students simply 'giving up' in mathematics very early in their education, because even a relatively short disruption such as that caused by illness, change of school or family circumstance, resulted in a gap in knowledge and subsequent loss of confidence. The Committee is also aware that occasionally some students simply fail to acquire a firm grasp of a concept in the time available; a particular problem within subjects of a sequential nature. Therefore, strategies to address knowledge gaps and student re-engagement in mathematics are an additional consideration in the context of this inquiry.

The Committee received more evidence in relation to science education than mathematics education. This can be explained by a number of factors. First, mathematics is a foundation subject that has traditionally been afforded greater priority throughout primary and secondary school. Mathematics also typically has a high level of participation through to Year 12 and therefore enrolments in mathematics were not of as great a concern to participants as enrolments in science subjects. Secondly, science is a broad area that has traditionally encompassed physics, chemistry, biology, environmental science and more recently, psychology. This has broadened the stakeholder base for science compared with

³ Written Submission, Australian Mathematical Sciences Institute, January 2005, p.1.

mathematics. Thirdly, science teaching is typically supported by a broad range of resources, including dedicated classrooms and laboratories, special allowances for equipment and materials, special safety requirements and the provision of technical assistance. All of these factors were the subject of evidence throughout this inquiry.

Additionally, the Committee received a substantial volume of evidence about new areas of science and the challenges associated with ensuring the science curriculum, student assessment, teacher training and professional development all keep up with the rapid advancement in scientific knowledge and theory. Some of these new or innovative areas of science identified throughout the inquiry include bioinformatics, nanotechnology, microtechnology, biotechnology, genomics, proteomics, neuroscience, neuropsychopharmacology, space science, robotics, medical science, cosmology, aerospace, alternative energy, photonics, relativity and 'synchrotron science'.

Definitions

Mathematics

The Commonwealth Department of Education, Science and Training has defined mathematics as:

Mathematics is the study of measurement, properties, and relationships of quantities and sets using numbers and symbols. It is a key learning area encompassing numeracy and related communication, cognition and problem solving. Mathematics is a study that develops logical reasoning and skills in communication, and uses written, spoken and visual symbols. While mathematics is a discrete learning area, it is often informed by or directed through other disciplines.⁴

Current national and international mathematics education literature often talks about the concept of mathematical literacy. The Organisation for Economic Co-operation and Development (OECD) defines mathematical literacy as:

[The] capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen.⁵

⁴ Department of Education, Science & Training 2005, *Boosting Innovation, Science, Technology and Mathematics Teaching: External Programme Guidelines 2004–05 to 2010–11*, DEST, Canberra, p.6.

⁵ S. Thomson, J. Cresswell & L. De Bortoli 2004, *Facing the Future: A focus on mathematical literacy among Australian 15-year-old students in PISA 2003*, ACER, p.5.

It is important to note that the term 'numeracy' is widely used in Britain, Australia and New Zealand to define the above concept, while educators in other countries sometimes adopt terms such as 'school mathematics' or 'quantitative literacy' to mean the same thing. For example, the Australian Association of Mathematics Teachers adopts the following definition of numeracy in its policy on numeracy education in schools:

To be numerate is to use mathematics effectively to meet the general demands of life at home, in paid work, and for participation in community and civic life.

In school education, numeracy is a fundamental component of learning, performance, discourse and critique across all areas of curriculum. It involves the disposition to use, in context, a combination of:

- Underpinning mathematical concepts and skills from across the discipline (numerical, spatial, graphical, statistical and algebraic);
- Mathematical thinking and strategies;
- General thinking skills; and
- Grounded appreciation of context.⁶

The Committee acknowledges that the term 'numeracy' has been often debated and has evolved over time. Similarly, debate has occurred regarding distinctions between terms such as 'numeracy' and newer alternatives such as 'mathematical literacy'. While in Britain there has been a tendency to equate 'numeracy' with number, a broader meaning has tended to be adopted in Australia, which is more in keeping with the term 'mathematical literacy' as used in many OECD countries. Therefore, for consistency with current national and international trends, the Committee has adopted the term 'mathematical literacy', as defined by the OECD throughout this inquiry.

Science

According to the Commonwealth Department of Education, Science and Training, science can be defined broadly as:

[The] observation, identification, description, experimental investigation, and theoretical explanation of phenomena. This definition relates to science as a key learning area that includes chemistry, biology, environmental science and physics. Science is applied

⁶ Australian Association of Mathematics Teachers 1998, *Policy on Numeracy Education in Schools*, AAMT, Adelaide, p.2.

through, and builds on inquiry and knowledge from, other disciplines.⁷

In addition to the key learning areas identified in the definition above, psychology is considered a science subject at Year 12 in Victoria as well as at some universities. This report, however, focuses predominantly on the enabling sciences of physics and chemistry and to a lesser extent, on biology and environmental science. This does not mean to imply that the Committee fails to recognise the importance, relevance or value of psychology as a science discipline. Rather, the inquiry received little evidence regarding the key learning area of psychology, perhaps because it is currently experiencing high levels of enrolments at Year 12, in contrast to the other sciences, which are experiencing either stable enrolments or an ongoing decline in enrolments.

Enhancing the definition of science as stated above, the concept of scientific literacy is of increasing significance worldwide. The OECD defines scientific literacy as:

The capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity.⁸

The Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA) expands this definition of scientific literacy in the 2003 *National Year 6 Science Assessment Report*, stating:

[Scientific literacy] is the application of broad conceptual understandings of science to make sense of the world, understand natural phenomena and interpret media reports about scientific issues. It also includes asking investigable questions, conducting investigations, collecting and interpreting data and making decisions.⁹

The Committee views each of the above definitions as complementary and consistent with concepts and meanings of scientific literacy as discussed in evidence to this inquiry.

⁷ Department of Education, Science & Training 2005, *Boosting Innovation, Science, Technology and Mathematics Teaching: External Programme Guidelines 2004–05 to 2010–11*, DEST, Canberra, p.6.

⁸ S. Thomson, J. Cresswell & L. De Bortoli 2004, *Facing the Future: A focus on mathematical literacy among Australian 15-year-old students in PISA 2003*, ACER, Melbourne, p.6.

⁹ Ministerial Council on Education, Employment, Training & Youth Affairs 2004, *National Year 6 Science Assessment Report*, MCEETYA, Melbourne, p.ix.

Enabling Sciences

Much evidence received by the Committee focused on issues associated with the 'enabling sciences', which are broadly considered to be the fundamental sciences essential to scientific discovery, technological advancement and innovation within emerging scientific fields. The definition of 'enabling science' varies somewhat throughout the relevant literature.

The Enabling Sciences Education Research Network defines the enabling sciences as 'mathematics, science and information and communications technology'. It considers all three as essential elements for technological advancement, economic prosperity and quality of life.¹⁰ The Commonwealth Committee for the Review of Teaching and Teacher Education took a different approach, considering physics, chemistry, biology and mathematics to comprise the enabling sciences.¹¹

Unless otherwise stated, the Committee's discussion of 'enabling sciences' refers to physics, chemistry and advanced mathematics. This is consistent with the definition adopted by the Australian Council of Deans of Science.¹² Where evidence referred to relates to a broader definition of 'enabling science', this has been noted.

¹⁰ Information on enabling science was obtained from the the Enabling Sciences Education Research Network website, <<http://scs.une.edu.au/EnSE/aims.html>>, accessed on 11 February 2006.

¹¹ Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Main Report*, Commonwealth of Australia, Canberra, p.33.

¹² Australian Council of Deans of Science 2003, *Is the Study of Science in Decline?*, ACDS Occasional Paper No. 3, ACDS, Melbourne, p.7.

2. Context for the Inquiry

Introduction

Much has been written about the need for sustained innovation as the key to future growth and prosperity in a competitive global economy. The commonwealth government and various state governments have therefore directed much policy attention to building a culture of continuous innovation through education, as well as through a broad range of initiatives supporting industry, research and development.

Many witnesses and submissions highlighted a number of innovative practices, high quality teaching and excellent outcomes being achieved in mathematics and science education in many Victorian schools. As the Committee noted during the inquiry:

... the quality of teaching of our best teachers and the quality of our best students is actually better than it ever was. We should not sit here thinking the whole system is terribly bad; that is not the case.¹³

Nonetheless, the Committee heard that there was much scope for further improvement in mathematics and science education in Victoria. Opportunities for improvement that were identified by many submissions and witnesses can be summarised as follows:

- Increasing the proportion of students who complete Year 12 studies in the enabling sciences.
- Increasing the proportion of students pursuing university studies or careers in the mathematics and science disciplines.
- Increasing the numbers of highly trained teachers in science, technology and mathematics.
- Reducing the inequities in where specialist mathematics and science teachers are located throughout Victoria.
- Increasing the amount of time and attention given to science education in primary schools.

¹³ Mr P. Ryan, Chief Executive Officer, Goulburn Ovens Institute of TAFE, Transcript of Evidence, Public Hearing, Shepparton, 2 August 2005, p.47.

- Addressing the inadequacy of some primary teachers' background and preparation to teach science studies arising due to the varying levels of participation and achievement among primary teachers in science during their schooling, as well as the inadequacy of some current teacher education programs in preparing teachers for teaching primary school science effectively.
- Addressing the continued disengagement of many students from science and mathematics studies early in their secondary schooling.
- Increasing the level of appreciation among students, teachers and parents about the importance of continuing with mathematics and science studies for those seeking careers within vocational areas.
- Ensuring science teaching emphasises the need to develop high levels of scientific literacy among all students, rather than simply preparing students for university level studies in science disciplines. This requires use of teaching strategies aimed at stimulating curiosity, problem solving and continued engagement in science among a diverse range of students.
- Taking greater account of the rapid advancement in scientific knowledge and how secondary teachers, in particular, can maintain the required breadth and depth of knowledge to teach our future innovators effectively.
- Addressing continued imbalances in levels of participation and achievement in mathematics and science among various student population sub-groups.

The following chapter offers a summary of the industry and policy contexts surrounding the above issues. Further chapters elaborate on some of the issues, together with examples of specific, innovative initiatives being implemented to promote the teaching and learning of mathematics and science in Victorian schools.

Industry Needs for Mathematics and Science Education

Fostering a high performing and skilled workforce to meet the needs of industry is a key government objective within both the state and national policy arenas. Thus, the mathematics and science education needs of the business, industry and research sectors were a central theme throughout this inquiry. Much evidence from these sectors focused on current and future needs for specific, high-level mathematical and scientific qualifications. Evidence also highlighted the tendency for many students, teachers and parents to underestimate the need to understand various principles of mathematics and science when pursuing a broad range of trades (refer below). Additionally, the importance of a high level of mathematical and scientific literacy among the broader workforce was also recognised. For example, in-depth knowledge and understanding of mathematical and scientific concepts could be applied directly in careers as diverse as law and journalism. High levels of mathematical and scientific literacy are also useful in facilitating effective communication and collaboration between specialists and generalists in a rapidly advancing economy.

Demand for Mathematics, Science and Technology Workers

Worldwide demand for appropriately qualified and/or skilled mathematics, science and technology workers is increasing. Over the past decade tertiary trained researchers in OECD countries increased by one million, or 42 per cent, and the rate of growth is predicted to increase in the short to medium term.¹⁴ Employment growth in science and technology in Australia has averaged 3.2 per cent, the highest rate in any sector and far in excess of the Australian average of 1.1 per cent.¹⁵ It is anticipated to remain at this or higher levels for the next few years.¹⁶ The Queensland Chief Scientist has predicted that an additional 75,000 research scientists will be required in Australia, although supply is a factor of 10 below this.¹⁷

There are strong indications that future needs for science and technology workers will not be fully met. The OECD estimates that knowledge and skills gained from formal science or engineering training are needed by 20 to 35 per cent of a country's workforce.¹⁸ The US Government estimates that in the coming decade, new and expanding technologies will account for 80 per cent of new jobs, with the majority of these requiring a mathematics and science

¹⁴ Ms J. Niall, Deputy Secretary, Business Development, Department of Innovation, Industry & Regional Development, Transcript of Briefing, Melbourne, 29 April 2005, p.2.

¹⁵ *ibid.*

¹⁶ *ibid.*

¹⁷ *ibid.*

¹⁸ *ibid.*

background.¹⁹ The Victorian Department of Innovation, Industry and Regional Development similarly estimates that 60 per cent of all new jobs early in the 21st century will require mathematics and science skills, which are possessed by only 20 per cent of the current workforce.²⁰ Of particular note in Victoria is the growth in innovation economy sectors such as advanced manufacturing and processing, biotechnology, nanotechnology, financial services, design, logistical supply, information and communication technology (ICT) and research and development based knowledge generation and commercialisation. The State Government estimates that Victoria will require an additional 18,000 science and technology workers within the emerging small technology and biotechnology sectors alone.²¹

Traditional industry sectors are also increasingly dependent on high quality educational outcomes in mathematics and science. As noted by Mr John Werry, Manager, Emerging Skills, Department of Innovation, Industry and Regional Development:

... 20 years ago if you wanted to be a car mechanic, you did not have to worry about computing, information technology, GPS [global positioning system], micro sensors or any of that. I find it very difficult to believe that people would be able to work in high-tech advanced manufacturing without a strong level of maths and science.²²

The Victorian Automotive Industry Training Board similarly stated in a written submission:

The Victorian Automobile Chamber of Commerce, the peak employer body, has been concerned for a number of years at the poor level of technology understanding, mathematics and science demonstrated by school leavers wishing to enter the automotive industry through apprenticeship.²³

Ms Sandy Roberts, General Manager, Central Victorian Group Training Company, also raised concerns about the level of mathematics and numeracy skills among young people seeking to enter a trade:

One of the criticisms we get from builders, for example, is that kids do not know their tables; they cannot instantaneously do a calculation ... which is very frustrating for a builder who wants instant calculations

¹⁹ *ibid.*

²⁰ *ibid.*

²¹ *ibid.*

²² Transcript of Briefing, Melbourne, 29 April 2005, p.6.

²³ Written Submission, Victorian Automotive Industry Training Board, November 2004, p.1.

and measurements. That is not uncommon; it is common right throughout all the trades.²⁴

Australia's then Chief Scientist, Dr Robin Batterham also emphasised the importance of mathematics and science studies to a broad student cohort, noting that despite differences between the old and new economic paradigms, Australia's traditional economic base depends heavily on the knowledge base that supports it. Therefore, science capability is crucial to both the development of the new economy and the competitiveness of existing industries.²⁵

The issue of effective career advice is therefore an important one and is addressed in Chapter 7.

Current Shortages in Supply of Mathematics, Science and Technology Workers

Exacerbating concerns regarding our capacity to meet the future needs for a workforce skilled in mathematics, science and technology related areas, are widespread shortages in many existing trades and professions. The Victorian Department of Innovation, Industry and Regional Development reported that there is currently a worldwide shortage of engineers, chemists and physical scientists.²⁶ Engineers Australia also noted that compared with OECD countries, Australia produces a very low number of engineers per head of population, dramatically fewer than Singapore, Korea, Japan, Finland, Denmark, Taiwan, Norway, Germany, Ireland, Switzerland, the United Kingdom and France.²⁷

Both the Commonwealth Government and the State Government publish lists of skills shortages in Victoria. As shown in Figure 2.1, the majority of professions experiencing shortages in Victoria require a high level mathematics and/or science background.

²⁴ Transcript of Evidence, Public Hearing, Bendigo, 1 August 2005, p.6.

²⁵ R. Batterham 2000, p.7, cited in Australian Council of Deans of Science 2000, *What Did You Do With Your Science Degree?: A national study of employment outcomes for Science degree holders 1990–2000* prepared by C. McInnis, R. Harley & M. Anderson, ACDS, Melbourne, p.2.

²⁶ Ms J. Niall, Deputy Secretary, Business Development, Department of Innovation, Industry & Regional Development, Transcript of Briefing, Melbourne, 29 April 2005, p.2.

²⁷ Ms K. Hurford, Associate Director Public Policy, Engineers Australia, Transcript of Evidence, Public Hearing, Melbourne, 31 August 2005, p.9.

Figure 2.1: Skills Shortages – Australia and Victoria (Professions), 2005

DEWR Skills in Demand List – Victoria (2005) ^a	Migration Occupations in Demand List (2005) ^b	Victorian Skills in Demand List (2005) ^c
Accountant	Accountant	Accountant
Audiologist	Anaesthetist	Biomedical Engineer
Civil Engineer	Chemical Engineer	Chemist
Dentist	Civil Engineer	Child Care Coordinator
Electrical Engineer	Dental Specialist	Civil Engineer
Enrolled Nurse	Dentist	Dentist
Lawyer	Dermatologist	Electrical Engineer
Mental Health Nurse	Emergency Medicine Specialist	Electronics Engineer
Nuclear Medicine Technologist	General Medical Practitioner	Engineer – Engineering Technologists
Occupational Therapist	Hospital Pharmacist	Environmental Health Officer
Pharmacist	Medical Diagnostic Radiographer	Extractive Metallurgist
Physiotherapist	Mining Engineer	General Mechanical Engineering Tradesperson
Podiatrist	Nuclear Medicine Technologist	Hospital Pharmacist
Range of ICT Specialisations	Obstetrician and Gynaecologist	Life Scientist (Biotechnology)
Registered Midwife	Occupational Therapist	Mathematician
Registered Nurse	Ophthalmologist	Mining Engineer
Secondary Teachers – Manual Arts/Tech Studies, Physics, Mathematics, LOTE, Information Technology	Paediatrician	Natural and Physical Science Professionals
Social Worker	Pathologist	Occupational Therapist
Speech Pathologist	Petroleum Engineer	Physicists
Urban and Regional Planner	Physiotherapist	Physiotherapist
	Podiatrist	Podiatrist
	Psychiatrist	Pre-Primary School Teacher (Kindergarten Teacher)
	Radiation Therapist	Radiography
	Radiologist	Range of ICT Specialisations
	Registered Mental Health Nurse	Registered Mental Health Nurse
	Registered Midwife	Registered Midwife
	Registered Nurse	Registered Nurse
	Retail Pharmacist	Research & Development Manager (Biotechnology)
	Sonographer	
	Specialist Medical Practitioners	
	Specialist Physician	
	Speech Pathologist	

Figure 2.1: Continued...

DEWR Skills in Demand List – Victoria (2005) ^a	Migration Occupations in Demand List (2005) ^b	Victorian Skills in Demand List (2005) ^c
	Surgeon	Retail Pharmacist Secondary School Teachers – LOTE, Technology Studies, IT, Mathematics, Physics (7–10) and Physical Education Speech Pathologist Statistician Urban and Regional Planner

Note: ^a Professions identified on the Department of Employment & Workplace Relations *Skills in Demand List*, October 2005.

^b List of professions in demand for migration purposes. These are occupations and specialisations identified by the Department of Employment & Workplace Relations as being in ongoing national shortage (as at November 2005). For further information, refer to the Department of Immigration & Multicultural Affairs website, <<http://www.immi.gov.au>>.

^c The *Skills in Demand List* identifies the occupations, including specialisations and sponsorship considerations, which are currently in demand in Victoria. The list is for occupations that are in shortage throughout Victoria (as at July 2005). Potential migrants with these skills may be eligible for sponsorship by the Victorian Government under the State/Territory Nominated Independent Visa. For further information, refer to the Live in Victoria website, <<http://www.liveinvictoria.vic.gov.au>>.

Source: Compiled by the Education and Training Committee.

In addition to skills shortages in the professions, there are also skills shortages in a wide range of trades (refer Figure 2.2). Most of these trades require at least a sound understanding of numeracy and basic mathematical applications. Others, however, including the electrical/electronic and engineering trades, require a more thorough understanding of a range of mathematical and/or scientific concepts.

Figure 2.2: Skills Shortages – Australia and Victoria (Trades), 2005

DEWR Skills in Demand List – Victoria (2005) ^a	Migration Occupations in Demand List (2005) ^b	Victorian Skills in Demand List (2005) ^c
Auto Electrician	Automotive Electrician	Automotive Electrician
Binder and Finisher	Bricklayer	Boat Builder and Repairer
Bricklayer	Cabinetmaker	Bricklayer
Cabinetmaker	Carpenter and Joiner	Cabinetmaker
Carpenter and Joiner	Cook	Carpenter and Joiner
Chef	Electrical Powerline Tradesperson	Chef
Cook	Electrician (Special Class)	Cook
Electrical Powerline Trades	Electronic Equipment Tradesperson	Electrical Powerline Tradesperson
Electronic Equipment Trades	Fibrous Plasterer	Electrician (Special Class)
Electronic Instrument Trades	Fitter	Electronic Equipment Trade
Fibrous Plasterer	Furniture Upholsterer	Electronic Instrument Tradespersons
Furniture Upholsterer	General Electrician	Fibrous Plasterer
Hairdresser	General Electronic Instrument Tradesperson	Fitter
Metal Fabricator	General Plumber	Furniture Upholsterer
Metal Fitter	Hairdresser	General Mechanical Engineering Tradesperson
Metal Machinist	Metal Fabricator (Boilermaker)	General Plumber
Motor Mechanic	Metal Machinist (First Class)	Hairdresser
Panel Beater	Motor Mechanic	Head Chef
Pastry Cook	Panel Beater	Metal Fabricator, Boilermaker
Plumber	Pastry Cook	Metal Machinist (First Class)
Refrigeration and Air-conditioning Mechanic	Refrigeration and Air-conditioning Mechanic	Motor Mechanic
Sheetmetal Worker	Sheetmetal Worker (First Class)	Nursery person
Solid Plasterer	Solid Plasterer	Panel Beater
Toolmaker	Toolmaker	Pastry Cook
Vehicle Painter	Vehicle Painter	Production Horticulture
Welder	Welder (First Class)	Refrigeration and Air-conditioning Mechanic

Figure 2.2: *Continued...*

DEWR Skills in Demand List – Victoria (2005) ^a	Migration Occupations in Demand List (2005) ^b	Victorian Skills in Demand List (2005) ^c
		Roof Slater and Tiler Sheet Metal Worker (First Class) Shipwright Solid Plasterer Toolmaker Vehicle Painter Welder (First Class)

Note: ^a Trades identified on the Department of Employment & Workplace Relations *Skills in Demand List*, October 2005.

^b List of trades in demand for migration purposes. These are occupations and specialisations identified by the Department of Employment & Workplace Relations as being in ongoing national shortage (as at November 2005). For further information, refer to the Department of Immigration & Multicultural Affairs website, <<http://www.immi.gov.au>>.

^c The *Skills in Demand List* identifies the occupations, including specialisations and sponsorship considerations, which are currently in demand in Victoria. The list is for occupations that are in shortage throughout Victoria (as at July 2005). Potential migrants with these skills may be eligible for sponsorship by the Victorian Government under the State/Territory Nominated Independent Visa. For further information, refer to the Live in Victoria website, <<http://www.liveinvictoria.vic.gov.au>>.

Source: Compiled by the Education and Training Committee.

Victorian Mathematics and Science Education Policy Setting

Mathematics and science have been afforded special priority within Victorian education over the past decade. The current Victorian Government's School Innovation in Science (SIS) program was the largest school science initiative of its kind in Australia for decades. The program was a major part of the Science in Schools initiatives developed by the Victorian Department of Education and Training, which, in turn, were part of the Victorian Government's science and technology strategy. The current Victorian Government also recognises the importance of mathematics and science education through *Growing Victoria Together*, the *Blueprint for Government Schools*, the *Science, Technology and Innovation* (STI) Initiative and a commitment to the *National Goals for Schooling in Australia*.²⁸ Similarly, the previous State Government's Science, Engineering and Technology Statement, *Creating Our Future*, incorporated a suite of programs and strategies

²⁸ Written Submission, Victorian Government, June 2005, pp.3–7.

targeted at science, engineering and technology within the industry, education and training sectors.

Growing Victoria Together

Growing Victoria Together sets out the Victorian Government's broad vision for the future. It identifies a range of important issues to be addressed in the pursuit of economic, social and environmental wellbeing. *Growing Victoria Together* was first released in 2001 and an updated version reflecting the changing environment was released in 2005.²⁹

As identified in the Victorian Government's written submission to this inquiry, *Growing Victoria Together* recognises the Victorian Government's commitment to achieving benefits for all Victorians through investment in education and emerging industries.³⁰ Two of the strategic issues outlined in *Growing Victoria Together* are of key relevance to this inquiry:

- Valuing and investing in lifelong education:

The Government believes that education is the key to our children's future and Victoria's prosperity. Education opens the doors to high quality jobs, to a full and creative life and a sense of common citizenship.³¹

- More jobs and thriving, innovative industries across Victoria:

The Government believes that the best way to generate high quality jobs across the State is to make full use of the abilities, skills and ideas of all Victorians. We are a creative, innovative and enterprising State. We need to build on our great strengths in the agricultural, food, manufacturing, medical research, tourism and cultural industries. At the same time we must develop our emerging strengths in new knowledge-based industries and jobs: information and communications, biotechnology, professional services, design, advanced manufacturing and environmental management.³²

²⁹ Refer Department of Premier & Cabinet website for further information, <<http://www.dpc.vic.gov.au>>.

³⁰ Written Submission, Victorian Government, June 2005, pp.4–5.

³¹ Department of Premier & Cabinet 2001, *Growing Victoria Together: Innovative State. Caring Communities*, State of Victoria, Melbourne, p.8.

³² *ibid.*, p.20.

Blueprint for Government Schools

The *Blueprint for Government Schools* (the Blueprint) outlines the Victorian Government's agenda for the government school system. Released in 2003, the Blueprint identifies three priority areas for reform:

- recognising and responding to diverse student needs;
- building the skills of the education workforce to enhance the teaching-learning relationship; and
- continuously improving schools.³³

The Blueprint articulates seven flagship strategies that encompass a range of initiatives aimed at ensuring that all schools actively pursue excellence in teaching and that learning outcomes for all students continue to improve. The Victorian Government identified for the Committee three Blueprint strategies, in particular, that contribute to systemic reforms that will support student performance in specific subject areas, including mathematics and science.³⁴ They are:

Flagship Strategy 1: Student Learning aims to develop a new approach to curriculum, standards and assessments that prepares students for life in the global knowledge economy.

Flagship Strategy 5: Teacher Professional Development seeks to enable teachers to enhance their content knowledge and develop the skills necessary to improve the teaching-learning relationship and student learning outcomes.

Flagship Strategy 7: Leading Schools Fund provides \$82 million to employ an extra 450 teachers in government secondary schools and \$80 million in capital for new or refurbished facilities to support the implementation of school and teacher effectiveness strategies.

The above three flagship strategies build on the capacity of the government school system to engage students in mathematics and science education. Collectively, these strategies facilitate the development and implementation of improved approaches to teaching and learning through sharing knowledge, professional learning, and research initiatives and through employing additional teachers and providing funding for improved facilities.

³³ Department of Education & Training 2003, *Blueprint for Government Schools: Future directions for education in the Victorian government school system*, DE&T, Melbourne, pp.2–4.

³⁴ Written Submission, Victorian Government, June 2005, p.5.

Science, Technology and Innovation Initiative

The Victorian Government has also made a commitment to science education through the Science, Technology and Innovation (STI) initiative. Funded through the Department of Innovation, Industry and Regional Development, STI has seen an investment of over \$900 million since 2000.³⁵ The initiative seeks to:

- build world class infrastructure to support innovation;
- develop the skills base to establish Victoria's international reputation as a leader in innovation through collaboration with education and industry sectors;
- provide strong leadership and investment to foster a culture of innovation in Victoria; and
- position Victoria as a nationally and internationally recognised leader in science, technology and innovation through celebrating our STI strengths and promoting our successes.³⁶

School mathematics, science and technology education underpins the above objectives, and contributes to them. Although most of the STI funding was directed towards infrastructure and targeted research, \$32 million has been allocated to the Department of Education and Training for its Science in Schools and School Innovation in Teaching initiatives.³⁷

School Innovation in Science

The Science in Schools Research Project was funded under STI over 2000–2002. The Project sought to identify approaches to enhancing the teaching and learning of science from Years Prep–10 and to raise the profile of science within government schools.

Project reports from primary schools involved in Science in Schools focused predominantly on evidence of increased teacher confidence and a willingness to talk about science and incorporate it into classroom practice. There was less emphasis on evidence of teacher change in terms of increased knowledge or teaching strategies.³⁸ Therefore, the focus of the Science in Schools Research Project in primary schools was on an increased amount of science taught and its

³⁵ *ibid.*, p.6.

³⁶ *ibid.*

³⁷ Ms J. Niall, Deputy Secretary, Business Development, Department of Innovation, Industry & Regional Development, Transcript of Briefing, Melbourne, 29 April 2005, p.3.

³⁸ Department of Education & Training 2005, *School Innovation in Teaching Handbook – Science, Mathematics and Technology*, DE&T, Melbourne, Section A (SIT:A).

acceptance as a mainstream responsibility and on better planning for the teaching of science. Secondary schools reported many similar instances of change as those seen in primary schools. However, there was a strong focus on changes to classroom teaching strategies and an increased emphasis on team planning and sharing ideas within secondary schools. There was less focus on teacher confidence and general competence in secondary schools.³⁹

The Research Project informed the School Innovation in Science (SIS) initiative, a multi-layered program designed to support the teaching of science and scientific literacy in Victorian government primary and secondary schools. In 2003, approximately 280 Victorian primary and secondary schools participated in SIS.

The SIS initiative is being extended during 2004–2007 to include mathematics and technology through the School Innovation in Teaching: Science, Maths and Technology (SIT) project.

School Innovation in Teaching: Science, Maths and Technology

The SIT Project sets out the Victorian Government's vision for school teaching in science, mathematics and technology. The vision encompasses the following concepts, as set out in the 2005 *SIT Handbook*:⁴⁰

- Science, mathematics and technology education in Victorian schools will encourage literacy for all as well as provide a sound basis for students to take up specific careers in science and technology.
- All schools will recognise the importance of science, mathematics and technology in each student's education. All students will have opportunities to develop an interest in, enthusiasm for, and understanding of, science, mathematics and technology and its importance in daily life and in their future wellbeing.
- Teachers will increasingly be enthusiastic and committed to the teaching of science, mathematics and technology. They will continue to develop their understanding and teaching of science, mathematics and technology and become more effective in supporting student learning and conveying the richness and relevance of science, mathematics and technology ideas.

³⁹ *ibid.*

⁴⁰ *ibid.*

- Classrooms will be innovative and active places, with strong links to the community and with a clear focus on supporting students to become autonomous thinkers and learners within a stimulating learning environment.
- Teachers will work together to develop a shared vision and program of science, mathematics and technology that will focus on deep understandings of teaching and learning principles, and will put science, mathematics and technology at the forefront of innovative thinking within schools and their communities.
- Teachers are to develop a deeper understanding of effective teaching, learning and assessment in science, mathematics and technology.
- Teachers will better understand the relationship of effective teaching and learning and curriculum planning in the various dimensions.

SIT has two major features:

- The SIT Components, which represent a framework of effective science, mathematics and technology teaching and learning; and
- The SIT Strategy, which is the process by which schools can improve their science, mathematics and technology teaching and learning.⁴¹

In addition, SIT fits into a model for school change, the SIT School Improvement Model, which is based on research and practice developed by SIS. The Committee notes that SIT is also a companion to complementary Victorian Government initiatives, such as:

- Schools for Innovation and Excellence;
- Middle Years Pedagogy Research and Development (MYPRAD);
- Improving Middle Years Mathematics and Science (IMYMS);
- Early Years Numeracy Program (EYNP);
- Principles of Learning and Teaching (PoLT); and
- Access to Excellence.

⁴¹ *ibid.*

The SIT Strategy aims to provide flexibility for schools and teachers to plan and implement initiatives based on the particular needs of the school, within an overall framework provided by the SIT Components. The Strategy supports school science, mathematics and technology teams to identify and capitalise on their strengths and experience, and to channel the enthusiasm many students and their families have for science, mathematics and technology.⁴² In each school, Science, Mathematics and Technology Co-ordinators work with teachers in developing ideas and materials, or in classrooms, to manage the change process. SIT assumes that the school-based teams are committed to improving teaching and learning and that they have the support of the school's leadership team in doing this.⁴³

The Victorian Government anticipated that 200 of the schools involved in SIS would extend their programs to include mathematics and technology, with some additional schools also being expected to join under the SIT program.⁴⁴

The Committee is supportive of the SIT vision for school mathematics, science and technology and would like to see it promoted more widely, to all Victorian school communities and not only to government schools participating in the SIT initiative. It seems that effective implementation of the SIT vision responds to many of the concerns about current mathematics and science education identified at the beginning of this chapter. Therefore, the Committee is recommending that the Victorian Government incorporate this vision into a comprehensive, co-ordinated mathematics and science education policy targeted at all Victorian schools (refer Recommendation 2.1).

National Goals for Schooling

The Victorian Curriculum and Standards Framework (CSF) has, since 2000, supported the *National Goals for Schooling in the Twenty-First Century*, which clearly identify the importance of mathematics and science education for all students (refer Figure 2.3). Building on the CSF, the Victorian Essential Learning Standards (VELS) have been developed as part of the Victorian Government's *Blueprint for Government Schools*. The VELS support the development of knowledge, skills and behaviours in students and incorporate a discipline-based learning strand that includes both mathematics and science domains. Further discussion of the VELS is contained in the following chapter.

⁴² *ibid.*

⁴³ *ibid.*

⁴⁴ Written Submission, Victorian Government, June 2005, p.10.

Figure 2.3: National Goals for Schooling in the Twenty-First Century

Goals

1. Schooling should develop fully the talents and capacities of all students. In particular, when students leave school, they should:

- 1.1 have the capacity for, and skills in, analysis and problem solving and the ability to communicate ideas and information, to plan and organise activities, and to collaborate with others.
- 1.2 have qualities of self-confidence, optimism, high self-esteem, and a commitment to personal excellence as a basis for their potential life roles as family, community and workforce members.
- 1.3 have the capacity to exercise judgement and responsibility in matters of morality, ethics and social justice, and the capacity to make sense of their world, to think about how things got to be the way they are, to make rational and informed decisions about their own lives, and to accept responsibility for their own actions.
- 1.4 be active and informed citizens with an understanding and appreciation of Australia's system of government and civic life.
- 1.5 have employment related skills and an understanding of the work environment, career options and pathways as a foundation for, and positive attitudes towards, vocational education and training, further education, employment and life-long learning.
- 1.6 be confident, creative and productive users of new technologies, particularly information and communication technologies, and understand the impact of those technologies on society.
- 1.7 have an understanding of, and concern for, stewardship of the natural environment, and the knowledge and skills to contribute to ecologically sustainable development.
- 1.8 have the knowledge, skills and attitudes necessary to establish and maintain a healthy lifestyle, and for the creative and satisfying use of leisure time.

2. In terms of curriculum, students should have:

- 2.1 attained high standards of knowledge, skills and understanding through a comprehensive and balanced curriculum in the compulsory years of schooling encompassing the agreed eight key learning areas: the arts; English; health and physical education; languages other than English; mathematics; science; studies of society and environment; and technology; and the interrelationships between them.
- 2.2 attained the skills of numeracy and English literacy; such that, every student should be numerate, able to read, write, spell and communicate at an appropriate level.

Figure 2.3: Continued...

- 2.3 participated in programs of vocational learning during the compulsory years and have had access to vocational education and training programs as part of their senior secondary studies.
 - 2.4 participated in programs and activities which foster and develop enterprise skills, including those skills which will allow them maximum flexibility and adaptability in the future.
- 3. Schooling should be socially just, so that:**
- 3.1 students' outcomes from schooling are free from the effects of negative forms of discrimination based on sex, language, culture and ethnicity, religion or disability; and of differences arising from students' socioeconomic background or geographic location.
 - 3.2 the learning outcomes of educationally disadvantaged students improve and, over time, match those of other students.
 - 3.3 Aboriginal and Torres Strait Islander students have equitable access to, and opportunities in, schooling so that their learning outcomes improve and, over time, match those of other students.
 - 3.4 all students understand and acknowledge the value of Aboriginal and Torres Strait Islander cultures to Australian society and possess the knowledge, skills and understanding to contribute to, and benefit from, reconciliation between Indigenous and non-Indigenous Australians.
 - 3.5 all students understand and acknowledge the value of cultural and linguistic diversity, and possess the knowledge, skills and understanding to contribute to, and benefit from, such diversity in the Australian community and internationally.
 - 3.6 all students have access to the high quality education necessary to enable the completion of school education to Year 12 or its vocational equivalent and that provides clear and recognised pathways to employment and further education and training.

Source: Commonwealth Department of Education, Science & Training website, <<http://www.dest.gov.au>>, accessed on 4 January 2005.

National Policy

Backing Australia's Ability: Building our Future through Science and Innovation

Backing Australia's Ability is an integrated national funding package for science and innovation, which was announced by the Prime Minister in January 2001.⁴⁵ It arose following a consultation and review process that included the Innovation Summit, the final report from the Innovation Summit Implementation Group, *Innovation: Unlocking the*

⁴⁵ Backing Australia's Ability website, <<http://backingaus.innovation.gov.au>>, accessed on 11 January 2006.

Future, and the Chief Scientist's Report, *A Chance to Change*. *Backing Australia's Ability* involved expenditure of over \$3 billion over five years for a range of programs addressing science and innovation, including research and development; adoption of technology; commercialisation of research; venture capital; school and university education; skilled immigration; intellectual property protection; public awareness of science and innovation; and entrepreneurship.⁴⁶

In 2004, a further \$5.3 billion was announced under *Backing Australia's Ability – Building Our Future through Science and Innovation*, for science and innovation initiatives to be implemented through to 2010–2011.⁴⁷ *Backing Australia's Ability – Building Our Future through Science and Innovation* targets three elements of the innovation system, namely:

- strengthening Australia's ability to generate ideas and undertake research;
- accelerating the commercialisation of ideas; and
- developing and retaining skills.⁴⁸

The third element, developing and retaining skills is of particular relevance to this inquiry. Specific initiatives within this element include:

- Expansion of the Questacon Smart Moves Program, aimed at inspiring Australian school students to pursue careers in science, mathematics, technology and innovation (\$11.4 million over seven years).
- Continuation of science awareness elements of the National Innovation Awareness Strategy (NIAS), aimed at sharing the achievements of scientists and science teachers and connecting the Australian community to the importance of science and technology (\$25.8 million over seven years).
- Implementation of the Boosting Innovation, Science, Technology and Mathematics Teaching (BISTMT) program to strengthen science, technology and mathematics education in Australian schools (\$38.8 million over seven years).
- Continuation of the Fostering Scientific, Mathematical and Technological Skills and Innovation in Government Schools measure introduced under *Backing Australia's Ability*, aimed at building stronger scientific, mathematical

⁴⁶ *ibid.*

⁴⁷ *ibid.*

⁴⁸ *ibid.*

and technological skills in Australian students and at encouraging school-based innovation.

Review of Teaching and Teacher Education

In 2002, the Commonwealth Government established the Review of Teaching and Teacher Education, undertaken by an independent committee chaired by eminent educationalist, Professor Kwong Lee Dow, AM, former Vice-Chancellor of the University of Melbourne. The purpose of the Review was to increase the number of talented people attracted to teach in the fields of science, technology and mathematics and to build a culture of continuous innovation in Australian schools in the long-term.⁴⁹

The Review Committee presented 54 recommendations in its final report entitled *Australia's Teachers: Australia's Future – Advancing Innovation, Science, Technology and Mathematics*. Many of the recommendations relate directly or indirectly to the promotion of science, technology and mathematics education in schools. The Review also identified the following five areas of priority to be addressed by governments, education authorities, school systems, schools, teachers, higher education institutions, teacher professional associations:

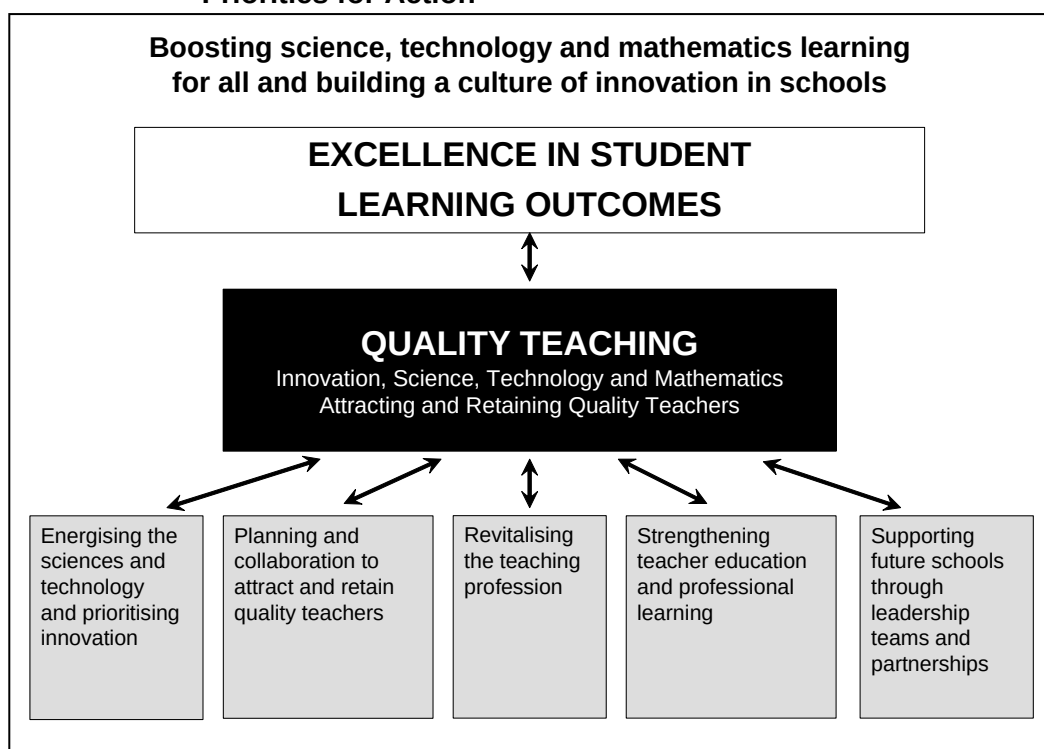
1. Energising the sciences and technology and prioritising innovation.
2. Planning and collaboration to attract and retain quality teachers.
3. Revitalising the teaching profession.
4. Strengthening teacher education and professional learning.
5. Supporting future schools through leadership teams and partnerships.⁵⁰

Figure 2.4 illustrates how the above priorities relate to high quality teaching and excellence in student learning.

⁴⁹ Correspondence from the then Minister for Education, Science & Training, the Hon. Dr Brendan Nelson MP, 4 January 2005.

⁵⁰ Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Agenda for Action*, Commonwealth of Australia, Canberra, p.20.

**Figure 2.4: Australia's Teachers: Australia's Future
Priorities for Action**



Source: Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Agenda for Action*, p.2.

The five key priority areas identified in *Australia's Teachers: Australia's Future* have also been a key focus of much evidence to this inquiry.

The Commonwealth Government is providing a total of \$38.8 million over seven years to 2010–2011 for improvements recommended by the Committee for the Review of Teaching and Teacher Education. This funding will be administered under the BISTMT program.⁵¹

Prime Minister's Science, Engineering and Innovation Council

The Prime Minister's Science, Engineering and Innovation Council (PMSEIC) is the Commonwealth Government's principal source of independent advice on issues in science, engineering and innovation and relevant aspects of education and training. The council meets in full session twice per year to discuss major national issues in science, engineering and technology and their contribution to the economic and social development of Australia.⁵²

⁵¹ Backing Australia's Ability website, <<http://backingaus.innovation.gov.au>>, accessed on 11 January 2006.

⁵² *ibid.*

In November 2003, a working group of the Council, chaired by Dr Jim Peacock AC, presented a report on science engagement and education.⁵³ The working group concluded that science engagement was critical to Australia's continued economic wellbeing and that a continuity of effective science experiences would play an important role in ensuring a prosperous future for Australia. The report offered practical proposals for raising science literacy and engagement across Australian society through young people within the education system. Its key recommendations focused on:

- national co-ordination of science outreach programs;
- linking the teaching of science with the teaching of literacy;
- engaging students in learning science through greater emphasis on investigation;
- strengthening links between business and science education institutions; and
- strengthening the professionalism and skills of Australian science teachers.⁵⁴

Again, evidence received by this Committee was largely consistent with the above themes. Specific initiatives responding to these themes are discussed throughout this report.

A Vision for a Future Mathematics and Science Education Policy for Victoria

The Committee acknowledges the significant investment made by successive state governments in mathematics and science education. Nonetheless, the Committee believes that greater impact would be gained through a more co-ordinated approach to the large number of initiatives currently offered in Victoria. The sheer number of programs and initiatives currently being implemented by all sectors, together with a lack of continuity of some initiatives, has resulted in a certain degree of confusion about the various programs, who operates them, how they can be accessed and how they fit within a broader policy context.

Understandably, the introduction of the Victorian Essential Learning Standards (VELS) may also have taken recent priority, both at the regional and school level, over existing programs and initiatives targeting specific disciplines. Changes occurring through VELS could,

⁵³ Prime Minister's Science, Engineering & Innovation Council 2003, *Science Engagement and Education: Equipping young Australians to lead us to the future*, DEST, Canberra.

⁵⁴ *ibid.*, p.4.

however, provide the perfect opportunity to co-ordinate, promote and integrate existing government and non-government initiatives aimed at improving mathematics and science education.

There are a number of recent examples of governments adopting co-ordinated approaches to mathematics and science education policy in Australia. In August 2002, the Commonwealth Government released a statement, *Supporting Science Teachers* to demonstrate its commitment to improving science education in Australian schools. The statement highlighted the importance of mathematics and science education and its contribution to the economy and a modern society. It also provided a snapshot of science in schools, the international perspective and various government and other initiatives aimed at professional learning and student performance.⁵⁵

More recently, the Queensland Government released a new vision for science education as a component of its education and training reform package.⁵⁶ The renewed vision for 2003–2006 was committed to achieving the best possible standard of science at all levels, from pre-school to postgraduate study. A six-step action plan was developed, aimed at improving the scientific literacy of Queenslanders, encouraging more young people to aspire to careers in science and to improve the overall quality of science education in Queensland (refer Appendix G). A high level taskforce was established to implement the action plan, chaired by a prominent science educator, known as the Queensland Science Education Ambassador. Importantly, the Committee notes that implementation of the plan was closely aligned with Queensland's overarching *Smart State Strategy* and the Commonwealth Government's Quality Teacher Program.

Similarly, the South Australian Government developed its *Strategic Directions for Mathematics and Science in South Australian Schools 2003–2006*. The strategy aims to ensure government school students experience mathematics and science as exciting, relevant and engaging. It includes approaches to attract and retain high quality teachers of science and mathematics and for partnership building with the wider community.⁵⁷

⁵⁵ Department of Education, Science & Training 2002, *Supporting Science Teachers*, DEST, Canberra.

⁵⁶ Education Queensland 2003, *Science State Smart State: Spotlight on Science 2003–2006*, Queensland Government, Brisbane.

⁵⁷ Department of Education & Children's Services 2004, *Strategic Directions for Science and Mathematics in South Australian Schools 2003–2006*, Government of South Australia, Adelaide.

The Science and Mathematics Strategy expresses the South Australian Government's commitment to:

- the role of science and mathematics education in community wellbeing;
- promoting science, technology and innovation in South Australia;
- the development of a workforce well educated in science and technology;
- supporting innovation and development;
- improving the participation and achievement of disadvantaged students in science and mathematics; and
- improving levels of literacy and numeracy.⁵⁸

Specific aspects of the Strategy are contained in Appendix H.

The Victorian Government, together with its partners in the education community, is already implementing and sometimes at the forefront of innovative mathematics and science programs and initiatives. However, even large scale government initiatives such as School Innovation in Science (SIS) and School Innovation in Teaching (SIT) have, to date, still only reached around 15–20 per cent of schools. Many other government and non-government programs reach only a very small number of schools. Therefore, while recognising the importance of a defined central policy position, the Committee also recognises that parents, and the broader community, need to be better incorporated into any renewed approach to further advancing the status and implementation of mathematics and science education in Victoria.

The Committee believes a new, concise and co-ordinated policy statement for mathematics and science education in Victoria would be beneficial. The statement should draw together a comprehensive suite of existing and complementary mathematics and science education programs and initiatives. It should help to strengthen and better target existing initiatives, and provide strong guidance to policy makers, educators, parents and the community about the role and importance of mathematics and science education. Visible and sustained government messages and support for the implementation of science and mathematics education throughout all years of schooling will also encourage parents to take an interest in and support their children's endeavours as they begin their exploration of mathematics and science.

⁵⁸ *ibid.*

Importantly, the mathematics and science education policy statement will need to co-ordinate a broad range of programs and initiatives implemented by the Department of Education and Training, the broader science, industry and innovation agenda of the Department of Innovation, Industry and Regional Development and other related initiatives operated by the non-government sectors. A re-focused, system-wide, strategic approach to mathematics and science education should focus on improved education outcomes among students, complement existing Victorian Government industry policy and incorporate aspects of the Commonwealth Government's *Backing Australia's Ability* policy, as appropriate.

The Committee believes that the commencement of the 2007 school year would be an ideal time to launch a re-focused mathematics and science education policy. This follows the first year of implementation of the VELs (which will initially focus on mathematics and English), and thus represents a renewed opportunity for educationalists to work together in bringing a strong science presence into the classroom.

Recommendation 2.1: That the Victorian Government define the future direction for mathematics and science education in Victoria, through a strategic statement outlining:

- the purpose of and goals for mathematics and science education in Victorian schools;
- principles for curriculum and assessment development and implementation;
- strategies for increasing engagement and participation in mathematics and science education, training and employment pathways;
- strategies for intervention for lower achieving students and for raising achievement among the entire student cohort;
- strategies for improving the quality of teaching in mathematics and science; and
- strategies and programs for an enhanced role for industry in mathematics and science education.

3. Curriculum Structure

Introduction

To contextualise many of the issues raised by participants during this inquiry, the Committee examined the mathematics and science curricula and how they fit within the overarching curriculum framework in Victoria. The Committee considered the general purpose of mathematics and science education, the broad curriculum framework in Prep to Year 10 and the post-compulsory years, and the specific subjects available to senior secondary students compared with those offered interstate. The role and purpose of student assessment in improving students' mathematics and science results were also considered.

General Purpose of the Mathematics and Science Curricula

During this inquiry the Committee received evidence regarding the fundamental and guiding purpose of the mathematics and science curricula. While the finer details of curriculum content were not often touched upon, the central purpose of the curricula was regularly raised as having a crucial influence on the outcomes of mathematics and science education in Victoria.

The Committee believes that the mathematics and science curricula should firstly aim to improve the levels of mathematical and scientific literacy of all students. As Engineers Australia stated:

All Australian citizens will need to gain scientific, engineering and mathematical knowledge and to develop technological understanding to enable them to make informed decisions about their lives and to engage intelligently in the knowledge economy.⁵⁹

Secondly, the curricula should seek to help prepare a greater number of students to progress onto specialised studies in the enabling and new sciences at university. As Associate Professor Kieran Lim of Deakin University stated:

Traditionally, the State of Victoria has been a manufacturing and industrial powerhouse within the Australian economy....The strength of the North

⁵⁹ Ms K. Hurford, Associate Director Public Policy, Engineers Australia, Victorian Division, Transcript of Evidence, Public Hearing, Melbourne, 31 August 2005, p.9.

American, Japanese and West German economies for much of the second half of the last century indicates how fundamental and applied research in Mathematics and Science leads to advances in engineering and technology, with resultant improvement in the community's health, economic wellbeing and standard of living.⁶⁰

Many submissions and witnesses emphasised the importance of identifying and promoting a primary purpose of mathematics and science curricula. However, the Committee found that the Victorian Government's vision for science education does not feature prominently in Victorian curriculum documentation. A variety of participants, including the Science Teachers' Association of Victoria, suggested that curriculum documents, statements and resources need to be explicit about what is valued in science. The Association stated that:

... without a clear notion about what is valued in science the approach to its teaching, including curriculum statements and preparation of resources, can become diffuse: bogged down in memorising factual content or mastery of 'process'. The excitement of science that arises from its unifying explanatory power and the grandeur of its reach are all too easily lost.⁶¹

The goals of raising scientific and mathematical literacy among all students, while also preparing a greater number of students to study science and mathematics at university, may at times seem to be competing goals:

Science education for 'science literacy' may not fit readily with notions of science teaching as preparation for detailed studies in science.⁶²

The Committee repeatedly heard concerns that irrespective of policy makers' views on the general purpose of mathematics and science education, the structure of the Victorian Certificate of Education (VCE) tends to push the curriculum in favour of the preparation of science specialists. A curriculum too focused on the preparation of those who wish to pursue specialised study may be to the detriment of the scientific and mathematical literacy of the remaining majority of students. Specialised science and mathematics studies invariably lack universal appeal and may be perceived to have less relevance to the lives of the wider student cohort. While the Victorian curriculum provides for the pursuit of a generalist science course until Year 10, a number of stakeholders argued that the division of science into

⁶⁰ Written Submission, Associate Professor K. Lim, January 2005, p.3.

⁶¹ Written Submission, Science Teachers' Association of Victoria, January 2005, p.2.

⁶² *ibid.*, p.3.

specialised streams in Years 11 and 12 is driving the same division down through the curriculum in the compulsory years.

Emeritus Professor Richard White, for example, stated:

The curriculum in years 11 and 12 in Victoria has always been towards the specialist end, and, whatever may have been the intent of curriculum developers, in practice has dragged the curriculum in junior years in that direction also.⁶³

The need to prepare students to undertake one or more of the specialised science courses at VCE level necessitates a similar specialised approach at the junior levels. Emeritus Professor Richard White outlined his concerns over specialised programs, stating:

An argument against specialist programs is that by divorcing science from culture and society they present a distorted picture of science itself. Part of the distortion is the notion that science is independent of values and cultural beliefs; another part is the separation of physics, chemistry, biology and other science from each other, so that science is perceived as a bundle of disciplines rather than as an integrated, self-consistent account of the natural world.⁶⁴

Professor Richard Gunstone, of Monash University, supported this view:

One of the things we have really mistakenly done in the 20th century in science and maths education is to see the education of experts as needing to necessarily be specific and focused and demanding, where demanding means narrow and you do what you might have done next year this year instead. What we do, then, is produce experts who are dislocated from the society they are supposed to advise ...⁶⁵

The Committee believes that the clear articulation of the purpose of the mathematics and science curricula by the Victorian Government would be of great benefit to teachers and curriculum developers. The Committee envisages that the primary purpose of the mathematics and science curricula is central to the development of government mathematics and science education policy (refer to recommendation 2.1).

⁶³ Written Submission, Emeritus Professor R. White, December 2004, p.1.

⁶⁴ R.T. White 2003, 'Challenges, opportunities and decisions for science education at the opening of the twenty-first century', *Innovation in Science and Technology Education*, Vol. 8, UNESCO, Paris, p.279.

⁶⁵ Transcript of Evidence, Public Hearing, Monash University, Clayton Campus, 10 June 2005, p.8.

There are a number of measures that may promote a more coherent approach to the learning and teaching of the different disciplines of science in the compulsory curriculum. The Committee recognises that the solutions to real world problems in science rarely lie in the application of just one pure discipline of science, especially in the enabling sciences. As discussed in Chapter 7, student investigations in science should integrate the traditional disciplines of science, and be focused on engaging students and building scientific literacy.

Curriculum Framework in Victoria

The two key authorities that have a major role in the mathematics and science curricula are the Victorian Curriculum and Assessment Authority (VCAA) and the Victorian Qualifications Authority (VQA). The two authorities work in partnership when reviewing and enhancing post-compulsory school education.

The VCAA is responsible for the curriculum and assessment used across Years Prep to 12 in Victorian schools.⁶⁶ The VCAA is a statutory authority that reports directly to the Minister for Education and Training. It was established to:

- develop curriculum for all Victorian schools;
- assess student learning and monitor student achievement; and
- conduct research leading to innovative educational programs.⁶⁷

The VQA is also a statutory body accountable to the Minister for Education and Training. The VQA is responsible for the accreditation, registration, certification and quality assurance of post-compulsory qualifications in Victoria, other than higher education qualifications.

The compulsory years curriculum was in a period of transition during this inquiry as the Victorian Essential Learning Standards (VELS) were in the process of being implemented as the basis for curriculum and assessment for Years Prep to 10 in Victoria. The Committee heard that many of the perceived limitations of the Curriculum and Standards Framework (CSF) II raised during this inquiry are likely to be resolved, or at least minimised, as the VELS are introduced.

The main post-compulsory qualification is the Victorian Certificate of Education (VCE). The VCE mathematics and science courses have

⁶⁶ Victorian Curriculum & Assessment Authority 2005, *Annual Report 2004–05*, VCAA, Melbourne, p.5.

⁶⁷ For further information, refer to the Victorian Curriculum & Assessment Authority website, <<http://www.vcaa.vic.edu.au>>.

also recently been reviewed or were undergoing review at the time of this report.

The Victorian Essential Learning Standards

As an initiative of the *Blueprint for Government Schools*, the Victorian Government requested the VCAA to identify a broad framework of essential learning for all students within Victorian schools. In response, the VCAA developed the VELS, which will be progressively implemented in Victorian schools from 2006. The VELS were developed in consultation with the Department of Education and Training (Office of Learning and Teaching), the Catholic Education Commission of Victoria, and the independent schools sector.

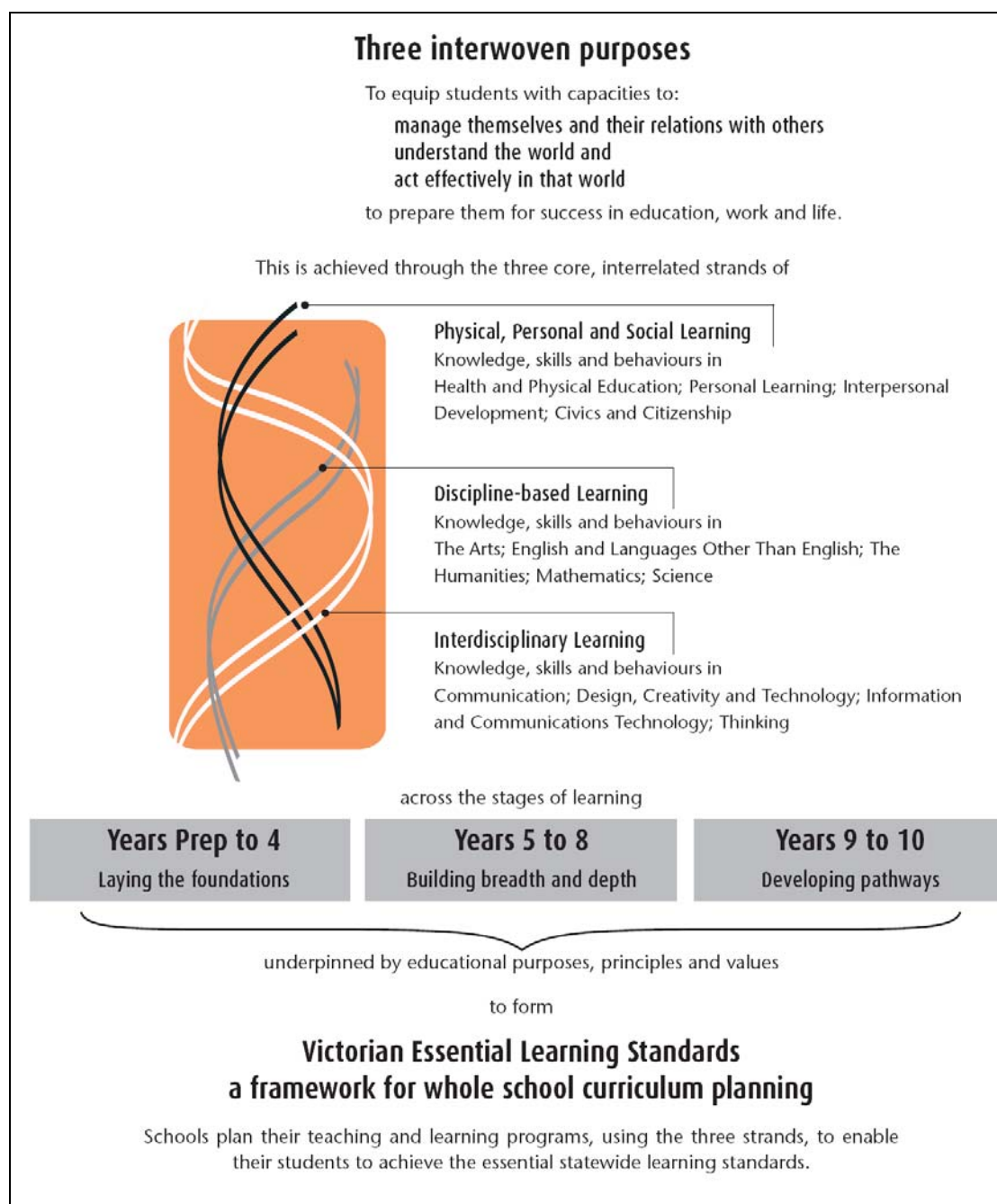
There are five educational principles underpinning the VELS:

- Learning for all – recognising that all students can learn given sufficient time and support, and that good schools and good teaching make a positive difference to student outcomes.
- Pursuit of excellence – seeking to accomplish something noteworthy and admirable individually and collectively, and performing at one's best.
- Engagement and effort – acknowledging that student ability is only one factor in achievement and that if students work hard and make an effort, they improve.
- Respect for evidence – seeking understanding and truth through structured inquiry and the application of evidence to test and question beliefs.
- Openness of mind – being willing to consider a range of different views and consider different ways that evidence is perceived and solutions can be reached.⁶⁸

The VELS are structured as three strands of learning, each having a number of components called domains (refer Figure 3.1).

⁶⁸ Information about the VELS is available on the Victorian Curriculum & Assessment Authority website, <<http://vels.vcaa.vic.edu.au/>>.

Figure 3.1: VELS Curriculum Planning Framework



Source: Victorian Curriculum & Assessment Authority 2005, *Victorian Essential Learning Standards Overview*, p.6.

Witnesses and submissions were generally supportive of the VELS, and, in particular:

- its interdisciplinary approach;
- the more flexible and less prescriptive framework; and
- the reduction of the curriculum down to essential learning, thereby reducing what was considered by some as an overcrowded curriculum.

The Faculty of Education at Monash University supported the moves away from what they describe as the ‘tightly defined outcomes-based education that characterised the CSF curriculum’. This curriculum change, the Faculty says, will contribute substantially to supporting high quality teaching.⁶⁹

The existing curriculum has also often been criticised as overcrowded, as indicated by Ms Pennie Stoyles, Education Officer for Scienceworks Museum:

I think in secondary school there is a crowded curriculum and compartmentalisation. Part of the science process and science literacy is understanding that science is not just taught in science lessons, that science is in everything ...⁷⁰

The VELS aim to provide opportunities for teachers to concentrate on what is essential, while striving to more effectively engage students in an interdisciplinary approach. The VELS will not only assess the knowledge, skills and behaviours of students in discipline-based areas, students will also be assessed in a number of communication and thinking-based domains, as well as physical, personal and social learning domains. The VELS also encourage interdisciplinary learning of the traditional disciplines. The Science Teachers’ Association of Victoria, welcomed the VELS:

The removal of the CSF as a straightjacket, confining science education to the demonstrated achievement by students of a disparate collection of ‘outcomes’ is welcome ...⁷¹

Mr Ranjith Dediwalage, President of the Science Teachers’ Association of Victoria, further elaborated on the interdisciplinary approach to science:

... science has to be an integrated one [subject] because when you go to society, you do not have science problems, you do not have maths problems or algebra problems – you have problems. So if we want our future generations to tackle problems, they have to be taught in that way ... Therefore, always teaching it in context with integrated disciplines is the best way to go ...⁷²

While most stakeholders support the VELS and recognise their potential to improve mathematics and science education in Victoria,

⁶⁹ Written Submission, Faculty of Education, Monash University, December 2004, p.2.

⁷⁰ Transcript of Evidence, Public Hearing, Scienceworks Museum, Melbourne, 19 August 2005, p.9.

⁷¹ Written Submission, Science Teachers’ Association of Victoria, January 2005, p.3.

⁷² Transcript of Evidence, Public Hearing, Scienceworks Museum, Melbourne, 19 August 2005, p.14.

many emphasised the need to ensure that the essence of the discipline studies are maintained in integrated studies. For example, the Science Teachers' Association of Victoria stated:

... lacking any articulate outline of what is central to science, of what distinguishes the scientific way of knowing from belief systems which are not self critical and self correcting, there is a danger of something going under the label 'science' becoming just another component in an 'integrated studies' program.⁷³

Mr Paul Sedunary, Manager of Curriculum and Innovation, Catholic Education Commission of Victoria, similarly commented on the importance of clearly identifying the science to students in integrated curricula:

Curriculum integration at times varies and the science gets lost. It is about being explicit and naming it as 'science' ...⁷⁴

The Victorian Schools Innovation Commission was supportive of a mathematics curriculum for the compulsory years that reduces content down to only what is essential for numeracy development. The Commission argued that this allows greater time for the understanding of the fundamental mathematical concepts to be developed. Furthermore, moves internationally to include financial literacy subjects were also supported by the Commission, having the potential to engage students who might otherwise not be interested in mathematics studies.⁷⁵

The Committee considers that the introduction of the VELs is a significant undertaking. It places considerable onus upon school- and faculty-based curriculum design teams to develop effective curricula. Successfully introducing VELs and ameliorating concerns of the many stakeholders involved is therefore a major change management process.

As Mr Barry Kissane, President of the Australian Mathematics Teachers Association stated:

There are always problems with curriculum change ... People feel a little bit overwhelmed by it in terms of finding the time to read and make sense of the documents, rethink how we will do things and so on. It takes massive amounts of time.⁷⁶

⁷³ Written Submission, Science Teachers' Association of Victoria, January 2005, p.3.

⁷⁴ Transcript of Evidence, Public Hearing, Melbourne, 20 June 2005, p.8.

⁷⁵ Written Submission, Victorian Schools Innovation Commission, December 2004, p.4.

⁷⁶ Transcript of Meeting, Perth, 1 June 2005, p.20.

The Committee heard feedback from teachers on the implementation of the VELS. Some of these teachers indicated that they felt support from the Department of Education and Training for the implementation of VELS had been limited. Similar concerns were initially raised at the time of the introduction of the CSF and the CSF II. The Committee notes, however, that any shift to a new curriculum framework is a large undertaking that takes place over a number of years.

VELS Curriculum Planning Guidelines

Decisions on how to implement the VELS are the responsibility of school-based teams of teachers. The VELS Curriculum Planning Guidelines have been developed to assist schools in undertaking a whole school approach to curriculum planning (refer Figure 3.2). The Curriculum Planning Guidelines assist schools in:

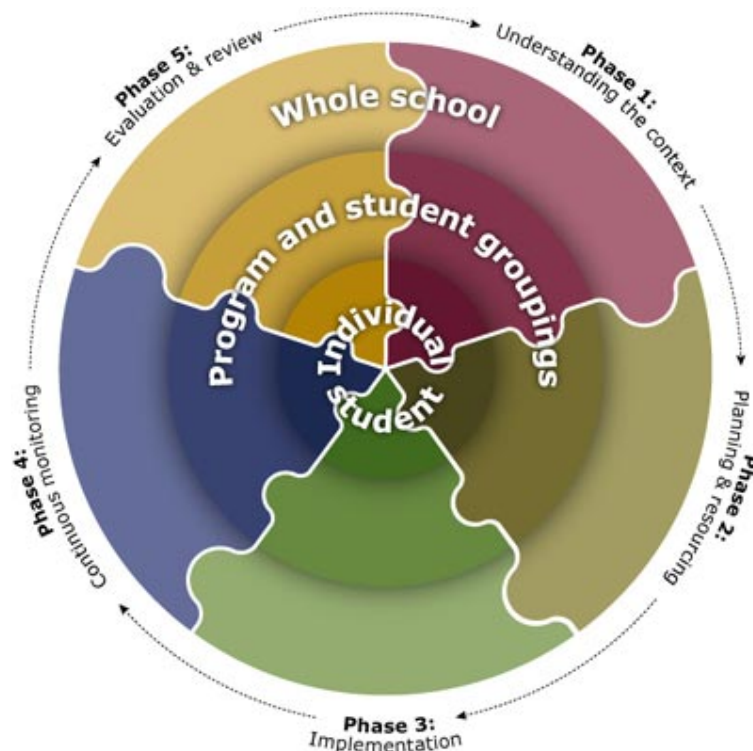
- constructing curriculum in line with VELS and the post-compulsory frameworks of the Victorian Certificate of Education, Vocational Education and Training (VET), and the Victorian Certificate of Applied Learning (VCAL);
- linking curriculum planning with the Principles of Learning and Teaching (PoLT), assessment processes, reporting practices and the Knowledge Bank;
- ensuring curriculum planning takes into account student diversity, organisational arrangements and resourcing; and
- promoting discussion about curriculum issues and building planning processes.⁷⁷

The key components of the Guidelines include: a model of curriculum planning; tools for curriculum planning; samples from schools; and Knowledge Bank.⁷⁸

⁷⁷ Information on curriculum planning guidelines was obtained from SOFweb, <<http://www.sofweb.vic.edu.au/blueprint/docs/tools/1>>, accessed on 13 January 2006.

⁷⁸ Knowledge Bank is a showcase for best practice in Victorian schools. Refer to SOFweb, <<http://www.sofweb.vic.edu.au/knowledgebank/default.asp>>.

Figure 3.2: VELS Curriculum Planning Guidelines



Source: SOFWeb, an initiative of the Department of Education & Training.
<<http://www.sofweb.vic.edu.au/blueprint/fs1/guidelines/default.asp>>,
accessed on 13 January 2006.

At the time of writing, much of the support material was directed at phases one to three.

Phase 1: Understanding the context. This phase involves an audit of the current curriculum provision and includes an analysis of all relevant information to build up an understanding of the learner profile (including student diversity), community partnerships and values, beliefs and understandings as they relate to particular programs and/or student groupings. This sets the context for future curriculum planning that will best support student learning.

Phase 2: Planning and Resourcing. This phase involves interpreting the VELS and post-compulsory education and training to create a curriculum plan that has a clear focus on what is to be learnt, how learning will occur and how it will be assessed at a whole school level. Consideration is given to organisational structures and resourcing that account for student diversity.

Phase 3: Implementation. This phase involves the progressive implementation of the curriculum plan.

The Curriculum and Standards Framework II

Following introduction of the VELS, the CSF II will remain as a curriculum development resource for teachers, and a support document to the VELS.

The CSF II is an outcomes-based curriculum framework, describing what students should know and be able to do in eight key areas of learning, at six intervals from Prep to Year 10.

Importantly, the CSF II was developed with consideration for the *National Goals for Schooling in the Twenty-First Century*, to ensure Victoria's curriculum is consistent with national objectives.

The CSF II sought to provide a balance between providing detail about the major elements for the curriculum and standards of successful learners, and allowing schools the flexibility to work out the best way to organise their own teaching and learning program. Nevertheless, the CSF II is more detailed than the VELS.

The eight key learning areas of the CSF II are: The Arts; English including English as a Second Language; Health and Physical Education; Languages other than English; Mathematics; Science; Studies of Society and Environment; and Technology. The major knowledge and skills required within each key learning area are arranged into strands that are either discipline- or skills-based. For instance, the key learning area of science at level three is divided into four strands: biological science; chemical science; earth and space sciences; and physical sciences. At the same level, mathematics is divided into the strands: space; number; measurement; chance and data; and reasoning and strategies.

For each strand, the CSF II documents the curriculum focus of that strand, at that particular level. It outlines the major content to be covered and describes appropriate contexts for course development. The CSF II also describes the standards expected at each level, including:

- the learning outcomes, which answer the question 'what should students know and be able to do as an outcome of their learning at this level?'; and
- the indicators, which seek to answer 'how do we know that students have achieved the learning outcomes?',⁷⁹

⁷⁹ Information on the CSF II strands was obtained through the Victorian Curriculum & Assessment Authority website <<http://csf.vcaa.vic.edu.au/ov/ov-e.htm>>, accessed on 13 January 2006.

The Victorian Certificate of Education

The VCE is the principal post-compulsory qualification in Victoria, undertaken by most Year 11 and Year 12 students. The VQA is responsible for the accreditation and issuing of the VCE, although it delegates responsibility for issuing qualifications to the VCAA. The VQA accredits proposals developed by the VCAA for improvements in the study design rules and component studies of the VCE. It regularly reviews these studies as part of a program of continuous improvement.⁸⁰ In addition to developing VCE courses, the VCAA is responsible for ensuring the quality of the school-assessed component of the VCE, the external examinations and the delivery of all VCE results to students throughout Victoria each year.⁸¹ As with Victoria's curriculum for the compulsory years, the VCE curriculum aims to realise the *National Goals for Schooling in the Twenty-First Century*.

Upon successful completion of the VCE, each student is awarded a study score by the VCAA, for each of their Unit 3 and 4 studies.⁸² Study scores are used by the Victorian Tertiary Admissions Centre (VTAC) to calculate an Equivalent National Tertiary Entrance Rank (ENTER). Before study scores can be fairly added together, however, they have to be compared and adjusted (scaled). VCE results are scaled because individual study scores are not an absolute measure of overall performance; students take very different combinations of VCE studies and VTAC can only legitimately add study scores together if the strength of competition in each study is about the same.⁸³

Extension Studies

Extension studies are university subjects undertaken by some Year 12 students, in conjunction with the VCE. Targeting the most capable students, extension studies build on VCE subjects to first-year university level. Although extension studies do not contribute to the award of the VCE, they are included in the final statement of results of

⁸⁰ Victorian Qualifications Authority 2005, *Annual Report 2004-05*, VQA, Melbourne, p.26.

⁸¹ Further information regarding the Victorian Curriculum & Assessment Authority's responsibilities relating to the VCE is available from the VCAA website, <<http://www.vcaa.vic.edu.au/vce/index.html>>.

⁸² A study score shows how well a student has performed in a study at Unit 3 and 4 level, compared to everybody else in Victoria who took that study. The maximum study score is 50. Each year, and for every study, the mean study score is set at 30. A score of between 23 and 37 shows that a student is in the middle range of students; a score of more than 38 indicates that a student is in the top 15%. Refer Victorian Curriculum & Assessment Authority website for further information, <<http://www.vcaa.vic.edu.au>>.

⁸³ For further information on scaling and the ENTER, refer to *ABC of Scaling – Scaling and the ENTER: A Simplified Explanation*, published on the Victorian Tertiary Admissions Centre website, <<http://www.vtac.edu.au/publications/index.html>>.

participating students, and also contribute to their ENTER.⁸⁴ Offered through a number of different universities, extension studies are taught either by university staff or by secondary school teachers who are recognised by the university as qualified to teach at that level. Students can choose from physics, chemistry, biology, psychology and mathematics, in addition to a range of non-mathematics or science subjects.

To qualify to undertake an extension study, students must first meet any prerequisites set for the same university study offered to undergraduate students.⁸⁵ Therefore, most mathematics and science extension studies require students to have completed a Unit 3 and 4 sequence in Year 11 and a Unit 1 and 2 sequence in Year 10. Generally, students are required to have achieved high results in their primary prerequisite, and had similar success in other subjects pursued.

The Victorian Certificate of Applied Learning

The VCAL is the senior secondary qualification implemented state-wide from 2003 to improve the pathways for young people from secondary school to work and/or further education and training. The VCAL aims to provide the skills and knowledge and, to foster attitudes to enable students to make informed choices regarding pathways, in the context of applied learning. VCAL is accredited at three levels: Foundation, Intermediate and Senior. Each VCAL award level contains four curriculum strands: literacy and numeracy skills; industry specific skills; work related skills; and personal development skills.⁸⁶

The VCAL is delivered through schools, TAFE institutes and Adult Community Education (ACE) centres throughout Victoria. In 2005, 85 per cent of government schools were funded to deliver VCAL. Students are required to enroll at their school, TAFE institute or ACE centre, although they may do part of their program at other schools, TAFE institutes, ACE centres, registered training organisations, community-based organisations and/or with employers.

⁸⁴ Information on VCE Extension Studies was obtained from the Victorian Curriculum & Assessment Authority website, <<http://www.vcaa.vic.edu.au/vce/studies/studiesextension.html>>, accessed on 10 February 2006.

⁸⁵ Victorian Curriculum & Assessment Authority 2004, 'Changes to VCE Extension Studies Program for 2006', *VCAA Bulletin*, No. 19 October 2004, VCAA, Melbourne, p.10.

⁸⁶ Information about the VCAL is available on the Victorian Curriculum & Assessment Authority website, <<http://www.vcaa.vic.edu/vcal>>.

By May 2005, there were almost 10,500 student enrolments in VCAL, a 28 per cent increase from 2004. Of the over 8,100 students who undertook VCAL in 2004, over 60 per cent were male.⁸⁷

Vocational Education and Training in Schools

In 2004, over 33,000 students participated in VET in Schools programs in Victoria.⁸⁸ Students undertaking the VCAL must include industry specific units from VET programs. The VCAA has also approved a range of VET subjects that students can undertake as part of their VCE. Twelve of the 27 VCE VET programs can contribute to a student's ENTER.

The Committee identified a number of VCE VET courses of relevance to this inquiry, including Cisco (a computer networking course); Electronics; Engineering; Information Technology; and Laboratory Skills.⁸⁹ The Committee considers the ongoing inclusion of these subjects important in addressing the more vocationally oriented skills demanded in the innovation, science and technology related industries. Importantly, as a key strategy in addressing skills shortages, the Committee seeks improvements to the quality of career and subject related advice to parents and students. This will help ensure more students pursuing vocational pathways undertake these types of studies, as well as appropriate mathematics and science studies (refer Chapter 7).

Mathematics Curriculum

Mathematics occupies a prominent position in the Victorian curriculum throughout both the compulsory and non-compulsory years of schooling. Numeracy has a considerable focus in the Victorian Government primary school curriculum, and on average in 2004, around 21 per cent of instructional time, or over an hour per day was dedicated to mathematics.⁹⁰ In secondary schools the curriculum focus naturally broadens and in 2004, instructional time devoted to mathematics was just under 15 per cent in Years 7 and 8, representing 225 minutes per week.⁹¹

⁸⁷ Victorian Curriculum & Assessment Authority 2005, *Annual Report 2004–05*, VCAA, Melbourne, pp.27–28.

⁸⁸ *ibid.*, p.31.

⁸⁹ Victorian Curriculum & Assessment Authority 2005, *VCAA Annual Report 2004–05*, VCAA, p.32. Electronics, Information Technology and Laboratory Skills may contribute to ENTER scores.

⁹⁰ Department of Education & Training 2004 *School Management Benchmarks*, DE&T, Melbourne, <<http://www.sofweb.vic.edu.au/standards/publicat/bench.htm>>, accessed on 17 January 2006.

⁹¹ *ibid.*

The following sections outline the broad structure of the mathematics curriculum in Victorian schools. The Committee has concentrated especially on mathematics within the VCE, given its role in consolidating compulsory years' learning, increasing mathematical literacy and/or providing the foundation for tertiary studies.

Mathematics and the Victorian Essential Learning Standards

The mathematics domain of VELS has five dimensions:

1. Number provides for our sense of counting, magnitude and order.
2. Space provides for our sense of shape and location.
3. Measurement, chance and data provides for our sense of unit, measure and error, chance and likelihood and inference.
4. Structure provides for our sense of set, logic, function and algebra. Standards for this dimension do not begin until level 3.
5. Working mathematically provides for our sense of mathematical inquiry: problem posing and problem solving, modelling and investigation.⁹²

An important initiative underpinning mathematics in government primary schools since 1999 is the Early Years Numeracy Program (EYNP). The EYNP is designed to support schools to plan and implement a strategic and comprehensive approach to successful early numeracy achievement.⁹³ The EYNP comprises four core components: a structured classroom program, including a daily one-hour numeracy block; additional assistance for students requiring further support; parental participation; and teacher professional development. The major numeracy approach being implemented in Victorian Catholic schools is the Success in Early Numeracy Education (SINE) program. SINE is a whole school approach designed to assist teachers to identify the mathematical understanding of the students they teach. The Committee acknowledges the success of both the EYNP and the SINE program, as evidenced by Victoria's results in the National Numeracy Benchmarks (refer to Chapter 4).

⁹² Information on VELS mathematics dimensions was obtained from the VELS website, <<http://vels.vcaa.vic.edu.au/>>, accessed on 17 January 2006.

⁹³ Further information on the Early Years Numeracy Program is available on SOFweb, <<http://www.sofweb.vic.edu.au/eys/num/numclass.htm>>.

Mathematics in the VCE

While there is no compulsory mathematics requirement for the award of the VCE, in 2004 around 95 per cent of Year 11 students enrolled in a Unit 1 and 2 mathematics study.⁹⁴ Around 80 per cent of Year 12 students enrolled in a Unit 3 and 4 mathematics subject.⁹⁵ The suite of mathematics within the VCE offers students opportunities to consolidate their mathematical understanding through Foundation Mathematics, or progress their mathematical knowledge further to a variety of levels, through a range of robust, and challenging courses.

There are four different Unit 1 and 2 mathematics subjects: Foundation Mathematics; General Mathematics; Mathematical Methods; and Mathematical Methods (CAS). There are also four Unit 3 and 4 subjects: Further Mathematics, which continues from General Mathematics; Mathematical Methods; Mathematical Methods (CAS); and Specialist Mathematics.

In recent years, there has been an encouraging growth in participation in VCE mathematics.⁹⁶ The growth has been primarily confined to Further Mathematics, a subject that Teese and Polesel describe as a 'terminal' mathematics course.⁹⁷ Terminal mathematics courses do not necessarily prepare students for the study of mathematics at a tertiary level. Nevertheless, Further Mathematics remains an intellectually challenging and demanding course and, along with Mathematical Methods, is considered to be of intermediate difficulty.⁹⁸ Participation in Further Mathematics by a broad cohort of students not planning to undertake mathematics studies at university level is therefore important in contributing to the goal of an increasingly mathematically literate society. According to Teese and Polesel, the inclusion of Further Mathematics almost doubles the number of students in lower socioeconomic areas participating in Year 12 mathematics, thereby increasing the 'social reach' of mathematics in Victoria.⁹⁹

Mathematical Methods and Specialist Mathematics are considered by Teese and Polesel as 'preparatory' mathematics and, are highly suited as preparation for tertiary level mathematics. Enrolments for both of the VCE preparatory mathematics courses have remained stable over

⁹⁴ Enrolment figures in the following sections include the government, Catholic and independent sectors.

⁹⁵ Supplementary material provided to the Committee by the Victorian Curriculum & Assessment Authority, October 2005.

⁹⁶ *ibid.*

⁹⁷ R. Teese & J. Polesel 2003, *Undemocratic Schooling: Equity and Quality in Mass Secondary Education in Australia*, Melbourne University Press, Melbourne, p.57.

⁹⁸ Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Background Data and Analysis*, Commonwealth of Australia, Canberra, p.13.

⁹⁹ R. Teese & J. Polesel 2003, *Undemocratic Schooling: Equity and Quality in Mass Secondary Education in Australia*, Melbourne University Press, Melbourne, p.57

recent years (refer Chapter 4) The Committee hopes that future improvements in mathematics education will result in greater participation in the preparatory mathematics subjects, with a greater flow-on to studies in advanced mathematics and the enabling sciences at university.

The current VCE Mathematics curriculum has been reviewed and re-accredited for the period 2006 to 2009.¹⁰⁰

Foundation Mathematics Units 1 and 2

Foundation Mathematics is a generalist mathematics course for students who may not wish to pursue Units 3 and 4 mathematics. Suited as a consolidation course, there is a strong emphasis on using mathematics in practical contexts relating to everyday life, recreation, work and study. This makes Foundation Mathematics especially useful for students undertaking VET studies. The content of this course overlaps with neither General Mathematics nor Mathematical Methods and could, in theory, be taken with either course simultaneously. Foundation Mathematics is the least popular mathematics course, with over 6,000 students undertaking the subject in 2004.¹⁰¹

Areas of study across the two units include: space, shape and design; patterns and number; handling data; and measurement. Teachers developing courses based on the areas of study and their outcomes are encouraged to embed content in contexts that are meaningful and of interest to students, for example, buying a car, investigating drink driving issues (including Blood Alcohol Content levels and accident statistics), gardening and landscaping and sport.

General Mathematics Units 1 and 2

General Mathematics is designed to cater to a broad range of students and can be combined and sequenced with all other mathematics courses. Students undertaking Unit 1 and 2 Mathematical Methods or Mathematical Methods (CAS) will generally also study Unit 1 and 2 General Mathematics.

Areas of study include: arithmetic; data analysis and simulation; algebra; graphs of linear and non-linear relations; decision and business mathematics; geometry and trigonometry.

¹⁰⁰ Victorian Curriculum & Assessment Authority 2005, *Mathematics: Victorian Certificate of Education Study Design*, VCAA, Melbourne, p.5.

¹⁰¹ Supplementary material provided to the Committee by the Victorian Curriculum & Assessment Authority, October 2005.

General Mathematics is the most popular mathematics with around 34,000 enrolments in 2004.¹⁰²

Further Mathematics Units 3 and 4

Further Mathematics is suited to students who require some mathematical literacy in their further study or work but not high level applications of pure mathematics or high level conceptual mathematics.

There are two main areas of study in further mathematics:

1. data analysis – the core compulsory area of study; and
2. applications module material consisting of three of the following six modules:
 - Module 1: Number patterns
 - Module 2: Geometry and trigonometry
 - Module 3: Graphs and relations
 - Module 4: Business-related mathematics
 - Module 5: Networks and decision mathematics
 - Module 6: Matrices.¹⁰³

Further Mathematics has consistently been the most popular Unit 3 and 4 mathematics subject, with over 21,500 enrolments, representing 47 per cent of the Year 12 cohort in 2004.¹⁰⁴ While Further Mathematics is a robust mathematics course, it is the easiest of the VCE Unit 3 and 4 mathematics subjects.

Numerous university courses require Further Mathematics as an optional prerequisite, including Forest Science and Agricultural Science at the University of Melbourne; Science and Primary Teaching at Deakin University; and Science/Education at Monash University. Some course providers stipulate that students undertaking Further Mathematics as an alternative to Mathematical Methods or Specialist Mathematics require a higher subject score in Further Mathematics, due to the differences in relative subject difficulty.

¹⁰² *ibid.*

¹⁰³ Victorian Curriculum & Assessment Authority 2005, *Mathematics: Victorian Certificate of Education Study Design*, VCAA, Melbourne, p.120.

¹⁰⁴ Supplementary material provided to the Committee by the Victorian Curriculum & Assessment Authority, October 2005.

Mathematical Methods and Mathematical Methods (CAS)

Units 1 to 4

Mathematical Methods is the most challenging of the Unit 1 and 2 mathematics subjects. Areas of study include: functions and graphs; algebra; rates of change and calculus; and probability. These studies continue into Units 3 and 4 Mathematical Methods.

Mathematical Methods Computer Algebra Systems (CAS) was piloted in Victorian schools over the period 2001 to 2005, and became a fully accredited course for implementation as of 2006. Mathematical Methods (CAS) follows a similar syllabus to the standard course, although it utilises CAS technology to support and develop the teaching and learning of mathematics. Students studying Mathematical Methods (CAS) generally use handheld calculators, although CAS programs are also available on personal computers and laptops. The technology allows complex algebraic functions to be represented graphically, permitting a higher level of analysis. Victoria is one of the world leaders in introducing these systems.

Aside from English, Unit 3 and 4 Mathematical Methods is one of the most common prerequisites for university studies. A sample of courses requiring Mathematical Methods as a mandatory prerequisite includes: Computer Systems Engineering and Aerospace Engineering at Monash University; Engineering–Communication/Computer Science at RMIT University; and Optometry and Commerce at the University of Melbourne. Mathematical Methods is often an optional prerequisite grouped with Physics and Specialist Mathematics, particularly for more demanding or popular courses.

Over 23,500 students enrolled in Mathematical Methods Unit 1 and 2 in 2004. Almost 18,000 students, or close to 39 per cent of the total Year 12 enrolments, studied Unit 3 and 4 Mathematical Methods in 2004.¹⁰⁵

¹⁰⁵ Supplementary material provided to the Committee by the Victorian Curriculum & Assessment Authority, October 2005. Note: these figures include enrolments in the Mathematical Methods (CAS) pilot.

Specialist Mathematics Units 3 and 4

Specialist Mathematics is the most challenging VCE mathematics course. Areas of study include: functions; relations and graphs; algebra; calculus; vectors; and mechanics.

Over 6,100 students or around 13 per cent of the Year 12 cohort undertook Specialist Mathematics in 2004. Most of these students were concurrently enrolled in Mathematical Methods.

University courses requiring Specialist Mathematics as a mandatory prerequisite are limited and include Computer Systems Engineering and Telecommunications Engineering at Monash University. A substantial number of courses list Specialist Mathematics as an optional prerequisite, including, Physics and Mathematics at RMIT University; Nanotechnology at La Trobe University; Medicine and Dentistry at the University of Melbourne; and Engineering – Robotics and Mechatronics at Swinburne University of Technology.

Senior Mathematics in Other Jurisdictions

In order to better understand Victoria's own suite of VCE mathematics courses, the Committee compared it with the range of mathematics courses offered interstate.

Drawn from a report commissioned by the International Centre of Excellence for Education in Mathematics and the Australian Mathematical Sciences Institute, Figure 3.3 identifies the mathematics courses offered in each state and territory, categorised according to levels of relative difficulty.

Figure 3.3: Comparison of Interstate Mathematics Courses by Relative Difficulty (2004 to 2005)

State or Territory	Terminal Mathematics	Intermediate Mathematics	Advanced Mathematics
Australian Capital Territory	Mathematical Applications	Mathematical Methods	Specialist Mathematics
New South Wales	General Mathematics	Mathematics	Mathematics Extension 1 & Mathematics Extension 2
Queensland	Mathematics A	Mathematics B	Mathematics C
South Australia and Northern Territory	Mathematical Methods	Mathematical Studies	Specialist Mathematics
Tasmania	Mathematics Applied	Mathematical Methods	Mathematics Specialised
Victoria	Further Mathematics	Mathematical Methods	Specialist Mathematics
Western Australia	Discrete Mathematics	Applicable Mathematics	Calculus

Source: Compiled by the Education and Training Committee from *Comparison of Year 12 Pre-tertiary Mathematics Subjects in Australia 2004–2005*, commissioned by the International Centre of Excellence for Education in Mathematics and the Australian Mathematical Sciences Institute, pp.1–2.

It is important to note that while the Committee has categorised the mathematics suite of each jurisdiction into three groups, the content, philosophies and approaches for each subject vary significantly throughout the states and territories. As stated in the above report:

Pre-tertiary entrance mathematics subjects across the Australian States and Territories vary enormously, with differences in philosophy, mathematical content and assessment so great that no two States' Year 12 mathematics subjects could be described as equivalent.¹⁰⁶

¹⁰⁶ F. Barrington & P. Brown 2005, *Comparison of Year 12 Pre-tertiary Mathematics Subjects in Australia 2004–2005*, Commissioned by the International Centre of Excellence for Education in Mathematics and the Australian Mathematical Sciences Institute, AMSI, Melbourne, p.iv.

The Committee understands that the VCAA benchmarks the entire VCE mathematics suite against interstate courses during the accreditation process. Despite this process, differences between interstate mathematics courses still persist, suggesting national co-ordination is required to establish consistency across mathematics courses. The study commissioned by the International Centre of Excellence for Education of Mathematics and the Australian Mathematical Sciences Institute concluded the issue was worthy of further investigation and documentation.¹⁰⁷

The above study report noted that the inconsistencies between senior mathematics courses throughout Australia are likely to affect students undertaking university mathematics interstate:

Students who move interstate are liable to find that their previous studies so mismatched their first year [university] mathematics that they must undertake extra reading on particular topics and adjust to new approaches.¹⁰⁸

The Committee believes the inconsistencies in mathematics studies across Australia also create problems for larger employers who cross interstate boundaries. Such variety of content and subject naming creates confusion for employers in understanding employees' qualifications, in what really should be a nationally consistent discipline. Much of mathematics content is universal, and should, therefore, differ little across international, and certainly interstate, jurisdictions.

The Committee believes that the confusion created by having inconsistent senior mathematics subjects throughout Australia warrants inter-jurisdictional attention. Therefore, the Committee recommends that the Victorian Government raise with the Ministerial Council on Education, Employment, Training and Youth Affairs, in consultation with the industry, business, research and higher education sectors, the need to work towards nationally consistent senior mathematics subjects.

Recommendation 3.1: That the Victorian Government raise with the Ministerial Council on Education, Employment, Training and Youth Affairs, in consultation with the industry, business and research sectors, the need for national consistency in the content and naming of senior mathematics subjects.

¹⁰⁷ *ibid.*, p.25.

¹⁰⁸ *ibid.*, p.iv.

VCAL Numeracy Requirements

The VCAL numeracy requirements may be satisfied through a number of pathways depending on the student's preferences and capabilities, and the courses offered by their providers. Students may choose from a range of options including VCE mathematics, specific VCAL numeracy units and modules from the Certificate in General Education for Adults. There are three VCAL numeracy units:

1. Numeracy Skills Intermediate
2. Numeracy Skills Senior
3. Advanced Numeracy Skills Senior.

Numeracy Skills Intermediate satisfies the requirements of either the foundation or intermediate VCAL levels. Either Numeracy Skills Senior or Advanced Numeracy Skills Senior satisfy the requirements of the senior level VCAL.¹⁰⁹

The purpose of the numeracy component of the VCAL is to develop skills for the practical applications of mathematics at home, work and in the community. This includes the ability to use mathematical skills related to designing, measuring, constructing, using graphical information, money, time, travel and the underpinning skills and knowledge for further study in mathematics related fields. This purpose is encapsulated in the four domains of the VCAL numeracy component: Numeracy for Practical Purposes; Numeracy for Interpreting Society; Numeracy for Personal Organisation; and Numeracy for Knowledge.

The Science Curriculum in Primary Schools

The CSF II identifies science as one of eight key learning areas. Science is also one of the key domains in the discipline-based learning strand of the new VELS. As detailed in Chapter 7, the Committee found that, for a number of reasons, science in primary schools is typically afforded less of an emphasis than in secondary schools. Nonetheless, Victoria has many dynamic primary school teachers with a strong interest and enthusiasm for teaching science who have been further assisted by various recent government initiatives aimed at promoting science in schools. Therefore, when science is taught in primary schools, it is generally taught in a way that is engaging and enjoyable for students.

¹⁰⁹ Victorian Qualifications Authority 2003, *Victorian Certificate of Applied Learning, Curriculum Planning Guide: Literacy and Numeracy Skills Strand*, VQA, Melbourne, pp.140–142.

Science and the Victorian Essential Learning Standards

There are two dimensions to the science domain in the VELs: 'science knowledge and understanding' and 'science at work'.

The 'science knowledge and understanding' dimension focuses on building deep understanding of the overarching conceptual ideas of science. These include:

- understanding the similarity and diversity of living things and their relationship with each other and their environment;
- understanding concepts related to matter – its properties and uses, and how different substances are created through chemical change;
- understanding concepts of energy and force as a way of explaining physical phenomena; and
- understanding the place of the Earth in time and space and the interaction between the Earth and its atmosphere.¹¹⁰

The 'science at work' dimension focuses on students experiencing and researching how people work with and through science. Students learn to be curious and to use scientific understanding and processes to find answers to their questions. They design and pursue investigations; generate, validate and critique evidence; analyse and interpret ideas and link them with existing understanding; work and reason with scientific models and communicate their findings and ideas to others. They identify and practice the underlying values, skill and attributes of science.¹¹¹

Through their investigations, students gain insight into science as a human activity and the relationship between science, technology and society and possible futures. They explore how science is used in multiple contexts throughout their lives and its pervasiveness throughout the workplace.¹¹²

¹¹⁰ Information on the Victorian Essential Learning Standards Science Domain was obtained from the Victorian Curriculum & Assessment Authority Website, <<http://vels.vcaa.vic.edu.au/>>, accessed on 17 January 2005.

¹¹¹ *ibid.*

¹¹² *ibid.*

Time Allocated to Science

Many submissions and witnesses raised concerns regarding the amount of time spent teaching science during the primary school years. According to the *School Management Benchmarks* report, the mean time spent teaching science in Victorian Government primary schools was less than 75 minutes per week in 2004.¹¹³ Ranking schools according to the time spent teaching science, the lower quartile of schools were teaching science for less than 60 minutes per week. According to the 2003 Trends in International Mathematics and Science Study (TIMSS), the international average for time spent teaching science in Year 4 was seven per cent of instructional time. The average in Australia (and Victoria) was five per cent, which was the fourth lowest of the countries participating in TIMSS.¹¹⁴ Of this, about 40 per cent was spent on instruction in the area of *life science*, 30 per cent in the area of *earth science* and 20 per cent in *physical science*.¹¹⁵

The Committee believes that the amount of time spent teaching should be increased in many primary schools. As stated in the Goodrum Report:

The relationship between learning achievement and time on learning is well accepted. If the quality of science learning is to be improved, it is obvious the amount of time devoted to this task needs to be increased.¹¹⁶

One of the key recommendations of a 2005 Commonwealth Government report, *Benchmarking Australian Primary School Curricula*, was that the science curriculum in Australian states should designate or at least suggest a recommended time allocation for teaching science in primary schools.¹¹⁷

Australia was one of the few TIMSS participants that does not designate in its curriculum documents the proportion of instructional

¹¹³ Department of Education & Training, *2004 School Management Benchmarks*, DE&T, Melbourne, <<http://www.sofweb.vic.edu.au/standards/publicat/bench.htm>>, accessed on 17 January 2006.

¹¹⁴ S. Thomson & N. Fleming, *Examining the Evidence: Science achievement in Australian schools in TIMSS 2002* (TIMSS Australia Monograph no. 7), ACER, Melbourne, p.85.

¹¹⁵ *ibid.*

¹¹⁶ D. Goodrum, M. Hackling & L. Rennie 2001, *The Status and Quality of Teaching and Learning of Science in Australian Schools*, report prepared for the Department of Education, Training & Youth Affairs, Commonwealth of Australia, Canberra, p.176.

¹¹⁷ Department of Education, Science & Training 2005, *Benchmarking Australian Primary School Curricula*, DEST, Canberra, p.9.

time that should be dedicated to teaching science.¹¹⁸ However, the Committee suggests that increasing instructional time dedicated to science without also addressing the quality of teaching during that time would be remiss. Further, the Committee notes that it is possible to increase the emphasis of science in the curriculum without necessarily specifying a minimum required amount of time to be spent teaching science. Evaluations of both the Schools Innovation in Science and Primary Connections programs, for example, revealed an increase in the time spent teaching science. Primary Connections, in particular, influenced the priority of science in the curriculum: it 'increased the amount of time devoted to science teaching, and science moved from being an afternoons-only subject to one taught across mornings and afternoons as science and literacy teaching were integrated'.¹¹⁹

The Science Curriculum in Secondary Schools

Although the curriculum framework in Victoria spans both primary and secondary levels, the transition between the two marks sizeable changes in the science curriculum and teaching practices. Science has greater prominence in the secondary curriculum than in primary schools. In Victoria, the average time spent teaching science in Years 7 and 8 was approximately 160 minutes per week in 2004.¹²⁰

Formal experimentation becomes a greater focus of the science curriculum in secondary schools. Also, unlike primary teachers who are generalists, science teachers are usually experts in their field and are therefore often more confident with their content knowledge than primary teachers.

The sciences in VCE are segregated into the key disciplines of Biology, Chemistry, Physics and Psychology. Additionally, a small proportion of VCE students study Environmental Science and/or Agricultural and Horticultural Studies. The following sections outline each of these subjects, based largely on supplementary material provided by the VCAA.

¹¹⁸ M.O. Martin, I.V.S. Mullis, E.J. Gonzalez & S.J. Chrostowski 2004, *TIMSS 2003 International Science Report – Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades*, TIMSS & PIRLS International Study Centre, Boston, pp.189-190.

¹¹⁹ M. Hackling & V. Prain 2005, *Primary Connections Stage 2 Trial: Research Report. Executive Summary*, Australian Academy of Science, Canberra, p.3.

¹²⁰ Department of Education & Training, *2004 School Management Benchmarks*, DE&T, Melbourne, <<http://www.sofweb.vic.edu.au/standards/publicat/bench.htm>>, accessed on 17 January 2006.

Biology

After Psychology, Biology is the second most popular VCE science subject. The new Biology course is accredited from 2006 to 2009. Biology makes strong connections between other fields of science including Chemistry and Physics. Furthermore, Biology draws upon increasingly specialised fields of science such as biochemistry, neuroscience, genetics, evolutionary biology, behavioural science and cell and molecular biology, including genomics and proteomics.

The VCE Biology course is structured as follows:

- Unit 1: Unity and diversity. Comprises 'cells in action' and 'functioning organisms'.
- Unit 2: Organisms and their environment. Comprises 'adaptations of organisms' and 'dynamic ecosystems'.
- Unit 3: Signatures of life. Comprises 'molecules of life' and 'detecting and responding'.
- Unit 4: Continuity and change. Comprises 'heredity' and 'change over time'.¹²¹

Biology was the fifth most popular VCE subject overall, with over 11,200 enrolments or over 22 per cent of the Year 12 cohort in 2004.¹²²

There are no Victorian university courses that specify Biology as a mandatory prerequisite. Many include Biology as an optional prerequisite, including Science at the University of Melbourne; Food Technology and Nutrition at RMIT University; and Biological Science at Deakin University.

Chemistry

Chemistry is one of the crucial enabling sciences and its status attracted particular attention during this inquiry.

Units 1 and 2 involve the following topics: introduction to materials; water; chemistry of surfaces; acids in the environment; the atmosphere; and corrosion of metals.

Units 3 and 4 include the study of analytical chemistry, (chemical) equilibrium, industrial chemistry, supplying and using energy, food chemistry and the periodic table: an overview of chemistry.

¹²¹ Victorian Curriculum & Assessment Authority 2005, *Biology: Victorian Certificate of Education Study Design*, VCAA, Melbourne, pp.13–28.

¹²² Supplementary material provided to the Committee by the Victorian Curriculum & Assessment Authority, October 2005.

There were over 8,600 enrolments in Unit 3 and 4 Chemistry in 2004, representing 17.3 per cent of the Year 12 cohort.

At the time of writing this report, the VCAA, in partnership with the Department of Innovation Industry and Regional Development, was in the midst of a review and redevelopment process of the VCE Chemistry course. The new course is to be introduced in 2007. The redevelopment program included a two-day symposium of invited key stakeholders (held in November 2004); interstate visits for key personnel to review alternative programs for senior secondary chemistry curriculum; development of a CD-ROM on emerging industries in chemistry, biochemistry, biotechnology and engineering; and the placement of 10 exemplary Victorian chemistry teachers with teams in innovative chemistry research centres.

The Committee is pleased to note that the terms of reference for the review process required the Review Committee to consider:

- the use of technology in chemistry and the opportunity to extend the use of technology appropriate to the study of chemistry; and
- the relevance of the content in terms of recent developments in the field of chemistry.

Courses listing Chemistry as a mandatory prerequisite include: Chemical Engineering, Chiropractic and Nanotechnology at RMIT University; Nutritional Science at La Trobe University; Biotechnology and Innovation at Box Hill TAFE; Forensic Science at Deakin University; and Biomedical Science and Pharmacy at Monash University. Courses listing Chemistry as an optional prerequisite include: Science/Teaching at the University of Melbourne; Arts/Science at Deakin University; Public and Environmental Health at Swinburne University; and Nursing at Deakin, La Trobe and Australian Catholic universities.

Physics

Accredited for the period 2005 to 2008, Physics is a crucial enabling science and is often considered to be the most challenging of the sciences. Of the core sciences, Physics has the least number of VCE enrolments. Numerous stakeholders expressed concerns over the participation rates in Physics, especially of females and students of lower socioeconomic status, who are considerably under-represented (refer Chapter 4).

VCE Physics comprises the following units:

Units 1 and 2 investigate light, nuclear and radioactivity physics, astronomy, medical physics, movement, electricity, astrophysics, aerospace and alternative energy sources.

Unit 3 students investigate motion, electronics and photonics, and one of Einstein's special theory of relativity, materials and their use in structures or further electronics.

Unit 4 investigates electric power, interactions of light and matter and one of synchrotron and its applications, photonics or sound.

The rationale and the content of VCE Physics have been recently revised to reflect the contemporary nature of Physics. A number of stakeholders were pleased to note the inclusion of new science such as photonics and synchrotron science into the Year 12 Physics curriculum.

Enrolments in Physics were just over 7,500 students (inclusive of the pilot of the proposed new course), or just over 15 per cent of the Year 12 cohort in 2004.¹²³

University courses specifying Physics as a mandatory prerequisite include Telecommunications Engineering at Monash University; and Medical Radiations, Physics and Applied Physics at RMIT University. Many courses also list Physics as an optional prerequisite, with Chemistry or Specialist Mathematics as common alternative studies. These courses include the combined Nanotechnology/Science course and Space Science at La Trobe University; Engineering courses at Monash University; and Medicine, Optometry and Dental Science at the University of Melbourne.

¹²³ *ibid.*

Psychology

Psychology has the highest enrolments of the VCE sciences, with over 14,000 enrolments or almost 29 per cent of the Year 12 cohort in 2004.¹²⁴

Psychology is not considered an enabling science and perhaps due to the high level of student enrolments in this subject, little of the Committee's evidence focused on Psychology. Nonetheless, Psychology is an important subject, leading to a range of pursuits in tertiary education, including a variety of social and behavioural sciences, marketing and communications, criminal justice, social work, a range of health sciences and many other courses.

Environmental Science

Less than 1 per cent of the total student cohort in Victoria study VCE Environmental Science. The Environmental Science course is accredited from 2005 to 2008.

The Environmental Science course is sequenced as follows:

- Unit 1: The environment. Comprises 'ecological components and interaction', 'environmental change' and 'ecosystems'.
- Unit 2: Monitoring the Environment. Comprises 'environmental indicators' and 'using environmental indicators'.
- Unit 3: Ecological issues: energy and biodiversity. Comprises 'energy and global warming' and 'diversity in the biosphere'.
- Unit 4: Ecological sustainability studies. Comprises 'pollution and health' and 'applied environmental science'.

As there are so few enrolments in Environmental Science, it is not listed as a mandatory prerequisite for any university studies. Some courses, however, specify Environmental Science as an optional prerequisite, including Physical Education at the University of Ballarat. Additionally, Environmental Science would meet the requirements for courses requiring the study of any subject from the science field.

¹²⁴ *ibid.*

Agricultural and Horticultural Studies

Although not generally identified as part of the VCE science suite by inquiry participants, this subject is important in the context of its emphasis on the scientific and technological aspects of agriculture.

The current Agricultural and Horticultural Studies course has been accredited from 2006 to 2010. The study provides a 'contextual overview of the scientific, management and operational skills and knowledge required to run a small agricultural and horticultural business project'. In this sense, the subject is notable for its applied and integrated inclusion of science, technology and innovation.¹²⁵ The content of the course is designed to complement the VET certificates in agriculture and horticulture.

The four units of the course are:

- Unit 1: Agricultural and horticultural operations
- Unit 2: Production
- Unit 3: Technology, innovation and business design
- Unit 4: Sustainable management.

A number of the outcomes for Agricultural and Horticultural Studies focus on biological processes, environmental issues, sustainability and scientific approaches to investigation.

In 2004, there were 46 providers of Unit 3 and 4 Agricultural and Horticultural Studies, with overall enrolments of around 450 students, representing around 1 per cent of the Year 12 cohort. Most providers of the course were in rural or regional areas.¹²⁶ The subject is not listed as a mandatory prerequisite for any university or TAFE studies.

Senior Science Courses in Other Jurisdictions

As a point of comparison the Committee examined the suite of science courses on offer in other jurisdictions throughout Australia (refer Figure 3.4).

¹²⁵ Information on Agricultural & Horticultural Studies obtained from the Victorian Curriculum & Assessment Authority website, <<http://www.vcaa.vic.edu.au/vce/studies/agrihorculture/agrihorindex.html>>, accessed on 14 February 2006.

¹²⁶ *ibid.*

Figure 3.4: Suite of Senior Science Courses throughout Australia (2006)

State or Territory	Physical Sciences	Life Sciences	General or Multi-Strand Sciences	Applied Science
Australian Capital Territory	Chemistry Physics	Biology Earth Science Psychology	General Science	Electrotechnology Agriculture & Horticulture
New South Wales	Chemistry Physics	Biology Earth and Environmental Science	Senior Science	Engineering Studies Agriculture
Queensland	Chemistry Physics	Biology Earth Science	Multi-Strand Science Science21*	Aerospace Studies* Marine Studies* Agriculture
South Australia (and Northern Territory)	Chemistry Physics	Geology Psychology Biology	Contemporary Issues and Science	Agricultural and Horticultural Science
Tasmania	Chemistry Physics Science of the Physical World/Physical Sciences	Biology Environmental Science Life Sciences Science of Natural Resources		
Victoria	Chemistry Physics	Biology Psychology Environmental Science		Agricultural and Horticultural Studies
Western Australia	Chemistry Physics	Biological Sciences Earth and Environmental Sciences Psychology Human Biological Sciences	Integrated Science*	Aviation Engineering Studies Marine and Maritime Technology*

Note: * Indicates subjects that are being trialled or under development.

Source: Compiled by the Education and Training Committee from state and territory curriculum authority websites, February 2006.

The Committee was particularly interested in a number of other jurisdictions that have expanded their suite of senior science courses beyond the traditional subjects of Biology, Chemistry and Physics. Often, these additional subjects focus upon scientific literacy; encapsulate science through contemporary, applied or real world approaches; and/or integrate the traditional science disciplines in broad yet challenging courses.

The following sections expand on some examples of innovative science subjects that the Committee believes enhance other jurisdictions' suite of science courses.

Science for Public Understanding

Science for Public Understanding is a subject on offer in England as part of the General Certificate of Education (GCE). This subject is said to help broaden the curriculum for those whose interests lie mainly in the arts or humanities. It also gives those studying the traditional science subjects an opportunity to reflect on their specialist studies in a wider context.

The subject is divided into three modules. The first two modules, *Issues in Life Sciences* and *Issues in the Physical Sciences*, provide the teaching topics to be covered including contemporary issues such as medical ethics, genetics and genetic engineering, evolution, energy resources and global warming. The third module, *Coursework*, provides the lens through which these topics are studied, contextualising 'ideas about science' and 'science explanations'. Ideas about science includes: consideration of data and explanations, social influences on science and technology, causal links, risk and assessment and decisions about science and technology. 'Science explanations' examines the teaching topics in the context of major scientific theories such as the 'particle model of chemical reactions' or 'the gene model of inheritance'.¹²⁷

Science21

Still under trial in Queensland, Science21 is an interdisciplinary science course that seeks to give students a broad understanding of science and its relevance to their lives in the twenty-first century. The subject seeks to boost participant's scientific literacy and appreciation for

scientific inquiry. The key objectives are categorised as:

- knowledge and conceptual understanding;

¹²⁷ Assessment & Qualifications Alliance 2002, *General Certificate of Education – Science for Public Understanding* 2005, AQA, Manchester, p.15.

- working and thinking scientifically;
- impacts of science; and
- attitudes and values.

Studies are principally undertaken through an inquiry-focused methodology. Students undertake a series of inquiries on contemporary issues relevant to the students' lives now or in the future. Student inquiries may be drawn from five key scientific priorities, which comprise: information and communication; technology; health and wellbeing; catalysts for discovery; and environment. Each inquiry must include at least two of the fundamental discourses of science, or focus areas: particle nature of matter; cellular life; earth and space; and energy.¹²⁸

Multi-Strand Science

The key focus of Queensland's Multi-Strand Science is on the technical applications of scientific knowledge and on examination of economic, environmental, political and social consequences of those applications. The key aims of the course include:

- the ability to recall specific knowledge and apply this in simple situations;
- scientific processes, complex reasoning processes and appropriate attitudes and values;
- proficiency and safety in the use of field and laboratory equipment and other resources; and
- English language and science-specific language skills through explicit teaching of, and immersion in, the language of science.¹²⁹

The core topics explored are: energy; environmental studies; matter and materials; disease and society; and resource management. Schools may also offer an elective subject, which might include topics such as forensic science, ecotourism or kitchen chemistry.

¹²⁸ Queensland Studies Authority 2004, *Science21 Trial Senior Syllabus*, QSA, Brisbane, accessed on QSA website, <<http://www.qsa.qld.edu.au/>> on 10 January 2006.

¹²⁹ Queensland Board of Senior Secondary School Studies 1998, *Multi-Strand Science: Senior Syllabus*, Queensland Board of Senior Secondary School Studies, Brisbane, p.3.

Engineering Studies

Engineering Studies in New South Wales is directed towards the application and advancement of skills associated with mathematics, science and technology and is integrated with business and management. The subject promotes environmental, economic and global awareness, problem-solving ability, engagement with information technology, self-directed learning, communication, management and skills in working as a team.¹³⁰ The course is designed to benefit students who intend to follow university studies, vocational education and training or workforce pathways.

At the Year 11 level, students study household appliances, landscape products, braking systems, bio-engineering and a school-based elective. At Year 12, students study civil structures, personal and public transport, lifting devices, aeronautical engineering and telecommunications engineering.¹³¹ An important part of the assessment at both year levels is the Engineering Report, which seeks to replicate the reports that form a prominent means of communication in the field of engineering.¹³²

Western Australia also offers an Engineering Studies course as part of the Western Australian Certificate of Education.

The Committee was particularly interested in the success of Engineering Studies in integrating the science disciplines, mathematics, technology, economics and management and social sciences.

Expanding the Suite of Victorian Senior Science Courses

Historically, a fifth science in the VCE science suite (not including Agricultural and Horticultural Studies) has not been widely embraced by Victorian schools. This is evidenced by the discontinuation of both Geology and a general Science course, due to poor enrolments. The Committee believes, however, that some new, contemporary science subjects at VCE level may have greater success, provided they are strategically targeted at current gaps in delivery. The success of Agricultural and Horticultural Studies in Victoria, and a range of applied science subjects interstate, indicates that new science subjects can be successful where they address specific industry and/or community needs. The Committee believes, however, that any attempt to introduce new science subjects should take account of the need to retain and even increase existing enrolment levels within the traditional, enabling science subjects.

¹³⁰ Board of Studies New South Wales 1999, *Engineering Studies Stage 6 Syllabus*, Board of Studies NSW, Sydney, p.6.

¹³¹ *ibid.*, p.9.

¹³² *ibid.*, p.11.

In seeking to address its vision for a more highly scientifically literate society, the Committee is recommending that the Department of Education and Training, together with the Victorian Curriculum and Assessment Authority, explore the potential for a new, contemporary VCE science study that focuses on science for citizenship and communication. The Committee believes that the development of such a subject should seek to:

- increase the profile of science and scientific literacy among the community;
- widen the appeal of science to a greater proportion of the student cohort;
- emphasise the importance of science and science communication in today's society;
- emphasise scientific thinking, methodology and understanding; and
- integrate studies of the various specialised science disciplines to reflect real-world contexts for scientific applications.

Importantly, a contemporary science course such as that outlined above, would need to retain the same level of difficulty and rigour expected of any VCE level study. Further, it is not envisaged that any such additional subject would compete for students who have traditionally undertaken the enabling sciences. Rather, the content and promotion of this proposed subject should distinguish the course from existing subjects and attempt to broaden the appeal of science to a wider student cohort.

In addition, the Committee believes that the Department of Education and Training and the Victorian Curriculum and Assessment Authority should investigate the merits of introducing engineering studies for VCE students. Shortages in the engineering trades and professions have been a long-term concern of governments at all levels (refer Chapter 2). The Committee therefore believes that further analysis of the specific needs of Victorian industry and the strengths and weaknesses of interstate engineering programs is warranted. This analysis should take place in consultation with key industry representatives.

Recommendation 3.2: That the Department of Education and Training, in partnership with the Victorian Curriculum and Assessment Authority and other relevant stakeholders reconsider the existing suite of VCE science courses and investigate the merits of introducing:

- a contemporary general science and science communication subject; and
- an applied or engineering-based science subject.

Student Assessment

Issues pertaining to student assessment were not often raised during the course of this inquiry. However, participants who did address assessment, raised a number of issues, consistent with perspectives noted by the Committee in contemporary educational literature.

A common perspective noted throughout this inquiry was that assessment is often, in fact, a key driver of curriculum. Professor Leonie Rennie commented, however, that assessment needs to not only be in context of what is taught in the curriculum, but also how it is taught.¹³³ Therefore, if teachers can only assess students through a limited range of strategies, their teaching methodologies and approaches may be similarly restricted.

Purpose of Assessment

The Commonwealth Government report *The Status and Quality of Teaching and Learning of Science in Australian Schools* (the Goodrum Report) states there are three main purposes of assessment: the support of learning; reporting of achievement of individuals (certification); and satisfying the demands of public accountability (benchmarking).¹³⁴

The Committee heard that the purposes of assessment often limit the assessment strategies available to teachers and thus may limit the mathematics and science curricula. A number of stakeholders acknowledged the necessity of each of these purposes, though they emphasised the importance and value of assessment that supports learning.

¹³³ Transcript of Meeting, Perth, 2 June 2005, p.50.

¹³⁴ D. Goodrum, M. Hackling & L. Rennie 2001, *The Status and Quality of Teaching and Learning of Science in Australian Schools*, report prepared for the Department of Education, Training & Youth Affairs, Commonwealth of Australia, Canberra, p.21.

Diagnostic and formative assessments were both identified as being highly effective in supporting learning. Diagnostic assessment may be administered in forms such as simple quizzes, brain storming, interviews or informal questioning of students. Diagnostic assessment allows teachers to gauge a student's understanding of a topic and any misconceptions they may have. This enables teachers to identify where they may need to adapt their program or teaching strategies.

Formative assessment is assessment *for* and *as* learning rather than *of* learning.¹³⁵ Formative assessment allows students to develop their understanding of a topic while undertaking the assessment and, provides students with meaningful feedback on ways of improving their learning. Crucially, as Ms Elaine Horne, Curriculum Officer with the Western Australian Curriculum Council noted, formative assessment allows teachers 'to tailor the learning to each kid's needs'.¹³⁶ Often characterised as 'rich authentic assessment tasks' such as open-ended problems in mathematics classes and extended scientific investigations, formative assessment can often be highly suited to promoting and fostering understanding in mathematics and science.

It is, however, often difficult to employ formative approaches to assessment when the purposes of assessment are either for certification or benchmarking. For such purposes, issues relating to the reliability and fairness of the test are often paramount. Summative assessment tasks that are typically used for certification and benchmarking are generally characterised by the standardised and uniform end-of-topic, end-of-term or end-of-year school tests.¹³⁷ The types of questions in summative assessment often include 'short answers or multiple choice for recall of facts, substitution in formulas and solution of problems; and brief explanations'.¹³⁸

The Victorian Schools Innovation Commission stated:

Most countries implement some form of national testing regime against which benchmarks can be set as well as a formal examination and certification regime at different stages during secondary school. This continues to be problematic when most testing regimes often tend toward short answer questions of low order

¹³⁵ Witnesses speaking about the importance of formative assessment included Mr C. McGuire, Assistant Principal, Parkdale Secondary College, Transcript of Evidence, Public Hearing, Parkdale Secondary College, 12 September 2005, p.20; and Ms N. Hayes, Maths & Science Teacher, Kyabram Secondary College, Transcript of Evidence, Public Hearing, Shepparton, 2 August 2005, p.26.

¹³⁶ Transcript of Meeting, 31 May 2005, Perth, pp.5–6.

¹³⁷ D. Goodrum, M. Hackling & L. Rennie 2001, *The Status and Quality of Teaching and Learning of Science in Australian Schools*, report prepared for the Department of Education, Training & Youth Affairs, Commonwealth of Australia, Canberra, p.22.

¹³⁸ Written Submission, Emeritus Professor R. White, December 2004, p.1.

skill which may be antithema to the moves in curriculum and pedagogy.¹³⁹

The Goodrum Report similarly identified the influence of summative assessment on curriculum and teaching approaches:

- reducing science to learning of isolated facts and skills;
- lowering cognitive level of classroom work;
- learning follows testing in focusing on aspects that are easy to test rather than focusing on competencies that are valuable learning outcomes; and
- creative, innovative methods and topical content are omitted.¹⁴⁰

In summary, the Committee's evidence suggests that summative assessment often has the potential to negatively influence the mathematics and science curricula and to lower student engagement. The Committee believes that summative assessment is essential and even suggests that science should be included in state-wide benchmarking, to help raise its profile and status in the Victorian curriculum (refer Recommendation 3.4). It is also necessary, however, that future summative assessment is aimed at assessing more than just a student's ability to recall facts and figures and to undertake simple procedures.

Assessing More than Just the Facts and Figures

This inquiry found that decisions about what to assess are important. Specifically, evidence focused on the importance of assessing student understanding, especially in mathematics and science, rather than of 'skill and drill'.

Mr Neil Champion was among a variety of participants who believe that 'too much emphasis has been placed on assessing what students already know'.¹⁴¹ In his written submission, Mr Champion stated:

Assessment should test for deep understanding and life-long learning in science, supporting attempts within curriculum to promote stable conceptual change in

¹³⁹ Written Submission, Victorian Schools Innovation Commission, December 2004, p.4.

¹⁴⁰ D. Goodrum, M. Hackling & L. Rennie 2001, *The Status and Quality of Teaching and Learning of Science in Australian Schools*, report prepared for the Department of Education, Training & Youth Affairs, Commonwealth of Australia, Canberra, pp.22–23.

¹⁴¹ Written Submission, Mr N. Champion, January 2005, p.7.

science (rather than recall and recognition of definitions, facts, formulae and routine procedures).¹⁴²

The Victorian Schools Innovation Commission shared this perspective, stating that there is a need for curriculum to 'shift to asking what students can do with their learning rather than reproduction of learning'.¹⁴³

The Committee believes that the curriculum and assessment strategies that prioritise student understanding are likely to engage a greater range of students and foster a greater culture of innovation. Future innovators must first *understand* existing paradigms, concepts and applications of mathematics and science, before they can be expected to develop new ideas.

Inquiry witness, Dr Mike Hollitt said that in his 21 years of experience in the mining and resources industry:

... it has not ever been possible to solve large, complex problems – the types of problems that we are solving pretty much every day out there, although not with the frequency that we would like – using deductive reasoning alone or by finding the answer in a publication or somewhere like that. Inductive reasoning – and that is the reasoning of invention – has always been there. You have always needed that to supplement deductive reasoning in order to create the new.¹⁴⁴

Emeritus Professor White suggests that in science at least, there are considerable opportunities to assess student understanding:

Better understanding of science would follow from use of a greater range of styles: drawings, Venn diagrams, prediction tasks, essays and interviews. Physics, in particular, would benefit from use of qualitative questions instead of relying almost completely, as is now the case, on numerical 'problems' that require little more than substituting in formulas.¹⁴⁵

¹⁴² *ibid.*, p.9.

¹⁴³ Written Submission, Victorian Schools Innovation Commission, December 2004, p.7.

¹⁴⁴ Transcript of Evidence, Public Hearing, Melbourne, 31 August 2005, p.35.

¹⁴⁵ Written Submission, Emeritus Professor R. White, December 2005, p.1.

As discussed above, summative assessment strategies associated with certification and benchmarking often influence curriculum. Yet, generally, summative assessment used in mathematics and science does not assess more than a student's ability to recall facts and figures. Assessment models that simultaneously address issues of fairness and reliability, while measuring students' understanding, as well as knowledge and skills, should therefore be investigated.

The Program for International Student Assessment (PISA), for instance, focuses on and measures young people's ability to use their knowledge and skills to meet real-life challenges, rather than on the extent to which they have mastered a specific school curriculum (see Chapter 5). Meanwhile, the test is considered valid, fair and comparable, even across international jurisdictions. More widespread use of similar approaches to assessment for all age groups within Victorian schools would be highly beneficial.

Also important in assessing student understanding is the use of a broad range of assessment tools. As with teaching strategies, the use of varying assessment strategies for different groups of students should be considered and encouraged, where appropriate. If taught well and assessed with appropriate tools, even some students with learning difficulties are capable of high achievement.¹⁴⁶ Similarly, Professor Leonie Rennie suggested that even subtle changes to assessment approaches in subjects such as physics may be mutually beneficial to males and females.¹⁴⁷ Having a flexible range of assessment strategies at hand enables a teacher to provide students with every chance to demonstrate their knowledge. The 5 Es curriculum and assessment model is useful here (refer Appendix I). It demonstrates opportunities for teachers to use diagnostic, formative and summative assessment strategies throughout the learning and teaching process of a unit of work.

Assessment also plays a crucial role in identifying students who have become, or are at risk of becoming, disengaged from their learning. The Committee heard of examples of students becoming disengaged in mathematics and science due to gaps in their knowledge and understanding. Such gaps may occur due to a relatively short disruption such as that caused by illness, change of school or family circumstance. Equally, a gap in knowledge and understanding may arise due to a student's inability to grasp complex concepts in a limited timeframe. The Committee considers it essential that teachers are skilled in identifying gaps in students' knowledge and understanding. The strategic use of diagnostic assessment when embarking on new topics may enable teachers to identify students who are likely to struggle with a particular topic. Furthermore, the appropriate use of summative assessment that explores student understanding and their

¹⁴⁶ Written Submission, Mr N. Champion, January 2005, p.7.

¹⁴⁷ Transcript of Meeting, Perth, 2 June 2005, p.50.

ability to apply their knowledge can also help to identify whether a student has fully grasped a concept throughout a unit, enabling a teacher to reinforce any concepts that may require additional attention.

Recommendation 3.3: That the Department of Education and Training revise existing summative assessment tools to ensure they measure and promote student understanding and students' ability to apply their mathematics and science knowledge.

Reporting

Just as assessment is often a driver of curriculum, reporting requirements can often be a driver of assessment and, therefore, subsequently of the curriculum.

Part of the current reporting structure in Victoria is the Achievement Improvement Monitor (AIM), an assessment and monitoring regime that measures the progress and achievement of students in literacy and numeracy. AIM testing is conducted at Years 3, 5 and 7. While the results of this testing is reported to parents, AIM testing is undertaken principally for benchmarking and accountability purposes. The state-wide reporting of student progress and achievement in literacy and numeracy reflects the priority of these subject areas to both the State Government and the Commonwealth Government. Mr Cliff Downey, Principal at Mooroopna Primary School, commented on the resulting prominence of literacy and numeracy in the primary school curriculum:

... when information on student progress is collected centrally by the education department, the government at state level and nationally, literacy and numeracy are the only areas in which there is an interest ... there is no collection of data on student progress in those other curriculum areas in primary school ... what then happens is that people get the impression in the community, even in other sectors of the education system, that primary schools are literacy and numeracy factories ...¹⁴⁸

The Committee, of course, considers the progression of literacy and numeracy in education to be of paramount importance. However, the Committee believes there is considerable value in science having a similar priority. The inclusion of science in the AIM testing regime would undoubtedly raise the profile of science throughout the primary school curriculum. The inclusion of science in state-wide benchmarking and accountability requirements would also be a major expression of the Victorian Government's commitment to the nationally important areas

¹⁴⁸ Transcript of Evidence, Public Hearing, Shepparton, 2 August 2005, p.10.

of science, innovation and technology. Furthermore, the central monitoring of achievement and progression of students in science will provide valuable information to the Department of Education and Training to enable more effective and targeted science education and teacher professional development programs.

Recommendation 3.4: That the Victorian Government include as part of the Achievement Improvement Monitor, the assessment of achievement and progression of students in science.

4. Trends in Enrolments in Mathematics and Science

Introduction

Enrolment trends in mathematics and particularly science were a key concern among stakeholders throughout the Committee's inquiry. Concerns were also raised that even where students do enrol and perform well in mathematics and science, they often later take up further education, training and employment in disciplines other than mathematics and/or science. The following chapter outlines trends in specific mathematics and science courses within the VCE and higher education, as well as some of the policy implications of these trends.

Enrolments in VCE Mathematics Subjects

In 2004, there were 46,600 enrolments in Victorian Certificate of Education (VCE) Unit 4 mathematics subjects, an overall increase of 15.3 per cent since 2000. Enrolments in Further Mathematics increased 28.3 per cent, while enrolments in Mathematical Methods and Specialist Mathematics increased 5.6 per cent and 5.5 per cent, respectively.

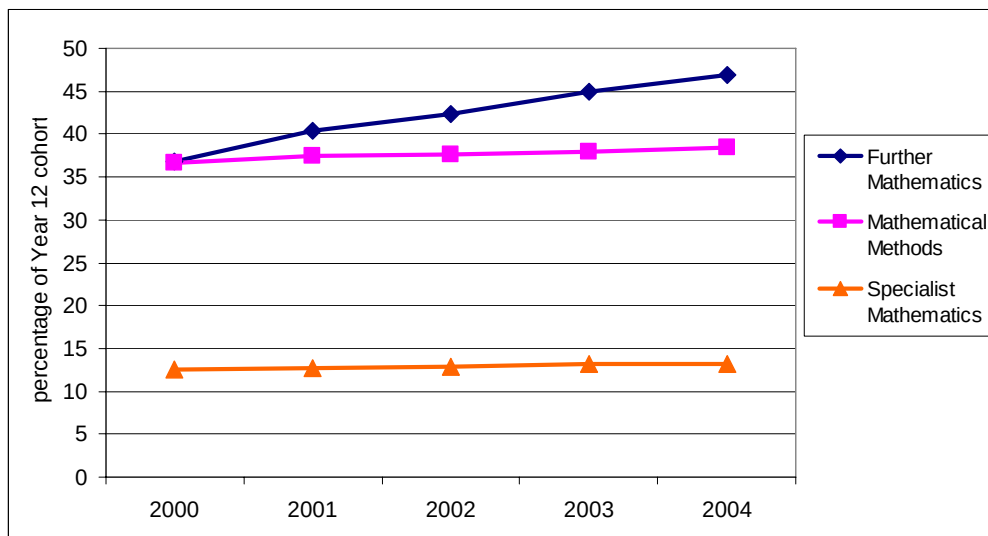
Figure 4.1 shows that there has also been an increase in the proportion of students undertaking Unit 4 VCE mathematics units.¹⁴⁹ It is important to note that substantial growth in Further Mathematics has not been at the expense of enrolments in either Mathematical Methods or Specialist Mathematics.

Compared to other Australian jurisdictions, Victorian levels of enrolment in mathematics are very positive. In 2004, 13.2 per cent of the Year 12 cohort were undertaking the most advanced mathematics subject, Specialist Mathematics. Comparable figures for other states were 10.7 per cent for South Australia, 8.4 per cent for Queensland, 8.2 per cent for Western Australia, 5.9 per cent for New South Wales and 5.3 per cent for the Northern Territory.¹⁵⁰ Refer to Chapter 3 for a summary of interstate mathematics subjects.

¹⁴⁹ In calculating the participation rates for mathematics and science enrolments, the Committee has used the number of Unit 4 English plus English as a Second Language enrolments as representative of the Year 12 cohort. This is the methodology recommended to the Committee by the Victorian Curriculum & Assessment Authority and data was supplied by the VCAA for this purpose.

¹⁵⁰ Supplementary material provided to the Committee by the Victorian Curriculum & Assessment Authority, October 2005.

Figure 4.1: Percentages of Year 12 Students Enrolling in VCE Unit 4 Mathematics (2000 to 2004)



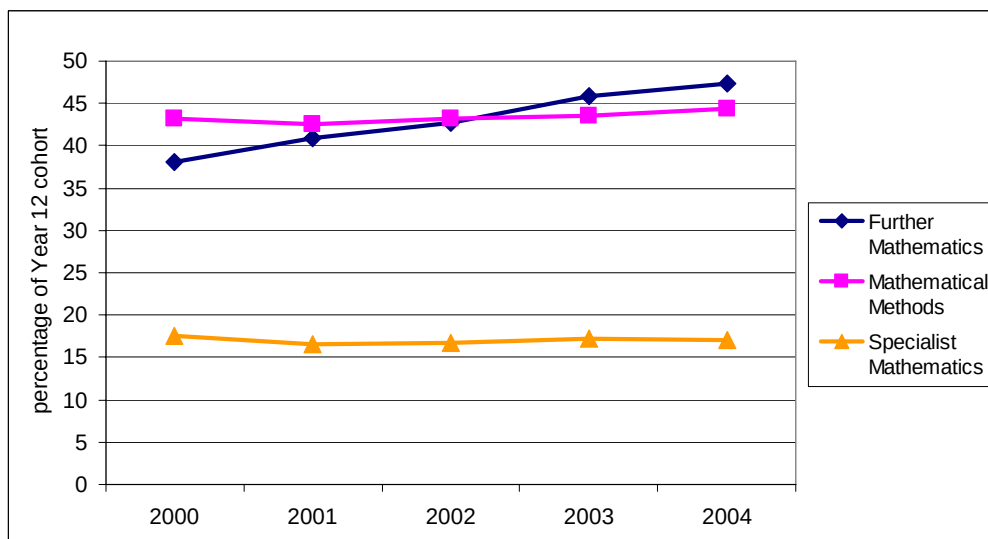
Note: Mathematical Methods includes Mathematical Methods (CAS) pilot for the years 2001 to 2004.

Source: Data supplied by the Victorian Curriculum & Assessment Authority, 2005.

Mathematics Enrolments by Gender

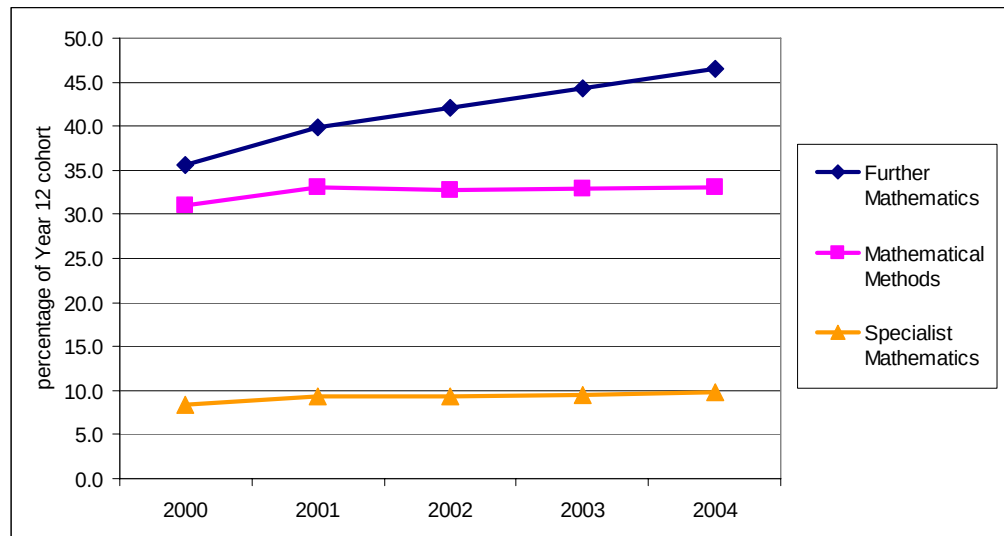
Figures 4.2 and 4.3 show trends in the proportion of male and female students enrolling in VCE mathematics over the period 2000 to 2004.

Figure 4.2: Percentages of Year 12 Students (Males) Enrolling in VCE Unit 4 Mathematics (2000 to 2004)



Note: Mathematical Methods includes Mathematical Methods (CAS) pilot for the years 2001 to 2004.

Source: Data supplied by the Victorian Curriculum & Assessment Authority, 2005.

Figure 4.3: Percentages of Year 12 Students (Females) Enrolling in VCE Unit 4 Mathematics (2000 to 2004)

Note: Mathematical Methods includes Mathematical Methods (CAS) pilot for the years 2001 to 2004.

Source: Data supplied by the Victorian Curriculum & Assessment Authority, 2005.

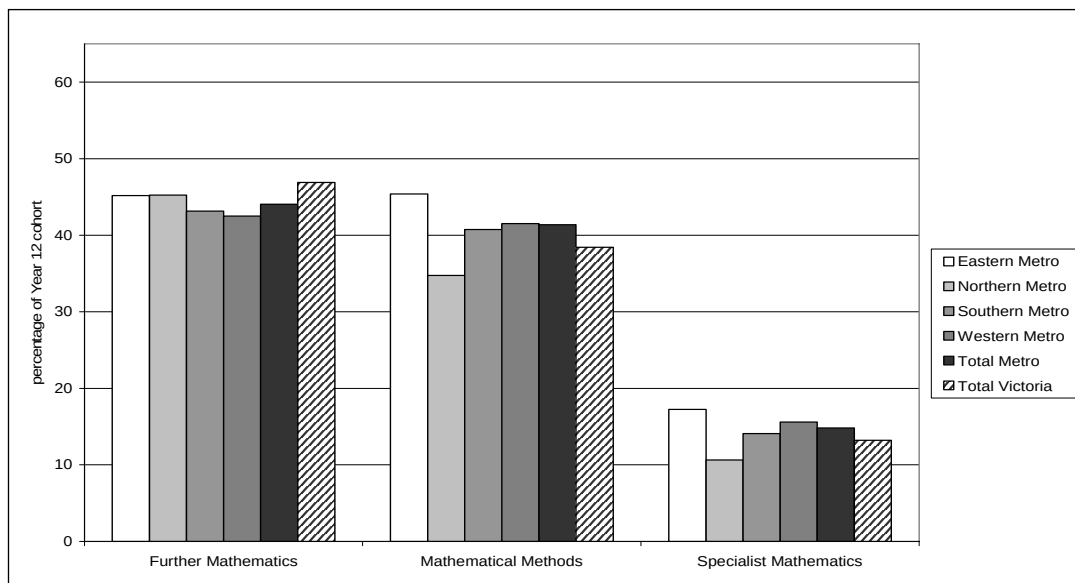
Both genders demonstrated strongest growth in Further Mathematics. Females demonstrated slightly stronger growth in all three VCE mathematics subjects compared to males, accounting for 54 per cent of growth in total enrolments in VCE mathematics over the period 2000 to 2004. Overall, female enrolments in mathematics increased by 17.8 per cent to 22,340 in 2004. Over the same period, male enrolments increased by 13.1 per cent to 24,254. Nonetheless, the proportion of females enrolled in Mathematical Methods and Specialist Mathematics remained substantially below that of male students.

Mathematics Enrolments by Region

Trends show that there is a greater tendency for metropolitan-based students to enrol in the more advanced mathematics subjects, compared with students in non-metropolitan regions. In 2004, metropolitan-based students were over-represented in Mathematical Methods and Specialist Mathematics and under-represented in Further Mathematics.

Figures 4.4 and 4.5 show the proportion of students in each Department of Education and Training region enrolling in the various mathematics subjects in 2004.

Figure 4.4: Percentages of Year 12 Students Enrolling in VCE Unit 4 Mathematics by Region (Metropolitan) (2004)[#]



Note: Mathematical Methods includes Mathematical Methods (CAS) pilot for the years 2001 to 2004.

Source: Data supplied by the Victorian Curriculum & Assessment Authority, 2005.

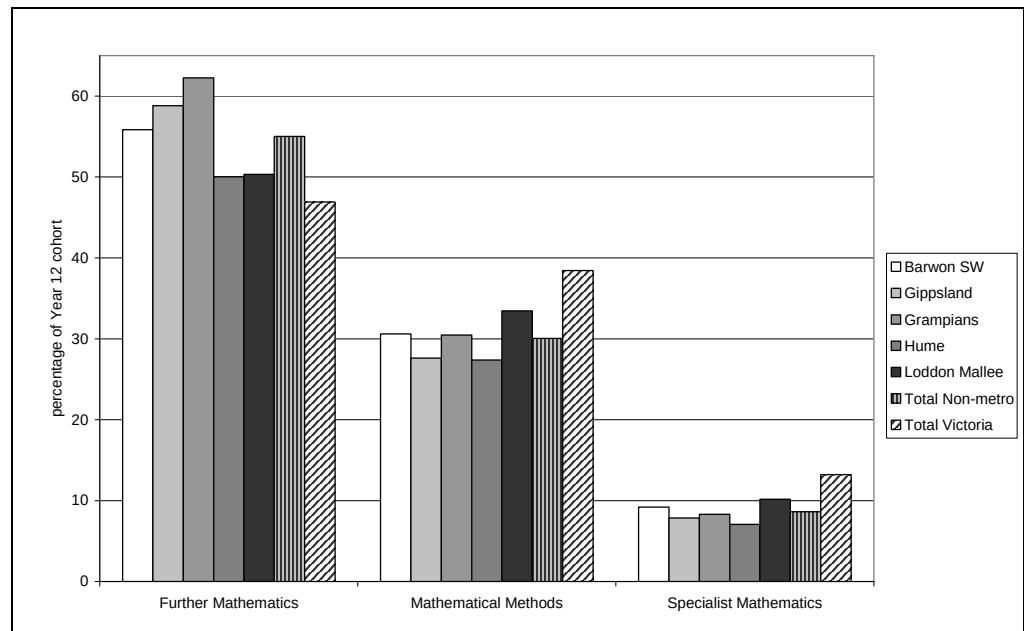
As shown in Figure 4.4, all four metropolitan regions had lower rates of enrolments in Further Mathematics than the average for Victoria in 2004. A comparison of enrolments among only the metropolitan regions, however, reveals that students from Eastern Metropolitan Region and Northern Metropolitan Region were over-represented in enrolments in Further Mathematics, while students in the other two regions were under-represented.

Significantly, students from Eastern Metropolitan Region were also over-represented in Mathematical Methods and Specialist Mathematics, while students in Northern Metropolitan Region were under-represented in these two subjects. This reveals a much stronger tendency for students in Eastern Metropolitan Region to undertake mathematics studies at all levels, compared with students in other regions. Students from Southern Metropolitan and Western Metropolitan Regions were also more likely to enrol in Mathematical Methods and Specialist Mathematics than the average for Victoria.

In comparison, students in the Northern Metropolitan Region are much less likely to enrol in mathematics subjects compared with the average for Victoria. Where they do undertake VCE level mathematics, they undertake the more advanced mathematics subjects at rates lower than the Victorian average.

[#] Please note that due to a printing error, Figure 4.4 in previous copies of this report was incorrect. The correct figure has been included in the web version, as of 18 March 2006

Figure 4.5: Percentages of Year 12 Students Enrolling in VCE Unit 4 Mathematics by Region (Non-Metropolitan) (2004)



Note: Mathematical Methods includes Mathematical Methods (CAS) pilot for the years 2001 to 2004.

Source: Data supplied by the Victorian Curriculum & Assessment Authority, 2005.

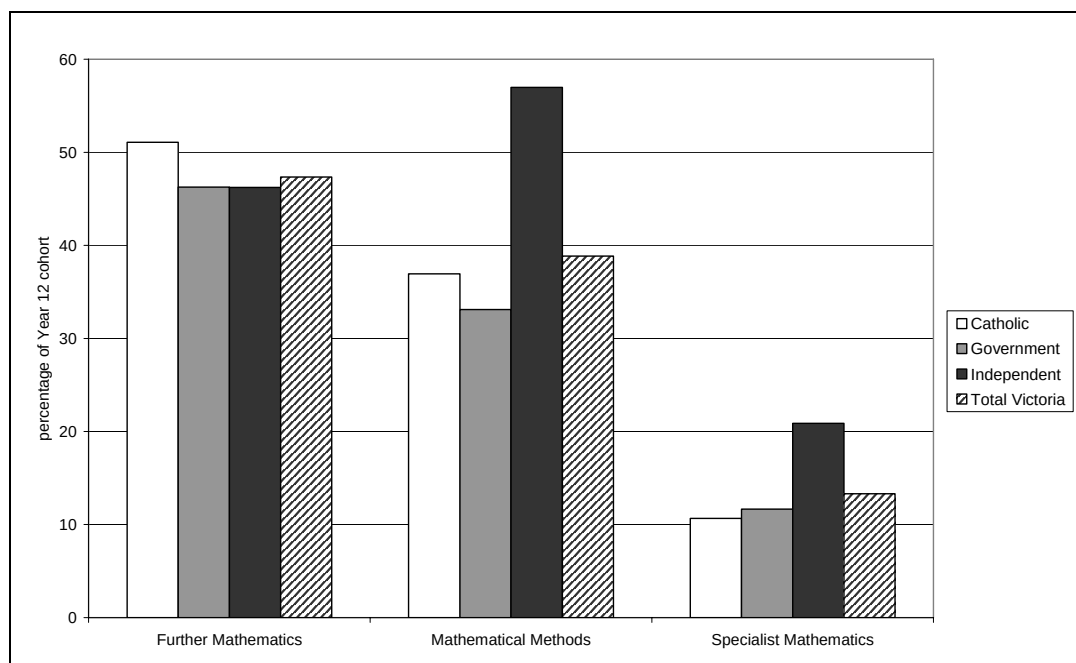
As shown in Figure 4.5, all five non-metropolitan regions had enrolments in Further Mathematics at rates above the average for Victoria in 2004 and enrolments in Mathematical Methods and Specialist Mathematics at rates below average for Victoria.

Barwon South Western Region had the highest number of VCE mathematics enrolments in 2004 and was slightly over-represented among non-metropolitan regions in all three mathematics subjects. In contrast, Hume Region was under-represented in all mathematics subjects compared to the non-metropolitan average. Loddon Mallee Region was over-represented among non-metropolitan regions in Mathematical Methods and Specialist Mathematics and under-represented in Further Mathematics.

Mathematics Enrolments by Sector

Student enrolment levels in mathematics also differ by school sector (refer to Figure 4.6).

Figure 4.6: Percentages of Year 12 Students Enrolling in VCE Unit 4 Mathematics by Sector (2004)



Note: Mathematical Methods includes Mathematical Methods (CAS) pilot for the years 2001 to 2004.

Source: Data supplied by the Victorian Curriculum and Assessment Authority, 2005.

As shown above, students in Catholic and government schools had enrolment levels in Mathematical Methods and Specialist Mathematics at rates below the average for Victoria in 2004. Students from the independent sector were substantially over-represented in these subjects. This trend is reflective of the socioeconomic profile of students in the independent sector, as discussed in Chapter 6.

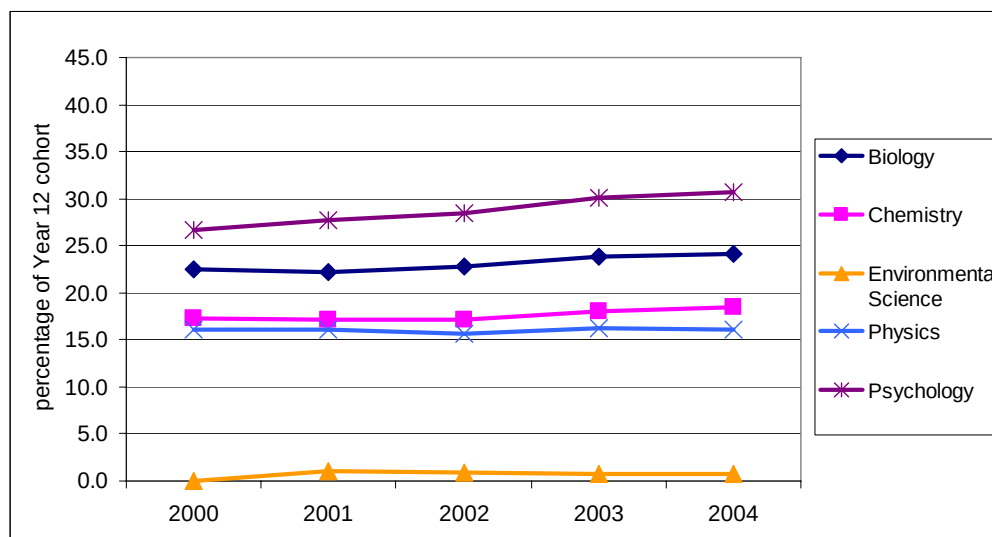
Government and independent school students were slightly under-represented in enrolments in Further Mathematics, while Catholic school students were over-represented in this subject.

Enrolments in VCE Science Subjects

In 2004, there were 42,600 enrolments in VCE Unit 4 science subjects. Growth in science enrolments between 2000 and 2004 was not as strong as mathematics, with enrolments increasing by only 9.9 per cent. Psychology experienced the greatest growth, up 16.0 per cent since 2000. Total enrolments in Physics remained steady (+0.2%) while Biology and Chemistry increased 8.0 per cent and 7.4 per cent, respectively.

Figure 4.7 shows trends in the proportion of Year 12 students undertaking science subjects over the period 2000 to 2004. It shows that Psychology had the greatest proportion of students enrolling, while Environmental Science was undertaken by only a very small proportion of total students (less than 1%).

Figure 4.7: Percentages of Year 12 Students Enrolling in VCE Unit 4 Science (2000 to 2004)



Source: Data supplied by the Victorian Curriculum & Assessment Authority, 2005.

The various states and territories offer a range of different science subjects at Year 12, although most states offer Biology, Chemistry and Physics as the core science subjects. Additional subjects offered by various states include Aerospace Studies, Contemporary Issues and Science, Earth Science, Engineering Studies, Environmental Science, Geology, Human Biological Sciences, Marine Studies and Psychology (refer to Chapter 3).

Enrolments in the range of science subjects vary considerably across states, even within the core science subjects. For example, while 22.6 per cent of the Victorian Year 12 cohort undertook Biology in 2004, the equivalent proportion was 21.7 per cent in New South Wales, 29.4 per cent in Queensland, and over 36 per cent in both South Australia and the Northern Territory. Year 12 enrolments in Chemistry varied from 10.9 per cent of the student population in South Australia to 23.2 per cent in the Northern Territory, while most states and territories had Year 12 enrolments in Physics of around 15–20 per cent.¹⁵¹

Australia's Teachers: Australia's Future reported on long-term national trends in Year 12 science enrolments. That study summarised the longer-term trend in science enrolments as follows:

In the sciences there has been a steady decline in the percentage of Year 12 students participating in biology, chemistry and physics that has been partly compensated by the emergence of participation in other science studies during the 1990s. Total Year 12 enrolments grew during the 1980s as a result of increases in school holding power. Consequently, when participation in biology, chemistry and physics is considered in relation to the full cohort (or as absolute numbers of students), the picture is one of a rise during the 1980s followed by a decline in 1990s. Although this decline is not dramatic there is also evidence of a decline in the numbers of students studying two or more science subjects.¹⁵²

As discussed below, participants in the inquiry were concerned about current enrolment levels of VCE science subjects in terms of their ability to meet the future needs of industry. Further, participants were concerned about varying levels of science enrolments among different student groups.

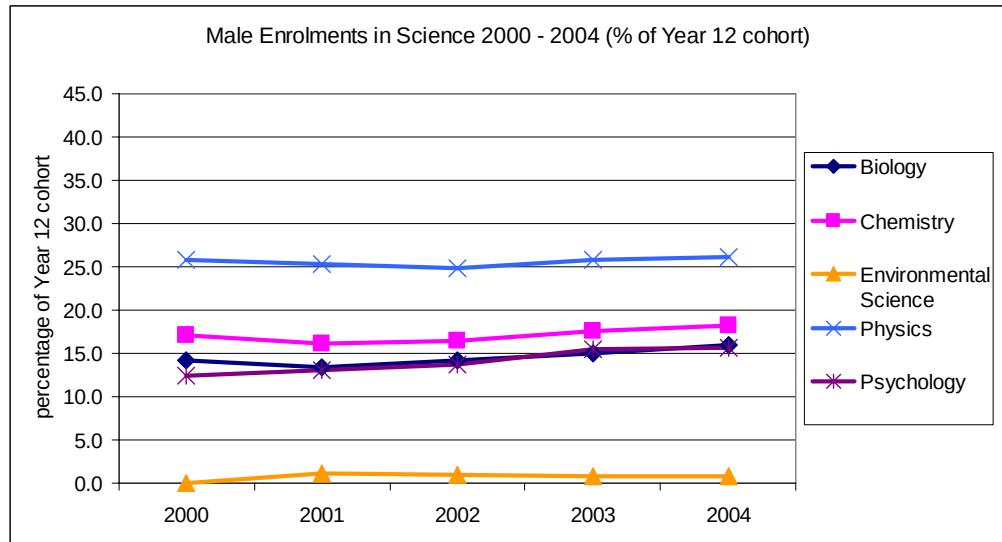
¹⁵¹ *ibid.*

¹⁵² Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Background Data and Analysis*, Commonwealth of Australia, Canberra, p.19.

Science Enrolments by Gender

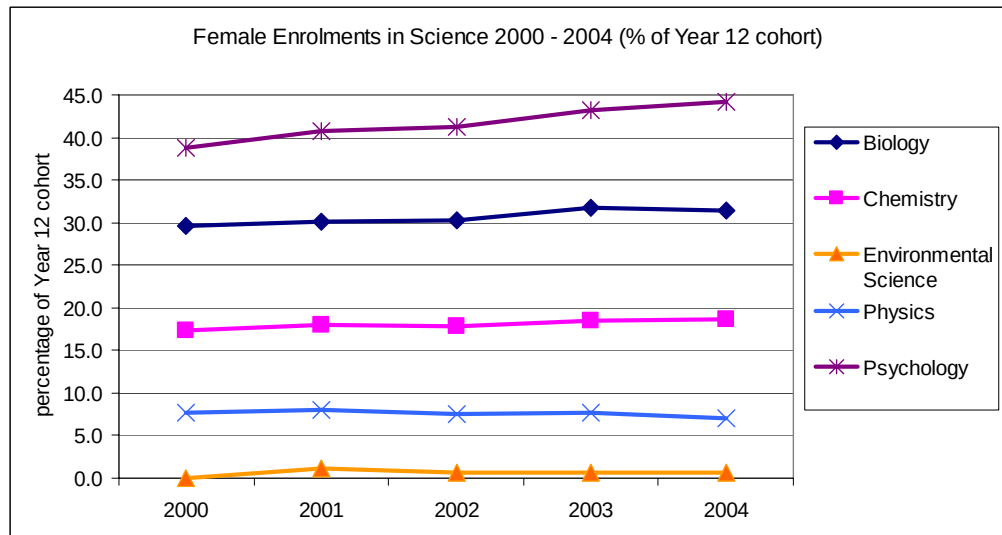
Figures 4.8 and 4.9 show significant differences in trends in the proportion of male and female students enrolling in VCE science over the period 2000 to 2004.

Figure 4.8: Percentages of Year 12 Students (Males) Enrolling in VCE Unit 4 Science (2000 to 2004)



Source: Data supplied by the Victorian Curriculum & Assessment Authority, 2005.

Figure 4.9: Percentages of Year 12 Students (Females) Enrolling in VCE Unit 4 Science (2000 to 2004)



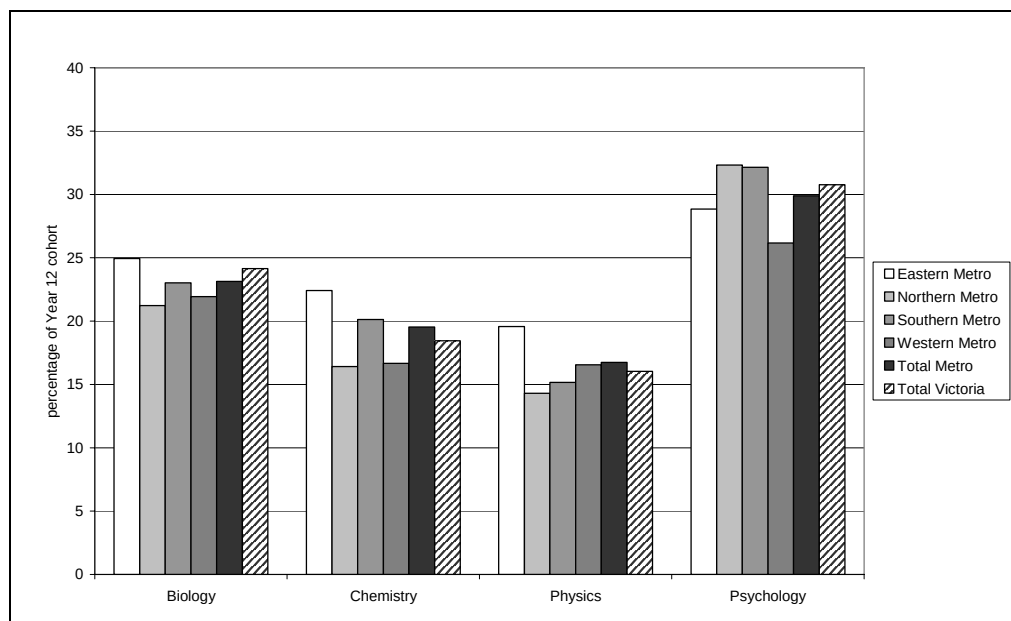
Source: Data supplied by the Victorian Curriculum & Assessment Authority, 2005.

Current enrolment trends in the enabling sciences were of significant concern to participants throughout this inquiry. Figure 4.8 shows that Physics enrolments for males have remained steady, with around one-quarter of males enrolling in this subject. Of concern, however, is the very low rate of female enrolments in Physics as well as the emergence of a downward trend in enrolments in this subject among females (refer Figure 4.9). Males and females enrol in Chemistry in similar proportions, while females enrol in Biology and Psychology at much higher proportions than males.

Science Enrolments by Region

Science enrolment trends among regions exhibit similar patterns as those seen in mathematics subjects. A greater proportion of metropolitan-based students undertake the enabling science subjects of Physics and Chemistry compared with the Victorian average. Conversely, a larger proportion of non-metropolitan students undertake Biology and Psychology (refer Figures 4.10 and 4.11).

Figure 4.10: Percentages of Year 12 Students Enrolling in VCE Unit 4 Science by Region (Metropolitan) (2004)



Source: Data supplied by the Victorian Curriculum & Assessment Authority, 2005.

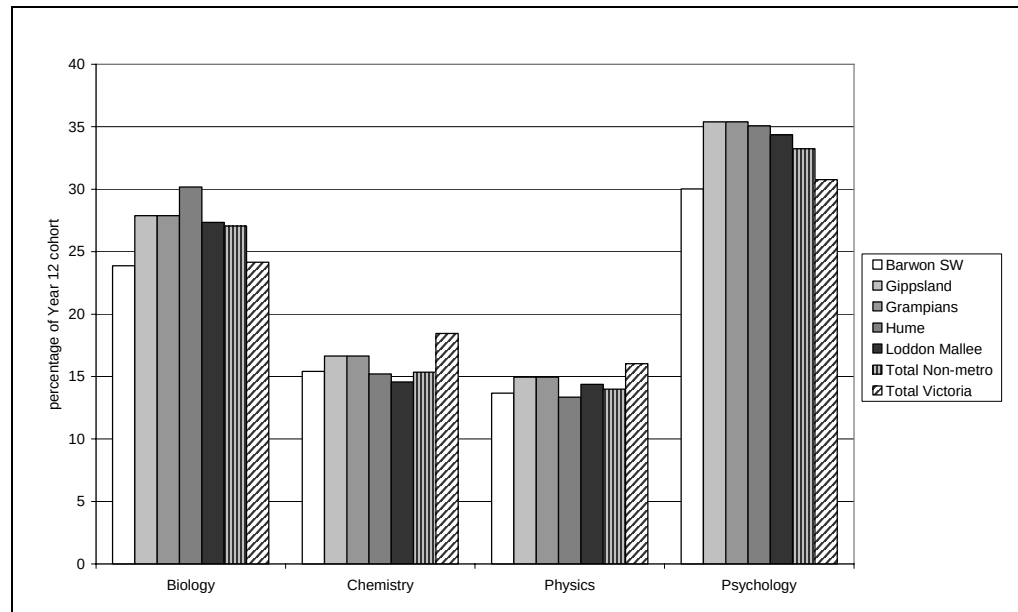
In 2004, the Eastern Metropolitan Region had enrolments in Biology, Chemistry and Physics at rates above average for both the metropolitan region and Victoria overall and was slightly under-represented in Psychology. Conversely, the Northern Metropolitan region was again under-represented in all science subjects, except Psychology, when compared with both the metropolitan and the Victorian averages.

The Western Metropolitan Region was under-represented in Biology, Chemistry and Psychology compared with the metropolitan and

Victorian averages. It was slightly under-represented in Physics compared to the metropolitan average, but slightly over-represented compared to the Victorian average.

Compared with the metropolitan average, the Southern Metropolitan Region was over-represented in Biology, Chemistry and Psychology, but under-represented in Physics.

Figure 4.11: Percentages of Year 12 Students Enrolling in VCE Unit 4 Science by Region (Non-Metropolitan) (2004)



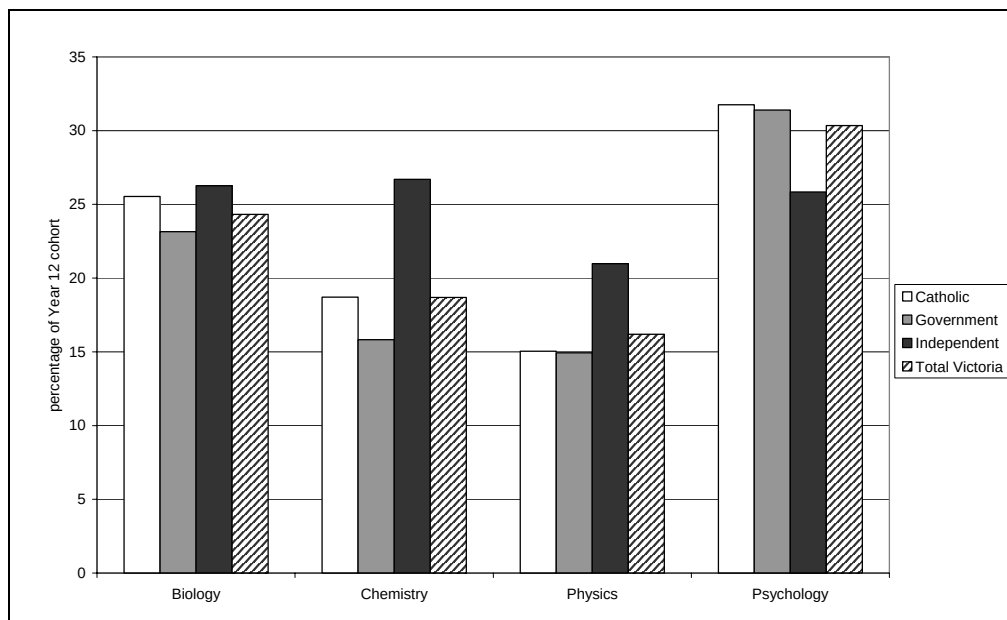
Source: Data supplied by the Victorian Curriculum & Assessment Authority, 2005.

Most non-metropolitan regions had enrolments in science subjects at, or close to, the average rate for non-metropolitan regions overall. In 2004, the notable variations to this pattern were Barwon South Western Region, which was under-represented in Biology and Psychology, and Hume which was over-represented in these subjects. The Grampians Region had the greatest proportion of students enrolling in Chemistry, Physics and Psychology among non-metropolitan regions, while its enrolment rate in Biology was also above both the non-metropolitan and Victorian average.

Science Enrolments by Sector

Again, enrolment rates in VCE science subjects vary considerably by sector (refer Figure 4.12).

Figure 4.12: Percentages of Year 12 Students Enrolling in VCE Unit 4 Science by Sector (2004)



Source: Data supplied by the Victorian Curriculum & Assessment Authority, 2005.

Students in the independent sector enrol in all of the science subjects, except Psychology, at rates above the average for Victoria. Enrolments in the enabling sciences are considerably higher for this sector.

Australia's Teachers: Australia's Future similarly reported that Australia-wide in 2001, participation in the three core sciences (biology, chemistry and physics) was higher in independent schools than in government schools by a factor of approximately 1.5.¹⁵³

Enrolment rates in the remaining two sectors are generally quite close (within 1–1½ percentage points) to the average for Victoria. The notable exception to this is enrolments in Chemistry within the government sector (15.8%, compared with 18.7% for Victoria).

¹⁵³ *ibid.*, p.11.

Mathematics and Science Enrolments in Higher Education

Science, engineering, mathematics and technology are integral to the knowledge and innovation economy and are of key interest to governments at all levels. Yet, without sufficient university graduates from these disciplines, governments will be unable to meet the knowledge and skill requirements of industry or the economy. Despite this, the Committee heard repeated concerns regarding the overall number of enrolments in mathematics and science related disciplines at university.

As shown in Figure 4.13, there were almost 12,750 award course completions in the Natural and Physical Sciences across Australia in 2003. There were a further 7,843 completions in Engineering and Related Technologies and 9,093 in Information Technology. Importantly, Victoria had the highest share of completions in these three broad fields of study (refer Appendix J for a comparison of course completions in other disciplines).

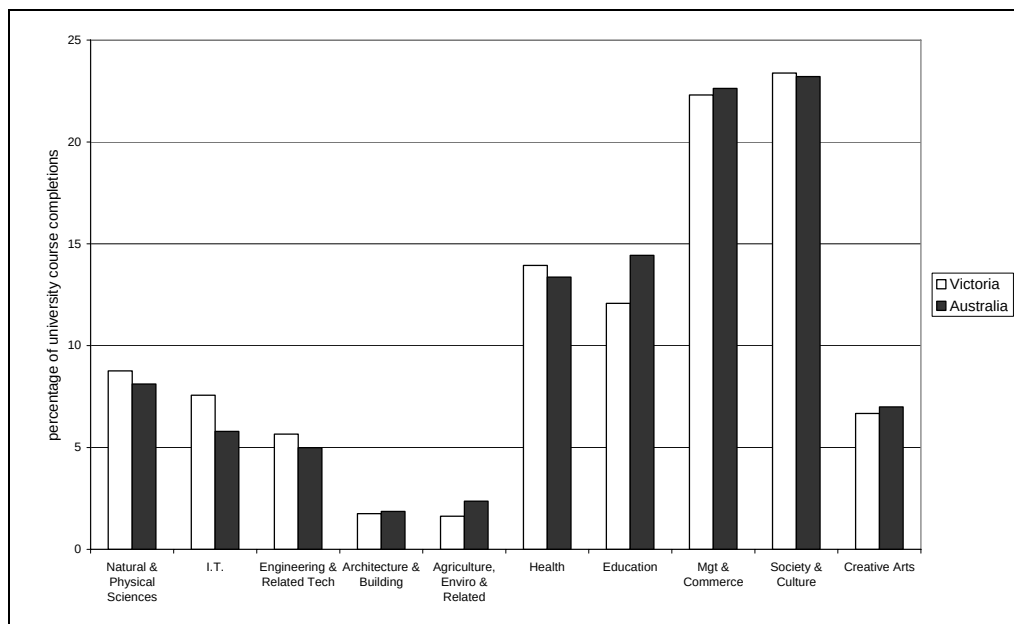
Figure 4.13: Award Course Completions for All Domestic Students by State and Broad Science Related Field of Education (2003)

State/Institution	Natural and Physical Sciences	State Share (%)	Information Technology	State Share (%)	Engineering and Related Technologies	State Share (%)
New South Wales	3,525	27.7	2,433	26.8	2,284	29.1
Victoria	3,616	28.4	3,126	34.4	2,333	29.7
Queensland	2,185	17.1	1,673	18.4	1,293	16.5
Western Australia	1,287	10.1	735	8.1	798	10.2
South Australia	1,073	8.4	430	4.7	578	7.4
Tasmania	334	2.6	226	2.5	315	4.0
Northern Territory	75	0.6	47	0.5	2	0.0
Australian Capital Territory	651	5.1	369	4.1	240	3.1
Multi-State (Australian Catholic University)	0	0.0	54	0.6	0	0.0
Total - Australia	12,746	100	9,093	100	7,843	100

Source: Adapted from Department of Education, Science & Training 2005, *Selected Higher Education Statistics Series*.

Figure 4.14 shows the proportion of Victorian university course completions accounted for by each broad field of study in 2003, compared to those for Australia overall. It shows that the proportion of course completions in the important science-related disciplines was greater in Victoria, than the average for Australia.

Figure 4.14: University Completions by Field of Study (%) (2003)



Source: Constructed by the Education and Training Committee using data from Department of Education, Science & Training 2005, *Selected Higher Education Statistics Series*.

Australia's Teachers: Australia's Future reported on nationwide university participation in the sciences and technology for the period 1990 to 2002. The key findings of this study were:

- Commencing enrolments in undergraduate courses in science-related fields varied over the period from 1990 to 2002. The overall pattern appears to have been that a post-1997 decline in commencements in the physical and natural sciences, and to a smaller extent in engineering, has been accompanied by a rise in information technology.¹⁵⁴
- Students who studied two physical sciences were more likely to proceed to university than students who studied any other combination of two science subjects and both groups were much more likely to continue to university study than those who did not study two science subjects.¹⁵⁵
- There is evidence of a fairly strong connection between specialising in science in the final year of secondary school and commencing science-related fields of education at university. Overall, 71 per cent of science specialists at Year 12 (any two science subjects) and 79 per cent of physical science specialists (two physical

¹⁵⁴ *ibid.*, p.33.

¹⁵⁵ *ibid.*, p.23.

science subjects) who enter university, study in a science-related field.¹⁵⁶

- Females provided a substantial majority of commencing enrolments in health but a substantial minority of enrolments in information technology and engineering. Females provided just a little more than half of the commencing enrolments in the natural and physical sciences and less than half in agriculture and architecture.¹⁵⁷
- Completion rates for veterinary science (almost 90%) and health (76% for nursing and 79% for other health) were substantially higher than those for arts, humanities and social science (58%), science (58%) and engineering (59%).¹⁵⁸

Many submissions and witnesses raised concerns about declining university enrolments in physics, chemistry, advanced mathematics, statistics and engineering, and/or about the ability of current levels of enrolments to meet the future needs of industry. Stakeholders raising such concerns included Science Industry Australia, Engineers Australia, Minerals Council of Australia (Victorian Division), BioMelbourne Network, Australian Institute of Physics, Victorian Institute for Chemical Sciences, Australian Council of Deans of Science and various higher education institutions.

What was not clear in the evidence, however, was the cause of declining or insufficient enrolments. Declining enrolments may be caused by a combination of factors, including:

- total levels of university funding and availability of government funded places;
- government and/or university mechanisms for allocating places among disciplines; and
- student demand for places within disciplines.

Student demand is influenced by levels of engagement and perceptions about future career paths in these disciplines, relative to those available in other areas. Student demand may also be influenced by student contribution charges. For post-2005 students, student contribution charges for units of study range from \$0–\$3,920 for

¹⁵⁶ *ibid.*, p.25.

¹⁵⁷ *ibid.*, p.21.

¹⁵⁸ *ibid.*, p.30.

national priority courses, and up to \$4,899 for Band 1 courses, \$6,979 for Band 2 courses and \$8,170 for Band 3 courses.¹⁵⁹

Much work has been undertaken by governments, industry, universities and many schools over recent years, to promote mathematics and science related studies and careers. Unfortunately, this work has not been matched by Commonwealth Government efforts to ensure qualified students interested in pursuing these disciplines can access a university place. The Committee notes that 2,000 university places nationwide were targeted towards mathematics, science and information and communications technology under *Backing Australia's Ability* in 2001, with Victoria being allocated 21.5 per cent of these places.¹⁶⁰ These nationwide places grew to around 5,470 in 2005 as students continued in their courses and will continue to be funded by the Commonwealth Government over the five years from 2006–2007.¹⁶¹ Nonetheless, these places have been allocated in the context of significant growth pressure over the past decade, as well as the elimination of marginally funded over-enrolled places from the system. This resulted in the number of domestic student commencements in Victoria dropping from around 63,300 in 2003 to 61,050 in 2004.¹⁶²

Policy Implications of Current Enrolment Trends

Current enrolment trends in Year 12 mathematics and particularly science were a key concern among stakeholders in this inquiry. Submissions and witnesses also noted that even where students do enrol and perform well in mathematics and science, they are often attracted or encouraged to take up studies and careers in other disciplines – for example, law, commerce, economics and business studies – rather than in areas such as engineering, mathematics and, to a lesser extent, science.¹⁶³ Further, despite some new university places being allocated by the Commonwealth Government, stakeholders continue to report that the overall number of university

¹⁵⁹ National priority courses are nursing and teaching. Band 1 courses include humanities, arts, behavioural science, social studies, foreign languages, visual and performing arts. Band 2 courses include accounting, commerce, administration, economics, maths, statistics, computing, built environment, health, engineering, science, surveying, agriculture. Band 3 courses include law, dentistry, medicine, veterinary science. Refer to the Department of Education, Science & Training *Going to Uni* website for more information, <<http://www.goingtouni.gov.au>>.

¹⁶⁰ Department of Education, Science & Training 2005, *Backing Australia's Ability: The Australian Government's Innovation Report 2004–05*, Commonwealth of Australia, Canberra, p.121.

¹⁶¹ Department of Education, Science & Training, 2004, *Backing Skills, Backing Australia's Ability* Fact Sheet, Commonwealth of Australia, Canberra.

¹⁶² Department of Education Science & Training 2003 and 2004, *Students: Selected Higher Education Statistics*, <http://www.dest.gov.au/sectors/higher_education/publications_resources/>, accessed on 12 January 2006.

¹⁶³ Written Submission, Engineers Australia, Victorian Division, August 2005, p.16.

places in the mathematics and science related disciplines remains insufficient to meet the needs of Victoria, its economy and its students.

It was suggested that current participation rates at secondary school and into further education and training need to be dramatically increased if Australia is to improve its innovation capacity and international competitiveness. Engineers Australia even suggested that a satisfactory target would be to have at least 50 per cent of students studying science, engineering, technology and mathematics subjects at Year 12.¹⁶⁴

Given the current and projected future skills shortage, the Committee supports the contention that education systems should set enrolment targets for certain disciplines, in schools and higher education institutions. The process of setting targets will allow governments to better identify current and future needs for education in the mathematics and science disciplines and to measure how well these needs are being met. The Committee is not, however, in a position to recommend appropriate enrolment targets, as this would require detailed economic modelling. The Committee also emphasises that in setting any future enrolment targets, governments must be mindful of the full range of valuable pathways being pursued by secondary school students. Governments should also consider potential additional resource requirements within the school and university sectors arising from any significant changes to current subject enrolment profiles.

The Committee also believes that the Commonwealth Government needs to take further action to ensure university funding and allocation of places is better targeted to meet the community's needs in mathematics and science related disciplines.

Recommendation 4.1: That the Victorian Government undertake an analysis of enrolment trends against forecast future workforce requirements and develop benchmark targets for Year 12 enrolments in the enabling science subjects (physics, chemistry and advanced mathematics).

Recommendation 4.2: That through the Ministerial Council on Education, Employment, Training and Youth Affairs, the Victorian Government work with the Commonwealth Government and other State and Territory Governments to ensure the funding and allocation of university places in mathematics and science related disciplines are sufficient to meet future industry and community needs.

¹⁶⁴ *ibid.*, p.18.

5. Trends in Student Achievement in Mathematics and Science

Introduction

In the context of this inquiry, the two key international studies are the Program for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS). The two studies have a different focus, with TIMSS focusing on the curriculum and what students know and PISA focusing strongly on what students can do with their knowledge. The influence of PISA and TIMSS on education policies and systems in Victoria is evidenced by the frequency with which key stakeholders, including government authorities, teacher associations, school leaders and others in the profession, referred to these studies throughout this inquiry. The Committee also notes the proposal currently before the Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA) for PISA to be used as the data source for national key performance measures (KPMs) for the performance of 15-year-old students in reading, mathematical and scientific literacy.¹⁶⁵

PISA and TIMSS complement state-based literacy and numeracy testing for students in Years 3, 5 and 7 and testing of other curriculum areas that are based on national sample surveys of achievement. The two key national studies of relevance to this inquiry are the annual *National Report on Schooling in Australia National Benchmark Results in Reading, Writing and Numeracy for Years 3, 5 and 7* and the 2003 *National Year 6 Science Assessment Report*.

National Numeracy Benchmarks

In 1997, all state, territory and commonwealth education ministers agreed on the national goal that every child leaving primary school should be numerate and be able to read, write and spell at an appropriate level. To provide focus to this goal, the ministers also agreed to a sub-goal that every child commencing school from 1998 will achieve a minimum acceptable literacy and numeracy standard within four years.¹⁶⁶ Agreement of these goals led to the implementation of the National Literacy and Numeracy Plan, the essential features of which are early assessment and intervention for

¹⁶⁵ S. Thomson, J. Cresswell & L. De Bortoli 2004, *Facing the Future: A focus on mathematical literacy among Australian 15-year-old students in PISA 2003*, ACER, Melbourne, p.4.

¹⁶⁶ Ministerial Council on Education, Employment, Training & Youth Affairs 2003, *National Report on Schooling in Australia Preliminary Report, National Benchmark Results Reading, Writing and Numeracy Years 3, 5 and 7*, MCEETYA, Melbourne, p.2.

students at risk of not achieving minimum numeracy and literacy goals; development of national benchmarks for each of Years 3, 5 and 7; and assessment of student progress against the benchmarks.

National Numeracy Benchmarks are used for reporting achievement in three aspects of numeracy – ‘Number sense’, ‘Spatial sense’ and ‘Measurement and data sense’ at each of Years 3, 5 and 7. The benchmarks are performance indicators that articulate nationally agreed *minimum* acceptable standards for numeracy at these years. The benchmarks describe *minimum* standards, below which students will experience difficulty in schooling. Results of national benchmarking are published in the annual *National Report on Schooling in Australia*.

In 2003, 95.8 per cent of Victorian Year 3 students achieved the numeracy benchmark (refer Figure 5.1). This was above the national average of 94.2 per cent but below the achievement of students in New South Wales (96.7%).

Figure 5.1: Percentage of Year 3 Students Achieving the Numeracy Benchmark by State and Territory (2003)

State/ Territory	All students	Male students	Female students	Indigenous ^(a) students	LBOTE ^(a) students
New South Wales	96.7 ± 0.6	96.3 ± 0.6	97.1 ± 0.6	91.4 ± 1.9	95.9 ± 0.6
Victoria	95.8 ± 0.5	95.2 ± 0.5	96.6 ± 0.6	86.7 ± 2.2	93.9 ± 0.7
Queensland	92.1 ± 1.6	92.0 ± 1.6	92.7 ± 1.8	78.3 ± 3.7	90.0 ± 2.0
South Australia	90.1 ± 1.7	89.3 ± 1.7	90.8 ± 1.9	67.5 ± 5.2	86.0 ± 2.4
Western Australia	89.7 ± 2.7	89.7 ± 2.6	89.7 ± 2.8	67.2 ± 6.6	87.6 ± 3.3
Tasmania	93.9 ± 1.4	93.9 ± 1.4	94.1 ± 1.7	90.2 ± 4.0	94.7 ± 3.3
Northern Territory	86.4 ± 2.4	85.8 ± 2.8	87.1 ± 2.6	65.5 ± 5.4	64.1 ± 5.4
Australian Capital Territory	95.2 ± 1.1	94.7 ± 1.1	95.8 ± 1.2	88.2 ± 7.7	89.5 ± 2.6
Australia	94.2 ± 1.1	93.8 ± 1.1	94.7 ± 1.2	80.5 ± 3.7	93.3 ± 1.1

Note: The achievement percentages reported in this table include 95% confidence intervals.

(a) The methods used to identify Indigenous students and students with a language background other than English (LBOTE) varied between jurisdictions.

Source: MCEETYA 2003, *National Report on Schooling in Australia*, p.7.

In 2003, Victoria had the highest proportion of Year 5 students achieving the national numeracy benchmark, with 94.7 per cent of students achieving the benchmark, compared to the Australian average of 90.8 per cent (refer Figure 5.2). The next highest performing jurisdictions at Year 5 were Tasmania (92.4%) and the Australian Capital Territory (91.9%).

Figure 5.2: Percentage of Year 5 Students Achieving the Numeracy Benchmark by State and Territory (2003)

State/ Territory	All students	Male students	Female students	Indigenous ^(a) students	LBOTE ^(a) students
New South Wales	91.3 ± 1.1	90.4 ± 1.1	92.2 ± 1.1	73.9 ± 3.0	90.8 ± 1.1
Victoria	94.7 ± 0.7	94.3 ± 0.7	95.2 ± 0.8	83.7 ± 3.3	92.2 ± 0.8
Queensland	86.3 ± 1.6	86.6 ± 1.7	86.4 ± 1.9	62.6 ± 3.4	83.7 ± 2.2
South Australia	90.7 ± 1.2	90.1 ± 1.3	91.3 ± 1.3	66.1 ± 4.9	85.8 ± 1.9
Western Australia	90.4 ± 2.0	90.0 ± 2.1	90.8 ± 2.1	66.2 ± 5.5	87.2 ± 3.0
Tasmania	92.4 ± 1.2	91.6 ± 1.4	93.3 ± 1.3	87.8 ± 4.1	93.4 ± 3.1
Northern Territory	76.1 ± 2.6	74.6 ± 3.0	77.6 ± 3.2	43.3 ± 4.9	39.1 ± 5.2
Australian Capital Territory	91.9 ± 1.7	91.7 ± 1.9	92.1 ± 1.9	71.6 ± 12.4	86.6 ± 3.2
Australia	90.8 ± 1.2	90.3 ± 1.3	91.4 ± 1.3	67.6 ± 3.9	89.3 ± 1.4

Note: The achievement percentages reported in this table include 95% confidence intervals.

(a) The methods used to identify Indigenous students and students with a language background other than English (LBOTE) varied between jurisdictions.

Source: MCEETYA 2003, *National Report on Schooling in Australia*, p.17.

Achievement of the national numeracy benchmark by Year 7 students was 85.8 per cent of the total student cohort in Victoria, as against a national average of 81.3 per cent (refer Figure 5.3). The Australian Capital Territory (86.4%) slightly outperformed Victoria, while Queensland and South Australia performed at a very similar level to Victoria (85.2% for both States).

Figure 5.3: Percentage of Year 7 Students Achieving the Numeracy Benchmark by State and Territory (2003)

State/ Territory	All students	Male students	Female students	Indigenous ^(a) students	LBOTE ^(a) students
New South Wales ^(b)	73.9 ± 0.8	72.9 ± 0.9	75.1 ± 0.9	41.1 ± 2.1	72.7 ± 1.0
Victoria	85.8 ± 0.7	86.3 ± 0.8	85.4 ± 0.9	64.1 ± 4.4	83.1 ± 1.0
Queensland	85.2 ± 0.6	85.5 ± 0.7	85.1 ± 0.7	56.9 ± 2.0	81.7 ± 1.4
South Australia	85.2 ± 0.8	84.9 ± 1.0	85.5 ± 1.0	54.1 ± 6.3	80.0 ± 2.6
Western Australia	84.3 ± 0.7	84.2 ± 0.8	84.5 ± 0.9	49.9 ± 3.3	78.8 ± 1.6
Tasmania	80.6 ± 1.1	80.4 ± 1.4	80.7 ± 1.6	66.5 ± 5.4	75.5 ± 4.5
Northern Territory	68.7 ± 2.1	69.0 ± 2.7	68.3 ± 2.9	30.0 ± 3.6	27.2 ± 3.9
Australian Capital Territory	86.4 ± 1.6	86.3 ± 1.8	86.5 ± 1.9	61.6 ± 12.8	81.0 ± 5.6
Australia	81.3 ± 0.8	81.0 ± 0.9	81.6 ± 0.9	49.3 ± 2.9	76.6 ± 1.2

Note: The achievement percentages reported in this table include 95% confidence intervals.

(a) The methods used to identify Indigenous students and students with a language background other than English (LBOTE) varied between jurisdictions.

(b) New South Wales considers that the year 7 results for New South Wales are anomalous. The national numeracy benchmark results show that:

- a lower proportion of New South Wales year 7 students are meeting the minimum numeracy benchmark than are meeting the reading and writing benchmarks.
- a lower proportion of students are meeting the numeracy benchmark in year 7 than in year 3 and year 5.

National benchmarks represent the minimum standard of performance a student must achieve to be able to progress through his/her schooling. The national benchmark results show that New South Wales students in years 3 and 5 are consistently performing at or above the national average for reading, writing and numeracy. The New South Wales results for year 7 reading and writing are also fairly consistent with the national average.

Source: MCEETYA 2003, *National Report on Schooling in Australia*, p.27

It should be noted that any analysis treating students from language backgrounds other than English as a homogenous group is, to some extent, flawed. Governments are well aware that there is a very wide gap in achievement among students from different backgrounds, arising from different cultural contexts and/or different socioeconomic circumstances. Achievement among students from a refugee background, who may be dealing with a range of barriers to learning in

their initial years of schooling in Australia, is likely to be lower than that among students from a language background other than English who may have entered the country under different circumstances, such as for business migration purposes. The results for students from a language background other than English as shown in the above tables should therefore be interpreted with caution. It should further be noted that the methodology for identifying Indigenous students and students with a language background other than English varied between jurisdictions. This reiterates the need to interpret the results for these cohorts with caution.

National Year 6 Science Assessment

In 2003, a nationally comparable science assessment was carried out under the auspices of MCEETYA for the first time, with the intention that further assessments will occur every three years. The 2003 *National Year 6 Science Assessment Report* provides a snapshot of student performance across the national science literacy scale and an analysis of various trends across states, territories and student sub-groups. Approximately six per cent of the total Australian Year 6 student population, drawn from schools in all sectors, were sampled randomly and assessed. One hundred Victorian schools and 2,130 Victorian students were involved in the study.¹⁶⁷

Minimum standards such as the national benchmarks for literacy and numeracy have not been set for scientific literacy. As MCEETYA argues, such benchmarks, defined as the critical level of skill and understanding without which a student will have difficulty making sufficient progress at school, are more suited to foundation areas such as reading, writing and numeracy, where deficiencies will have a significant effect on students' future learning and functioning in society.¹⁶⁸ Instead, scientific literacy is defined against proficiency standards. The proficient standard (proficiency level 3.2 or above) is a challenging level of performance that requires students to demonstrate more than minimal or elementary skills. Students who have not achieved the proficient standard have demonstrated only partial mastery of the skills and understandings for Year 6 science, while there are also students who have shown superior results and exceeded the proficient standard.¹⁶⁹

¹⁶⁷ Ministerial Council on Education, Employment, Training & Youth Affairs 2004, *National Year 6 Science Assessment Report 2003*, MCEETYA, Melbourne, p.5.

¹⁶⁸ *ibid.*, p.xii.

¹⁶⁹ *ibid.*

Three strands of scientific literacy were assessed:

1. formulating or identifying investigable questions and hypotheses, planning investigations and collecting evidence;
2. interpreting evidence and drawing conclusions, critiquing the trustworthiness of evidence and claims made by others and communicating findings; and
3. using science understandings for describing and explaining natural phenomena, interpreting reports and making decisions.

The assessed items drew on four concept areas: Life and Living; Earth and Beyond; Natural and Processed Materials; and Energy and Change.

Nationally, 58.2 per cent of students achieved or exceeded the proficient standard (refer Figure 5.4). The comparable figure for Victoria was 58.7 per cent.¹⁷⁰ The Australian Capital Territory was the only jurisdiction with performance significantly above the national mean and no jurisdiction performed significantly below the national mean. The Australian Capital Territory was the only jurisdiction to achieve results that were statistically higher than Victoria's.

¹⁷⁰ *ibid.*, p.xiii.

Figure 5.4: Percentage of Students at or above Scientific Literacy Proficiency Levels by State and Territory (2003)

State/Territory	Proficiency Level			
	3.1 or Above	Proficient 3.2 or Above	3.3 or Above	4 or Above
New South Wales	96.6 (±0.8)	62.8 (±2.1)	10.2 (±1.7)	0.1 (±0.2)
Victoria	95.6 (±1.0)	58.7 (±2.5)	6.4 (±1.2)	0.0 (±0.1)
Queensland	94.9 (±0.9)	54.9 (±2.1)	5.9 (±1.1)	0.0 (±0.0)
South Australia	95.6 (±1.2)	57.0 (±2.4)	6.9 (±1.3)	0.0 (±0.1)
Western Australia	94.9 (±1.0)	54.6 (±2.2)	6.0 (±1.2)	0.0 (±0.0)
Tasmania	95.0 (±1.4)	59.3 (±2.9)	9.4 (±1.8)	0.1 (±0.3)
Northern Territory	89.3 (±3.6)	49.4 (±5.5)	6.9 (±2.8)	0.0 (±0.0)
Australian Capital Territory	97.3 (±1.1)	69.8 (±3.9)	13.6 (±2.8)	0.2 (±0.5)
Australia	95.4 (±0.4)	58.2 (±0.9)	7.7 (±0.5)	0.1 (±0.1)

Note: Figures in parentheses refer to 95 per cent confidence intervals.

Source: Adapted from MCEETYA 2004, *National Year 6 Science Assessment Report 2003*, p.41.

Victoria had one of the lowest spread of achievement scores in Australia in this study, in contrast to the international studies reported below.

At the national level, the scientific proficiency levels showed the following trends:

- for males and females, there were no significant differences in proficiency;¹⁷¹
- the proficiency of Indigenous students was significantly lower than that of non-Indigenous students;

¹⁷¹ Although the differences were not statistically significant in any particular state and territory or overall, the tendency for males to perform better than females was consistent in all cases.

- students who spoke English at home showed significantly higher levels of proficiency than those who spoke a language other than English at home; and
- proficiency of students in remote locations was significantly below that of students in other locations.¹⁷²

The Committee notes that the above trends are consistent with findings of PISA and TIMSS.

Student Achievement in PISA

The OECD launched the Programme for International Student Assessment (PISA) in 1997, in response to the need for cross-nationally comparable evidence on student performance. PISA represents a commitment by governments internationally to monitor the outcomes of education systems in terms of student achievement on a regular basis and with an internationally accepted common framework. According to the OECD, PISA is the most comprehensive international program to assess student performance and to collect data on student, family and institutional factors that can help explain differences in performance.¹⁷³

PISA seeks to measure how well young adults, at age 15 and therefore approaching the end of compulsory schooling, are prepared to meet the challenges of today's knowledge societies. The assessment is forward-looking, focusing on young people's ability to use their knowledge and skills to meet real-life challenges, rather than on the extent to which they have mastered a specific school curriculum.¹⁷⁴ As noted by the OECD, this orientation reflects a change in the goals and objectives of curricula themselves, which are increasingly concerned with what students can do with what they learn at school, and not merely whether they can reproduce what they have learned.¹⁷⁵

As summarised in *PISA in Brief from Australia's Perspective*, Australia's results in PISA 2003 were above the OECD average in reading, mathematical and scientific literacy, as well as in problem solving and in each of the mathematical literacy subscales.¹⁷⁶ All Australian states and territories performed at or better than the OECD

¹⁷² Ministerial Council on Education, Employment, Training & Youth Affairs 2004, *National Year 6 Science Assessment Report*, MCEETYA, Melbourne, p.xi.

¹⁷³ Organisation for Economic Co-operation and Development 2004, *Learning for Tomorrow's World: First Results from PISA 2003*, OECD, Paris, p.20.

¹⁷⁴ *ibid.*

¹⁷⁵ *ibid.*

¹⁷⁶ Australian Council for Educational Research 2004, *PISA in Brief from Australia's Perspective*, ACER, Melbourne, p.3.

average in all four domains and there were few significant differences among the states/territories.¹⁷⁷

An important aspect of any analysis of PISA results is the range of scores achieved by participants from each jurisdiction. A lower spread of scores means that there is a smaller gap in performance between the highest and lowest achieving students, indicating more equitable educational opportunities in that jurisdiction. Australia's range of scores between the 5th and 95th percentile is narrower than the OECD average for all three literacies tested.¹⁷⁸ Importantly, the range of scores between Australia's 5th and 25th percentile, or the 'tail' was also less than the average for the OECD.¹⁷⁹ This suggests that Australia has made progress in bringing the skills of the lowest achieving students closer to those of the higher achievers.¹⁸⁰ Nonetheless, this Committee would like to see a further narrowing of the gap between Victoria's highest achieving and lesser achieving students.

The following sections look at PISA 2003 results in the mathematics and science domains.¹⁸¹

Australia's Performance in Mathematics

PISA draws its mathematical content from four broad content areas:

- Space and shape, relating to spatial and geometric phenomena and relationships, often drawing on the curricular discipline of geometry.
- Change and relationships, relating most closely to algebra.
- Quantity, involving numeric phenomena, as well as quantitative relationships and patterns.
- Uncertainty, involving probabilistic and statistical phenomena.¹⁸²

As shown in Figure 5.5, four countries outperformed Australia in mathematical literacy in PISA 2003 – Hong Kong-China, Finland, Korea

¹⁷⁷ *ibid.*, p.5.

¹⁷⁸ S. Thomson, J. Cresswell & L. De Bortoli 2004, *Facing the Future: A focus on mathematical literacy among Australian 15-year-old students in PISA 2003*, ACER, Melbourne, p.ix.

¹⁷⁹ *ibid.*

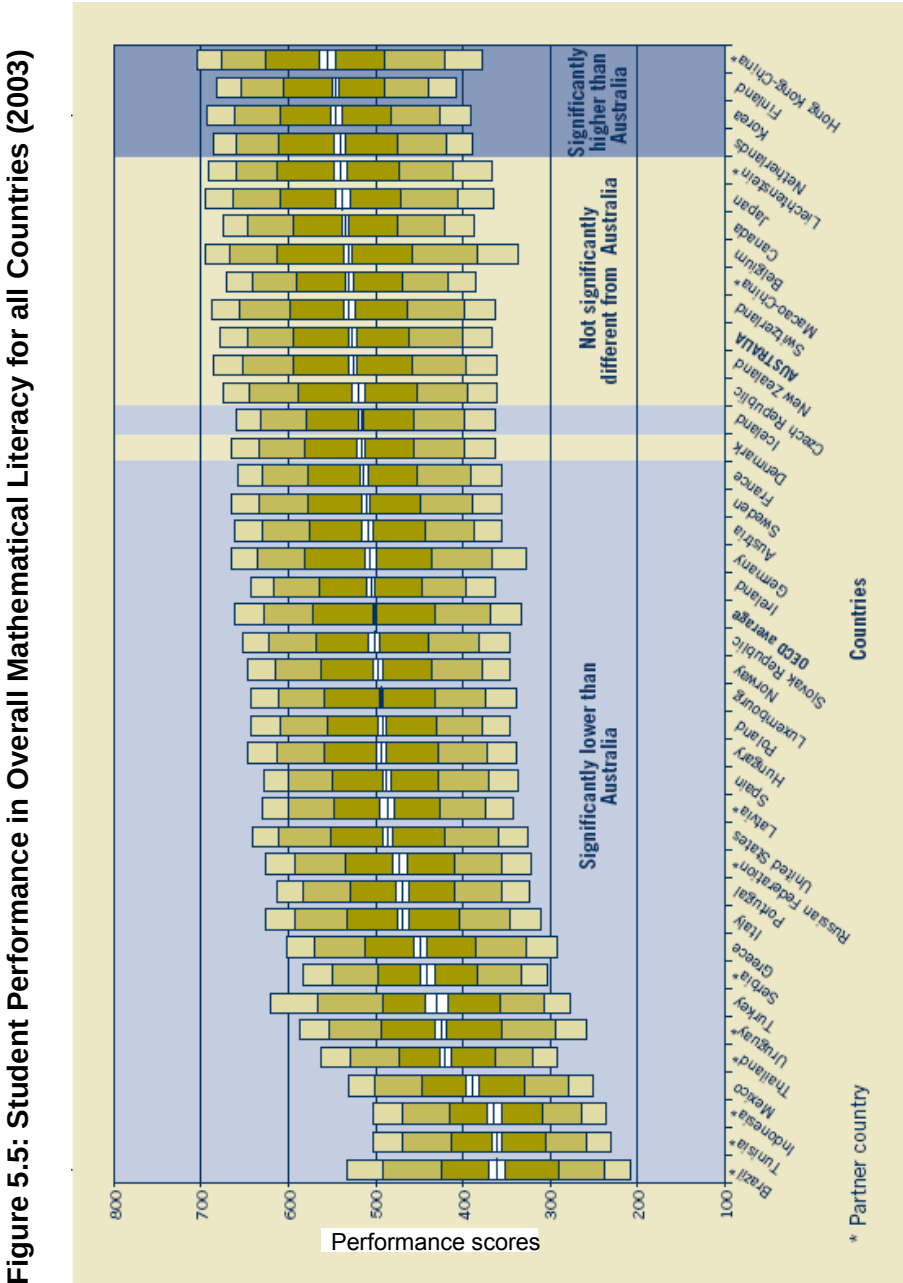
¹⁸⁰ *ibid.*

¹⁸¹ Note: Any differences between Australia and other countries and between various states and territories within Australia that are referred to in the following sections are statistically significant.

¹⁸² Organisation for Economic Co-operation and Development 2004, *Learning for Tomorrow's World: First Results from PISA 2003*, OECD, Paris, p.39.

and the Netherlands. In PISA 2000, only two countries performed better than Australia – Japan and Hong Kong-China.¹⁸³

Australia was one of 17 countries to score significantly higher than the OECD average on mathematical literacy. Australia is in a group of 10 countries whose results are considered statistically similar – Liechtenstein, Japan, Canada, Belgium, Macao-China, Switzerland, New Zealand, the Czech Republic and Denmark.¹⁸⁴



Source: S. Thomson, J. Cresswell & L. De Bortoli 2004, *Facing the Future: A Focus on mathematical literacy among Australian 15-year-old students in PISA 2003*, p.30.

¹⁸³ Australian Council for Educational Research 2004, *PISA in Brief from Australia's Perspective*, ACER, Melbourne, pp.3–4.

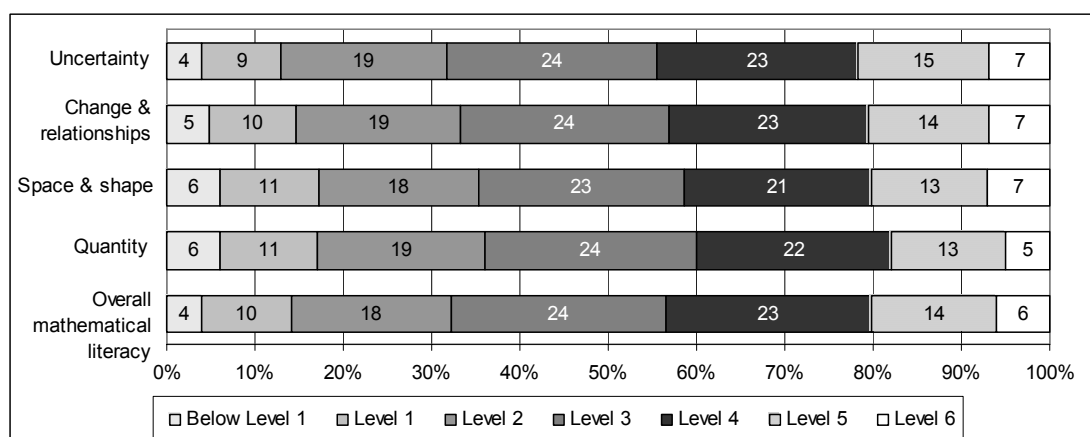
¹⁸⁴ S. Thomson, J. Cresswell & L. De Bortoli 2004, *Facing the Future: A focus on mathematical literacy among Australian 15-year-old students in PISA 2003*, ACER, Melbourne, p.29.

Appendix K shows the proficiency levels on the overall mathematical literacy scale for all countries. Six per cent of Australia's students achieved the highest mathematical literacy proficiency level (Level 6), which was slightly above the OECD average of four per cent. Hong Kong-China had the highest proportion of students achieving the highest proficiency level, with 11 per cent of its students at Level 6.¹⁸⁵

Twenty per cent of Australian students achieved Level 5 or higher in mathematical literacy, just over 40 per cent at Level 4 or higher and two-thirds at Level 3 or higher. Corresponding figures for the OECD as a whole were 15 per cent at Level 5 or higher, 34 per cent at Level 4 or higher and 58 per cent at Level 3 or higher. Only 14 per cent of Australian students did not reach at least Level 2, compared with the OECD average of 21 per cent.¹⁸⁶

In relative terms, the performance of Australian students on the uncertainty subscale was slightly better than their performance on the other three subscales, while performance on the quantity subscale was not as strong as the other three (refer Figure 5.6).¹⁸⁷ Only Finland achieved higher performance scores than Australia in all four subscales, while Hong Kong-China outperformed Australia in three (quantity; space and shape; and uncertainty) and Liechtenstein in three (quantity; space and shape; and change and relationships).

Figure 5.6: Proficiency Levels on the Overall Mathematical Literacy and the Mathematics Subscales (Australia) (2003)



Source: S. Thomson, J. Cresswell & L. De Bortoli 2004, *Facing the Future: A focus on mathematical literacy among Australian 15-year-old students in PISA 2003*, p.47.

There were few significant differences among the states and territories in mathematical literacy (refer Figure 5.7). However, the average performance of students in the Australian Capital Territory was significantly higher than the average achieved by students in New

¹⁸⁵ *ibid.*, p.ix.

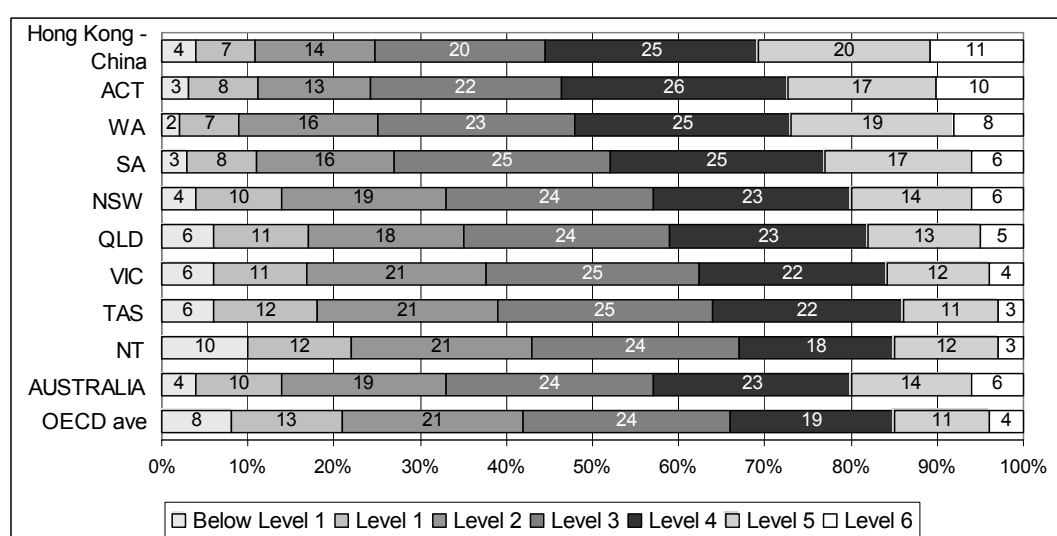
¹⁸⁶ *ibid.*, p.x.

¹⁸⁷ *ibid.*

South Wales, Queensland, Victoria, Tasmania and the Northern Territory. Students in Western Australia, the Australian Capital Territory and South Australia performed as well as students in Hong Kong-China, the highest performing country in mathematical literacy.¹⁸⁸ The 'tails' for South Australia and Victoria were wider than the Australian average although still narrower than the OECD average.¹⁸⁹

The Committee notes that students in the Australian Capital Territory are likely to perform well in national and international benchmarking studies due to their higher socioeconomic status and greater access to education resources compared to many students in other states.

Figure 5.7: Proficiency Levels on the Overall Mathematical Literacy for Australian States (2003)



Source: S. Thomson, J. Cresswell & L. De Bortoli 2004, *Facing the Future: A focus on mathematical literacy among Australian 15-year-old students in PISA 2003*, p.82.

The Committee notes that a number of Australian states recognise international studies such as PISA as an important tool in developing education policy and programs. There has, therefore, been an expansion of programs across Australia recently, aimed at lifting the mathematical literacy of students at all levels. It will be important to continue to monitor future interstate comparisons to determine what level of success these programs have in raising standards in mathematics achievement.

¹⁸⁸ *ibid.*, p.79.

¹⁸⁹ *ibid.*, p.80.

Australia's Performance in Science

Scientific literacy is concerned with scientific knowledge (including knowledge of concepts), scientific processes and scientific situations (or contexts). The scientific knowledge that was assessed in PISA 2003 was selected from the areas of physics, chemistry, biological science and earth and space science according to three criteria: relevance to everyday situations; relevance to life throughout the next decade; and knowledge required for understanding scientific processes.¹⁹⁰ The interaction of these criteria with the content of the science areas produced a selection of scientific themes such as chemical and physical changes; biodiversity; genetic control; and geographical change.¹⁹¹

Within the PISA framework, scientific processes involve the ability to acquire, interpret and act upon evidence. PISA identifies three process skills of describing, explaining and predicting scientific phenomena; understanding scientific investigation; and interpreting scientific evidence and conclusions. The scientific literacy framework identifies three main scientific situations or contexts for assessment: science in life and health; science in Earth and environment; and science in technology.¹⁹²

Three countries achieved better results than Australia in scientific literacy – Finland, Japan and Korea (refer Figure 5.8). In PISA 2000, only Korea and Japan outperformed Australia.¹⁹³ Australia is in a group of nine countries that have results not significantly different from each other in scientific literacy: Hong Kong-China, Liechtenstein, Macao-China, the Netherlands, the Czech Republic, New Zealand, Canada and Switzerland.¹⁹⁴ The 2003 scientific literacy mean score in Australia is not significantly different from the 2000 mean score, although the spread of scores is wider.¹⁹⁵

¹⁹⁰ *ibid.*, p.6.

¹⁹¹ *ibid.*

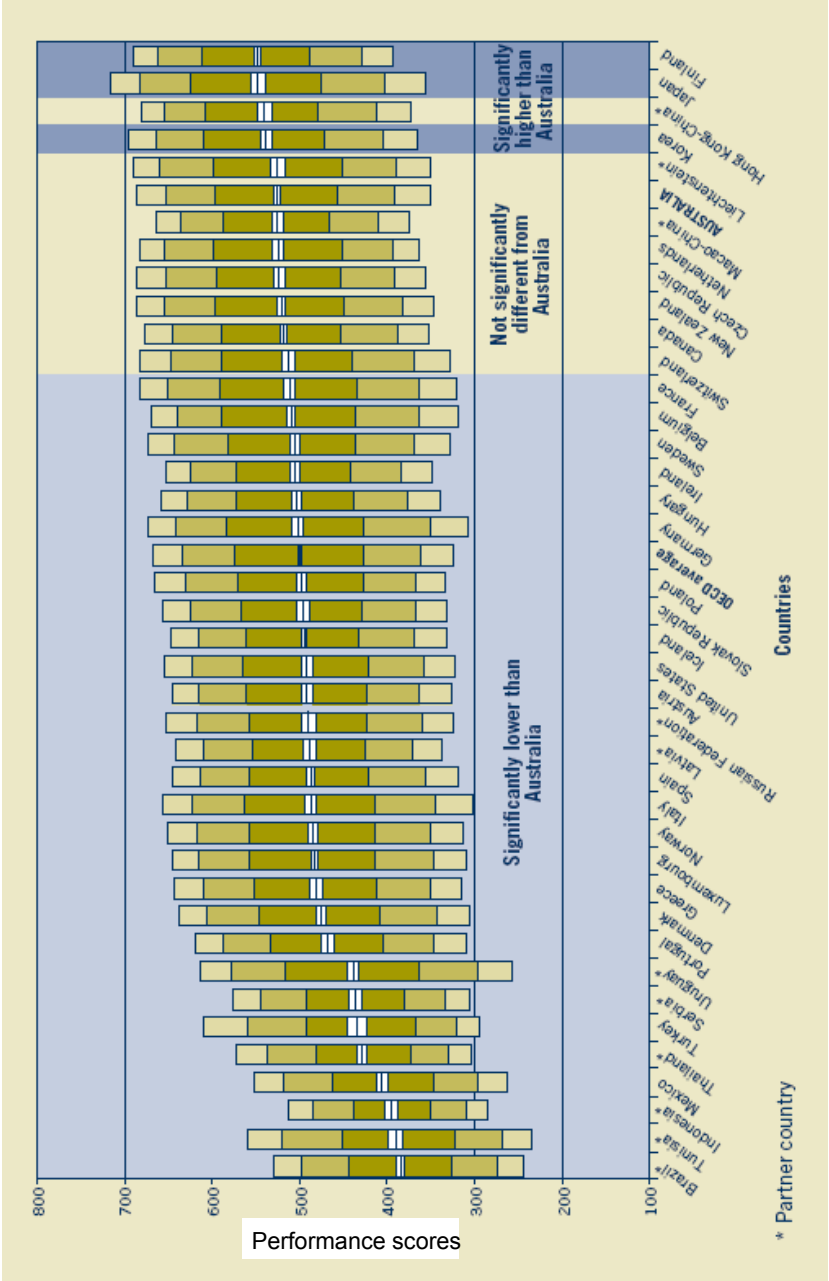
¹⁹² *ibid.*, pp.6–7.

¹⁹³ Australian Council for Educational Research 2004, *PISA in Brief from Australia's Perspective*, ACER, Melbourne, pp.3–4.

¹⁹⁴ S. Thomson, J. Cresswell & L. De Bortoli 2004, *Facing the Future: A focus on mathematical literacy among Australian 15-year-old students in PISA 2003*, ACER, Melbourne, p.119.

¹⁹⁵ *ibid.*

Figure 5.8: Student Performance in Overall Scientific Literacy for all Countries (2003)



Source: S. Thomson, J. Cresswell & L. De Bortoli 2004, *Facing the Future: A focus on mathematical literacy among Australian 15-year-old students in PISA 2003*, p.120.

Figure 5.9 shows multiple comparisons of overall scientific literacy performance by state. The Australian Capital Territory and Western Australia achieved means that were statistically similar, with the Australian Capital Territory performing significantly better than the remaining states. Western Australia performed significantly better than Queensland, Victoria, Tasmania and the Northern Territory but not significantly better than South Australia or New South Wales. Again, the Committee notes that a number of states and territories have recently implemented targeted science education programs in their schools. It will be interesting to monitor future results, to determine whether programs such as Victoria's *Science in Schools* initiative, South Australia's *Strategic Directions for Science and Mathematics in South Australian Schools 2003–2006* and Queensland's *Spotlight on Science 2003–2006* help in raising performance standards in these states.

Figure 5.9: Multiple Comparisons of Overall Scientific Literacy Performance by Jurisdiction (2003)

	Mean	Mean SE	ACT 553 4.7	WA 546 4.3	SA 535 4.33	NSW 530 4.4	QLD 519 6.6	VIC 510 5.2	TAS 509 9.5	NT 495 5.8
ACT	553	4.7		●	▲	▲	▲	▲	▲	▲
WA	546	4.3	●		●	●	▲	▲	▲	▲
SA	535	4.3	▼	●		●	●	▲	●	▲
NSW	530	4.4	▼	●	●		●	▲	●	▲
QLD	519	6.6	▼	▼	▼	●		●	●	▲
VIC	510	5.2	▼	▼	▼	▼	●		●	●
TAS	509	9.5	▼	▼	●	●	●	●		●
NT	495	5.8	▼	▼	▼	▼	▼	●	●	

Note: Read across the row to compare a jurisdiction's performance with the performance of each jurisdiction listed in the column heading.

- ▲ Average performance statistically significantly higher than in comparison state or territory.
- No statistically significant difference from comparison state or territory.
- ▼ Average performance statistically significantly lower than in comparison state or territory.

Source: S. Thomson, J. Cresswell & L. De Bortoli 2004, *Facing the Future: A focus on mathematical literacy among Australian 15-year-old students in PISA 2003*, p.123.

Student Achievement in TIMSS

The Trends in International Mathematics and Science Study (TIMSS) is conducted under the aegis of the International Association for the Evaluation of Educational Achievement (IEA). Those who established the IEA wanted to study organisational and curriculum-related issues that could not easily be investigated in a single school system or country. The sequence of studies that have followed provide the opportunity to study changes over time as well as differences among countries.¹⁹⁶

The 2002 TIMSS mathematics and science tests were organised along two domains: a content domain and a cognitive domain. In mathematics, the content domain comprised the areas of number, algebra, measurement, geometry and data; the cognitive domain comprised facts and procedures, using concepts, routine problems and reasoning.¹⁹⁷ In science, the content domain comprised the areas of earth science, life science and physical science for Year 4 participants and earth science, life science, physics, chemistry and environmental science for Year 8 participants. The cognitive domains for the science tests comprised factual knowledge, conceptual understanding and reasoning and analysis.¹⁹⁸

TIMSS reports achievement in terms of average score as well as in terms of international benchmarks (low, intermediate, high and advanced). Australia's results, along with international comparisons, are summarised below.¹⁹⁹

Achievement in Mathematics – Year 4

A group of fourteen countries had scores significantly higher than Australia in mathematics at Year 4 level: Singapore, Hong Kong SAR, Japan, Chinese Taipei, Belgium (Flemish), Netherlands, Latvia, Lithuania, Russian Federation, England, Hungary, United States and Cyprus. Australia's performance was very similar to the international average. In comparison, the 1994–1995 TIMSS reported Australia's performance in Year 4 mathematics as significantly higher than the

¹⁹⁶ S. Thomson & N. Fleming 2004, *Examining the Evidence: Science achievement in Australian Schools in TIMSS 2002 (TIMSS Australia Monograph no. 7)*, ACER, Melbourne, p.ii.

¹⁹⁷ S. Thomson & N. Fleming 2004, *Summing it up: Mathematics achievement in Australian schools in TIMSS 2002 (TIMSS Australia Monograph no. 6)*, ACER, Melbourne, pp.7–8.

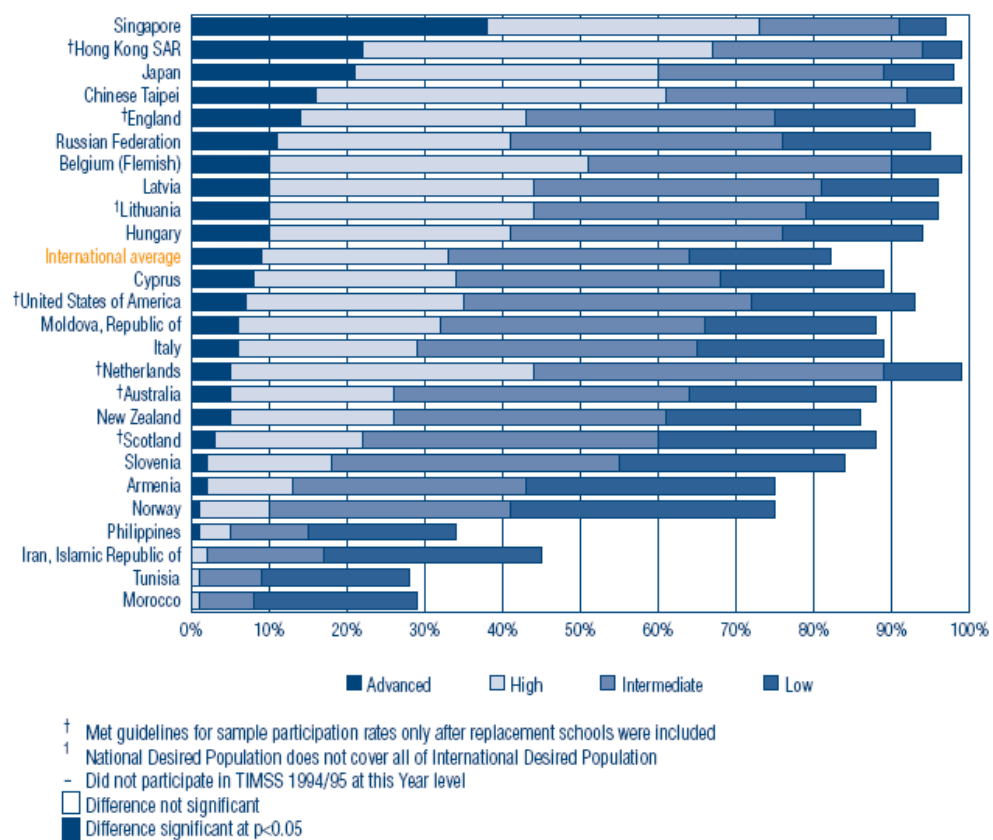
¹⁹⁸ S. Thomson & N. Fleming 2004, *Examining the Evidence: Science achievement in Australian Schools in TIMSS 2002 (TIMSS Australia Monograph no. 7)*, ACER, Melbourne, pp.7–8.

¹⁹⁹ Note: Any differences in achievement identified in the following sections are statistically significant.

international average.²⁰⁰ This change in ranking was caused by other countries improving their performance, while Australia's level of performance remained the same over the two studies. There was no significant gender difference in the level of mathematics achievement at Year 4 level in Australia.²⁰¹

Figure 5.10 shows the proportion of Year 4 students in each country reaching the international mathematics benchmarks. While Victoria's performance against the benchmarks was slightly above the Australian average, it was below the average for both the Australian Capital Territory and New South Wales.²⁰²

Figure 5.10: Proportion of Year 4 Students Reaching International Mathematics Benchmarks (2002)



Source: S. Thomson & N. Fleming 2004, *Summing it up: Mathematics achievement in Australian schools in TIMSS 2002 (TIMSS Australia Monograph no. 6)*, p.21.

²⁰⁰ S. Thomson & N. Fleming 2004 *Highlights from TIMSS from Australia's Perspective: Highlights from the full Australian reports from the Trends in International Mathematics and Science Study 2002/03*, ACER, Melbourne, p.4.

²⁰¹ *ibid.*

²⁰² *ibid.*, p.8.

Internationally, the largest differences between highest and lowest scores in the content area of mathematics were in the area of data. Australia's average score was significantly higher than the international average in Year 4 in measurement, geometry and data. Australia's average score was similar to the international average in patterns and relationships and lower than the international average in number.²⁰³

Achievement in Mathematics – Year 8

Singapore scored higher than all other countries in mathematics at Year 8 level. Australia also performed significantly higher than the international average overall and in each of the mathematics content areas. Overall achievement in the United States, England, Scotland, New Zealand and Malaysia was similar to that of Australian students.²⁰⁴ As was the case at Year 4 level, Australia's performance in Year 8 mathematics was the same as that in the 1994–1995 TIMSS, while the performance of some other countries had improved. This resulted in half of the countries that were outscored by Australia in the earlier study performing at a similar level to Australia in the TIMSS 2002–2003.²⁰⁵

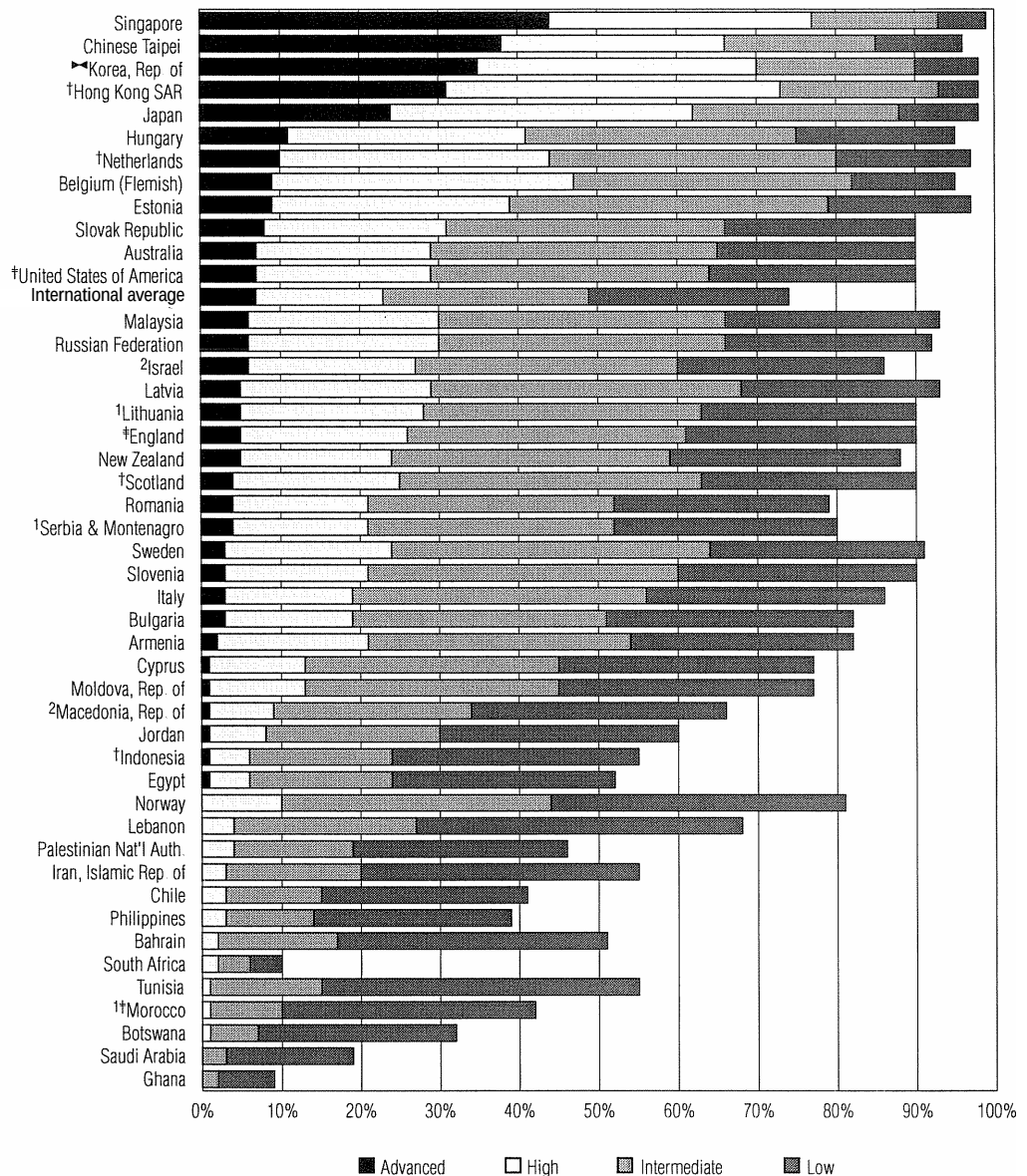
Achievement against the international benchmarks was better for Year 8 mathematics than for Year 4 mathematics. Overall, achievement of international benchmarks at Year 8 was equal to or greater than the international average (refer Figure 5.11). However, the proportion of Australian Year 8 students reaching each of the international benchmarks in mathematics was far less than that of the highest achieving country Singapore. Furthermore, there had been no significant improvement in Australia's achievement from the 1994–1995 study.²⁰⁶

²⁰³ *ibid.*, p.10.

²⁰⁴ *ibid.*, p.5.

²⁰⁵ *ibid.*

²⁰⁶ *ibid.*, p.8.

Figure 5.11: Proportion of Year 8 Students Reaching International Mathematics Benchmarks (2002)

▶ Korea tested the same cohort of students as other countries, but later in 2003, at the beginning of the next school year

† Met guidelines for sample participation rates only after replacement schools were included

‡ Nearly satisfied guidelines for sample participation rates only after replacement schools were included

‡ Did not satisfy guidelines for sample participation rates

¹ National Desired Population does not cover all of International Desired Population

² National Desired Population covers less than 90% of National Desired Population

Source: S. Thomson & N. Fleming 2004, *Summing it up: Mathematics achievement in Australian schools in TIMSS 2002 (TIMSS Australia Monograph no. 6)*, p.23.

Internationally, the largest difference between the highest and lowest performing countries was in geometry. Australia's performance in geometry was weaker than in the other content areas, it was still higher than the international average.²⁰⁷ Australia's score was significantly higher in data than in any other content areas.²⁰⁸

Achievement in Science – Year 4

There were seven countries with scores higher than Australia in Year 4 science. These were Singapore, Chinese Taipei, Japan, Hong Kong SAR, England, United States and Latvia. Nonetheless, Australia's performance was still significantly higher than the international average. Australia's performance in Year 4 science was consistent across the three content areas. Consistent with the result in mathematics, Australia's performance in Year 4 science has remained the same since TIMSS 1994–1995, while the performance of other countries has improved. Consequently, half of the participating countries now have an average score significantly higher than that of Australia, compared to only one such country in TIMSS 1994–1995.²⁰⁹

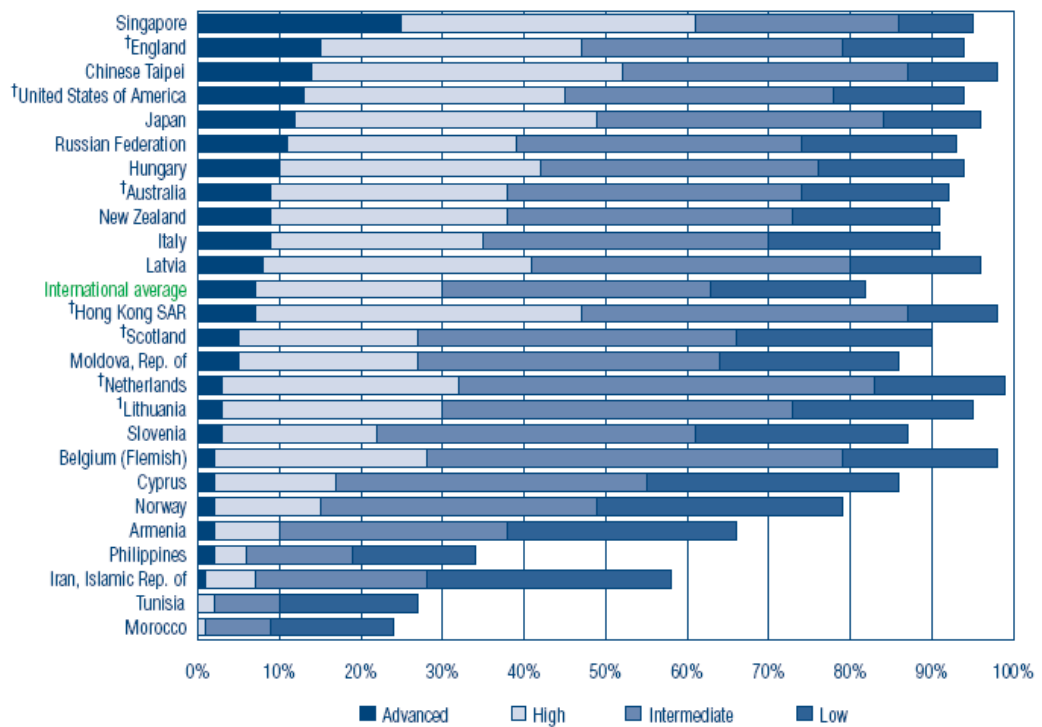
Disappointingly, the proportion of Australian students in Year 4 who achieved the advanced international benchmark in science was significantly lower than in TIMSS 1994–1995. However, the proportion of Australian students achieving the other benchmarks did not change significantly. Overall, the proportion of students at each international benchmark is higher than the international average (refer Figure 5.12).²¹⁰

²⁰⁷ *ibid.*, p.10.

²⁰⁸ *ibid.*

²⁰⁹ *ibid.*, p.8.

²¹⁰ *ibid.*, p.9.

Figure 5.12: Proportion of Year 4 Students Reaching International Science Benchmarks (2002)

† Met guidelines for sample participation rates only after replacement schools were included

1 National Desired Population does not cover all of International Desired Population

Source: S. Thomson & N. Fleming 2004, *Examining the Evidence: Science achievement in Australian Schools in TIMSS 2002 (TIMSS Australia Monograph no. 7)*, p.21.

Within Australia, the Australian Capital Territory had the highest proportion of students attaining each of the international benchmarks in Year 4 science. The Northern Territory had the lowest proportion of students reaching at least the low international benchmark.²¹¹ Victoria's achievement against the international benchmarks was very similar to that of the Australian average and above that of the international average.²¹²

²¹¹ *ibid.*

²¹² *ibid.*

Achievement in Science – Year 8

In Year 8 science, Singapore and Chinese Taipei significantly outscored all other countries, although Australia also performed significantly higher than the international average. In contrast to the trends in Year 4 and Year 8 mathematics and Year 4 science, Australia showed a significant improvement in Year 8 science since the 1994–1995 study. Consequently, some of the countries that were statistically similar to Australia in the earlier study were significantly lower than Australia in 2002–2003.²¹³

Australian students scored higher in environmental science, while the weakest area was chemistry, although achievement in this content area was still higher than the international average.²¹⁴ The largest difference in average scores between the highest and lowest scoring countries was in physics, which was Australia's second weakest area.²¹⁵

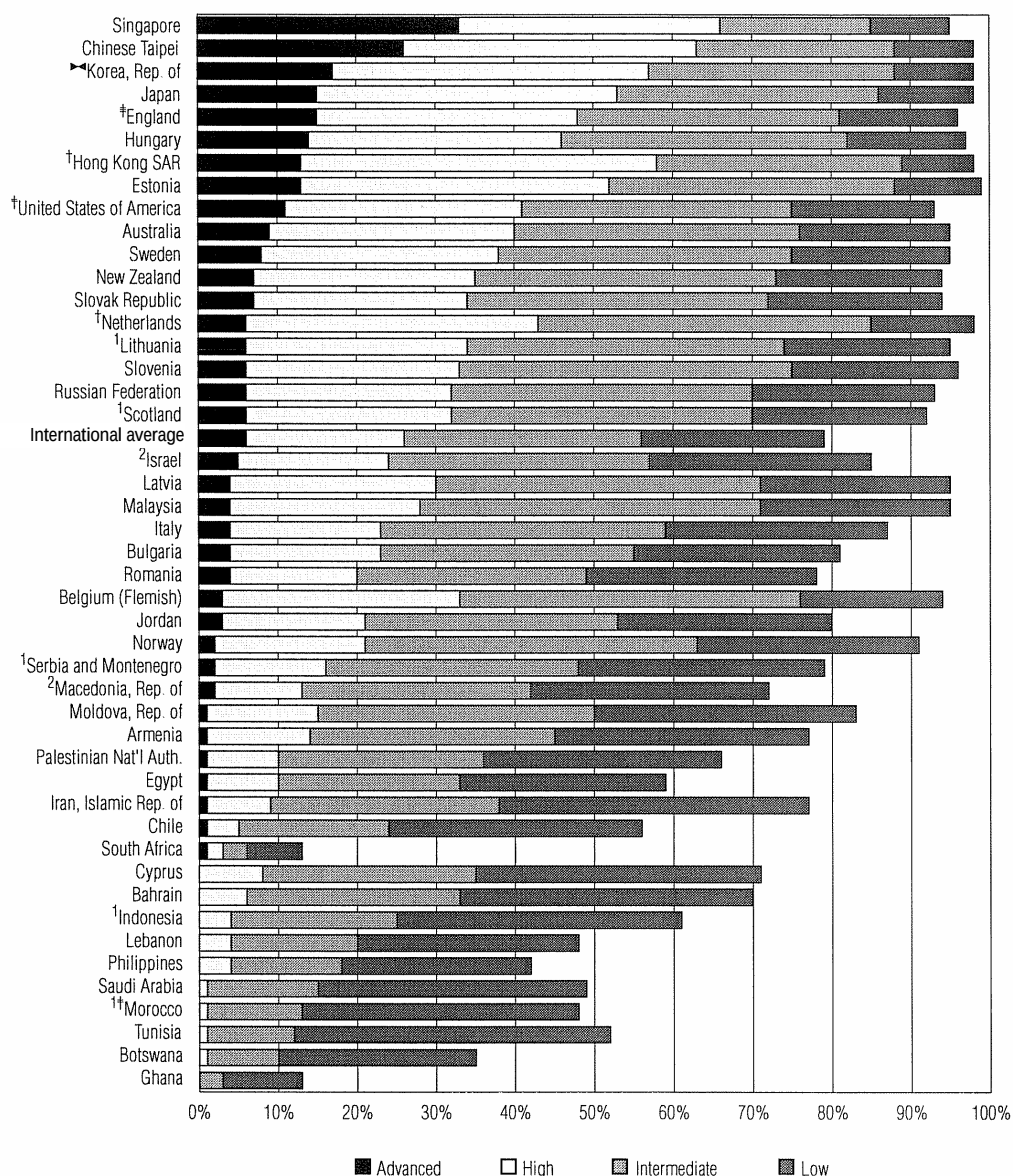
Overall, 95 per cent of Australian Year 8 science students reached the low international benchmark, with 76 per cent reaching the intermediate benchmark, 40 per cent reaching the high benchmark and nine per cent reaching the advanced benchmark (refer Figure 5.13).²¹⁶

²¹³ *ibid.*, p.7.

²¹⁴ *ibid.*, p.11.

²¹⁵ *ibid.*

²¹⁶ *ibid.*, p.9.

Figure 5.13: Proportion of Year 8 Students Reaching International Science Benchmarks (2002)

✧ Korea tested the same cohort of students as other countries, but later in 2003, at the beginning of the next school year

† Met guidelines for sample participation rates only after replacement schools were included

‡ Nearly satisfied guidelines for sample participation rates only after replacement schools were included

‡ Did not satisfy guidelines for sample participation rates

¹ National Desired Population does not cover all of International Desired Population

² National Desired Population covers less than 90% of National Desired Population

Source: S. Thomson & N. Fleming 2004, *Examining the Evidence: Science achievement in Australian Schools in TIMSS 2002 (TIMSS Australia Monograph no. 7)*, p.23.

Students in the highest achieving state, New South Wales, performed at an equivalent level to students in Chinese Taipei and very close to the level of Singaporean students. In the same group were Korea, Hong Kong SAR, Estonia, Japan and England. Students in the Australian Capital Territory also performed at a very high level.²¹⁷ The group of states around the Australian average (South Australia, Western Australia, Queensland and Victoria) had similar achievement levels as students in the United States, New Zealand and Sweden.²¹⁸

Policy Implications of Current Achievement Trends

On the whole, Victoria performs very well in mathematics and science, as compared with national and international achievement benchmarks. However, there are certain groups of students who continue to not achieve to the same standards as the average for the Victorian student cohort (refer Chapter 6). Therefore, there is considerable scope for students in the middle and lower ranges of achievement to improve their levels of mathematical and scientific literacy. There also remains scope for increased improvement at the higher end of achievement, to bring the achievement levels of Victorian students up to the best in the world.

Generally, there are few statistically significant differences in performance among students across Australian states and territories. There are indications, however, that on some measures, Victoria falls within the middle range of performance levels. This Committee would like the level of performance to be raised, to match not only the best in Australia, but also internationally. In seeking to achieve this goal, the Committee believes the Victorian Government should continue to monitor the performance of various states and territories, against key policies and programs operating within those states. An analysis of different interstate and international programs and their comparative success in meeting the different needs of diverse groups of students should also be undertaken. This will offer some guidance as to what types of initiatives are most effective in raising student achievement levels. It will also facilitate better targeting of existing mathematics and science education and awareness programs, to ensure that they reach those who could most benefit from them. This issue is explored in the following chapter.

²¹⁷ S. Thomson & N. Fleming 2004, *Examining the Evidence: Science achievement in Australian schools in TIMSS 2002 (TIMSS Australia Monograph no. 7)*, ACER, Melbourne, p.51.

²¹⁸ *ibid.*

Recommendation 5.1: That the Victorian Government undertake an analysis of the comparative success of interstate and international mathematics and science education and awareness programs in engaging and assisting students from diverse backgrounds.

6. Participation and Achievement Differences between Students

Introduction

Overall, Victoria's results in national and international benchmarking studies are encouraging. However, the education community must remain concerned about the broad range of performance among Victorian students, and the considerable disparity of participation and performance in mathematics and science between different groups of students.

The Committee's terms of reference required it to examine gender issues in the teaching and learning of mathematics and science. Gender undoubtedly has an influence within mathematics and science education. That influence is most obvious in the patterns of participation in post-compulsory mathematics and science subjects. The Committee heard, however, that there are more significant differences within the genders than between genders. Socioeconomic status was found to be a greater influence on participation and achievement in mathematics and science than gender, for example. Levels of participation and achievement in mathematics and science can also vary among different geographic locations. This chapter explores some of these differences in participation and achievement in mathematics and science education.

The Influence of Socioeconomic Status in Mathematics and Science Education

The influence of socioeconomic status within mathematics and science education was a significant concern among a range of participants in this inquiry. The following sections outline differences in levels of participation and achievement in mathematics and science; differing levels of access to various mathematics and science education, awareness and enrichment programs against a range of socioeconomic indicators; and the potential for university-to-school mentoring to be better targeted to help raise attainment levels for students from lower socioeconomic backgrounds.

Influence of Socioeconomic Status on Participation and Achievement in Mathematics and Science

Much previous research reveals a trend for higher levels of mathematics and science participation and achievement among students from higher socioeconomic groups.²¹⁹ This includes an increased tendency for higher socioeconomic groups to undertake mathematics and science subjects that are most valued by society. Highly valued subjects include those associated with high status careers, university pre-requisites and upwards scaling in ENTER calculations. Students from higher socioeconomic groups also tend to do better in these subjects compared to those from lower socioeconomic groups.

In 2003, the Commonwealth Department of Education, Science and Training published data showing the proportions of Year 12 students from different socioeconomic groups studying various science subjects (refer Figure 6.1). The data shows that the participation rate in Chemistry and Physics from the highest of four socioeconomic groups is more than twice that for students from the lowest socioeconomic group. In Biology, the difference between the top and bottom socioeconomic groups was less, but was still higher in the top two socioeconomic groups compared with the bottom two groups.²²⁰

Figure 6.1: Percentage of Year 12 Students Studying Science by Socioeconomic Status (2001)

Socioeconomic Status (SES) Group	Biology	Chemistry	Physics
Lowest SES	21.0	12.2	11.4
Lower SES	24.0	15.1	15.5
Higher SES	30.2	20.2	18.0
Highest SES	28.9	26.3	23.3

Source: Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Background Data and Analysis*, p.10.

²¹⁹ See for example, R. Teese & J. Polesel 2003, *Undemocratic Schooling: Equity and Quality in Mass Secondary Education in Australia*, Melbourne University Press, Melbourne, pp.42–43. Also, Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Background Data and Analysis*, Commonwealth of Australia, Canberra, p.10 & p.14.

²²⁰ Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Background Data and Analysis*, Commonwealth of Australia, Canberra, p.10.

The Committee received a submission from Mr Peter Cox, who completed his PhD study on gender and socioeconomic differences in participation, performance and subject selection in Year 12. The study involved a quantitative analysis of subject participation and performance at Bendigo Senior Secondary College over the period 1999 to 2001 and a qualitative analysis of students' and teachers' beliefs and attitudes towards subjects and reasons for subject choices.

Cox made similar findings to a previous study by Teese and Polesel. Cox reported that the core mathematics and science subjects were the highest ranked subjects considered most valued by society.²²¹ Cox further found that 'the more diverse subject selections of girls, and of lower socioeconomic students, takes them to areas of the curriculum where subjects have less value'.²²² This leaves higher proportions of boys and higher socioeconomic students in the high value 'niches' of the curriculum.²²³ Thus, as Cox states, the tendency of lower socioeconomic groups to restrict their options post-Year 12 'may perpetuate social and economic positions between generations'.²²⁴

Teachers in the Bendigo Senior Secondary College study reported a belief that students from higher socioeconomic backgrounds have higher expectations and more ambitious goals than do students from lower socioeconomic backgrounds. Teachers also reported that having parents from higher socioeconomic backgrounds may be more of an advantage to children in terms of valuing education, the quality of subject selection information, tutoring resources, expectations, confidence and encouragement to persevere.²²⁵ In comparison, students from lower socioeconomic homes experience an environment that is less conducive to effective learning. The Committee notes that teacher beliefs such as these:

... may help to create a system which perhaps treats some socioeconomic groups of students differently, places different expectations upon these different groups, creates a self-fulfilling prophecy in their educational outcomes, and perpetuates social differences.²²⁶

Professor Peter Sullivan suggested during a public hearing that family involvement in a young person's education is 'the most important determinant of educational outcomes'.²²⁷ He suggested, however, that it is not necessarily the lack of family resources that causes families with lower incomes to be less involved in their child's education:

²²¹ Written Submission, Mr P. Cox, La Trobe University, August 2005, p.6.

²²² *ibid.*, p.6.

²²³ *ibid.*

²²⁴ *ibid.*, p.4.

²²⁵ *ibid.*, pp.4–5.

²²⁶ *ibid.*, p.5.

²²⁷ Transcript of Evidence, Public Hearing, Melbourne, 20 June 2005, p.21.

Even though there is a high correlation between socioeconomic status and family involvement – there is an indication that high-income families tend to be more involved in their kids' education and read to kids at home and so on – the fact that lower socioeconomic groups are not involved is not a resource issue, it is just a lack of familiarity. The projects that are very successful are those ... encouraging them [parents] to take a much more active role in their kids' education in the early years.²²⁸

It was therefore suggested by a number of participants in the inquiry, including Professor Sullivan, that anything that can be done to support parents to help their children in their education is going to be valuable.

As stated by the University of Melbourne, governments need to capitalise on the important influence parents and families have on students:

Parental influence and decisions are crucial for [primary students]. Visible and sustained Government messages and support for the importance of science and mathematics in the early years of schooling will encourage parents to take interest in and to encourage and support students' endeavours as they begin their exploration of science.²²⁹

The Committee recognises the challenges faced by many parents in participating fully in their children's education. Approaches to teaching of fundamental mathematics concepts may have changed since their own education. Application of mathematics and science, particularly in rapidly advancing areas of new science have also changed. Therefore, initiatives targeting family involvement in mathematics and science require regular reviews and updates.

The Committee also acknowledges that promoting parental and family involvement in education may have unique challenges in areas of socioeconomic disadvantage or in some culturally and linguistically diverse communities. Nevertheless, it is these communities that are likely to benefit the most from such initiatives. Therefore, some schools may need assistance to develop resources and programs meeting the specific needs of their communities.

Recent Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) reports made similar observations. However, PISA 2003 reported that socioeconomic background was not as strong a determinant of mathematical and scientific literacy in Australia as in some other countries. Nonetheless:

²²⁸ *ibid.*

²²⁹ Written Submission, The University of Melbourne, January 2005, p.3.

... there still exists a distinct advantage for students with higher socioeconomic backgrounds. While schools are not able to influence students' socioeconomic backgrounds, they are able to introduce policies that help to counteract the effects of disadvantage. Although many schools already do this there is work to be done because the differences observed are greater than would be considered desirable in relation to our national aspirations.²³⁰

Influence of Socioeconomic Status on Access to Enrichment Programs

The Committee undertook an analysis of the level of participation by schools in a wide range of mathematics and science education and awareness programs over recent years. These included excursions to Melbourne-based science and technology centres, student competitions, science and scientific research related placement programs, mentoring programs, science education and awareness outreach programs (including careers presentations) and other enrichment activities (for example, extension project work). A list of programs examined by the Committee is contained at Appendix E.²³¹ Descriptions of the programs are contained in Appendix L (Centres of Excellence), Appendix M (University-to-School Mentoring Programs) and Appendix N (Education and Awareness Programs).

The profiles of participating schools were examined against a number of socioeconomic indicators, including the SEIFA Index of Relative Advantage/Disadvantage (refer Appendix D)²³² and for government schools, their 'Like School Group'. The 'Like School Group' indicator has been developed by the Victorian Department of Education and Training and takes into account the proportions of students from a language background other than English and the proportions of students receiving either the educational maintenance allowance or the youth allowance (refer Appendix O for Like School Group categories).

As shown in Figure 6.2, the independent school sector has a very different socioeconomic composition to the average for Victoria, thereby making school sector another indicator of socioeconomic status. Only 38.9 per cent of schools in the independent sector are located in areas with a score indicating relative socioeconomic

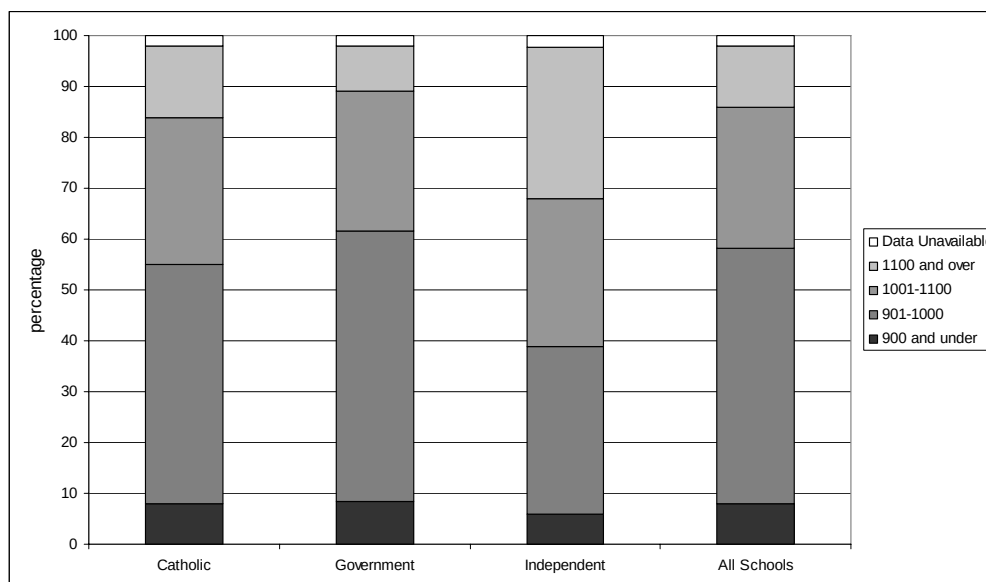
²³⁰ Australian Council for Educational Research 2004, *PISA in Brief from Australia's Perspective*, ACER, Melbourne, p.13.

²³¹ Most data was obtained from the various mathematics and science education and awareness program managers in response to a request from the Committee. The Committee acknowledges that preparation of the data was a significant undertaking for many organisations and thanks them for the quality and timeliness of their responses. The resulting analysis forms the basis of some of the Committee's recommendations.

²³² Use of this indicator provides an indication of the likely socioeconomic profile of students, based on the location (postcode) of the school.

disadvantage, compared to 61.7 per cent of government schools and 55.0 per cent of Catholic schools. Conversely, 58.9 per cent of independent schools are located in areas with scores indicating relative socioeconomic advantage, compared with 36.3 per cent of government schools and 42.9 per cent of Catholic schools.

Figure 6.2: Index of Relative Socio-Economic Advantage/Disadvantage by School Sector (%) (2001)



Note: An Index of Relative Socio-Economic Advantage/Disadvantage score over 1,000 denotes relative advantage, while scores below 1,000 denote relative disadvantage.²³³

'All Schools' refers to the overall distribution of all schools in Victoria by sector.

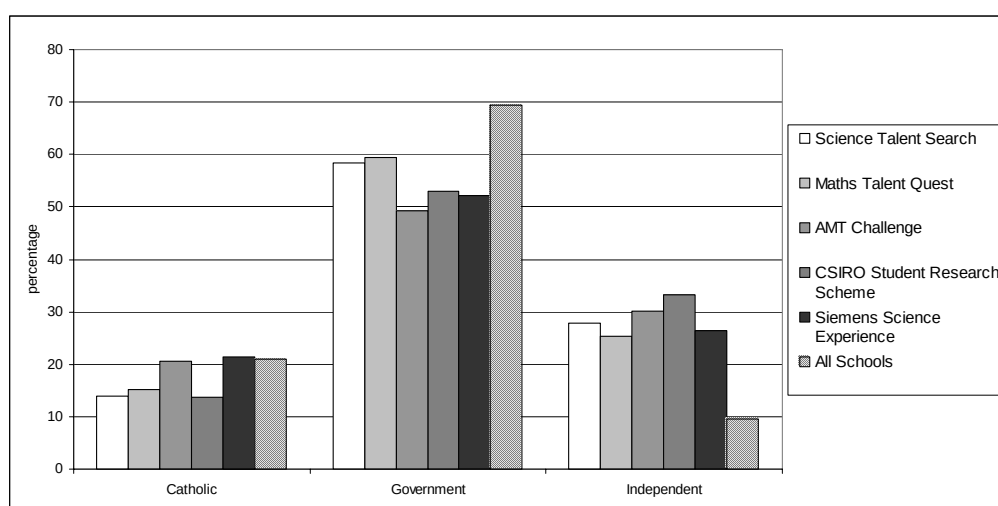
Source: Education and Training Committee analysis.

The participation rate of students from independent schools is greater than students in other school sectors in a range of mathematics and science education and awareness programs (refer Figure 6.3). This includes elite programs in which only a small number of selected students can participate, such as CSIRO Student Research Scheme and Siemens Science Experience, as well as competitions and events that are open to all schools and students. The Catholic sector is reasonably well represented in some of these programs, while under-represented in others and the government sector is generally substantially under-represented in mathematics and science enrichment programs.

²³³ The Index of Relative Socio-Economic Advantage/Disadvantage measures an area's wellbeing, and is a continuum of advantage to disadvantage. It is derived from attributes relating to income, education, occupation, employment status, internet usage and size of dwelling. Scoring well on this index indicates that an area has a relatively high proportion of people with high incomes, tertiary qualifications and professional occupations and a low proportion of people with low incomes, lack of qualifications and unskilled occupations. A lower score on this index indicates the reverse. For further information, refer Appendix E.

The Committee noted that the Catholic and government schools were substantially under-represented among participants in the Science Talent Search in 2004 and 2005, while the independent sector was substantially over-represented. This is surprising given the wide accessibility and the educational value of the event. The 2005 exhibition and presentation was attended by representatives of the Committee who observed firsthand the high levels of student engagement and satisfaction with the program. Importantly, the event offers many categories in which students can enter, covering Years Prep to 12. These include experimental research, creative writing, working models and inventions, games, computer programs, posters/scientific wallcharts, science photography, video productions and class projects. The breadth of these categories, together with the low cost of participation and the availability of detailed program materials and a teacher professional development kit, make the program highly accessible for almost any school.

Figure 6.3: Profile of Schools Participating in Mathematics and Science Enrichment Programs by School Sector (%) (2003 to 2005)^a



Note: ^a Years for which data was obtained varied by program. Refer Appendix E for details.

'All Schools' refers to the overall distribution of all schools in Victoria by sector.

Source: Education and Training Committee analysis of participation in mathematics and science education and awareness programs.

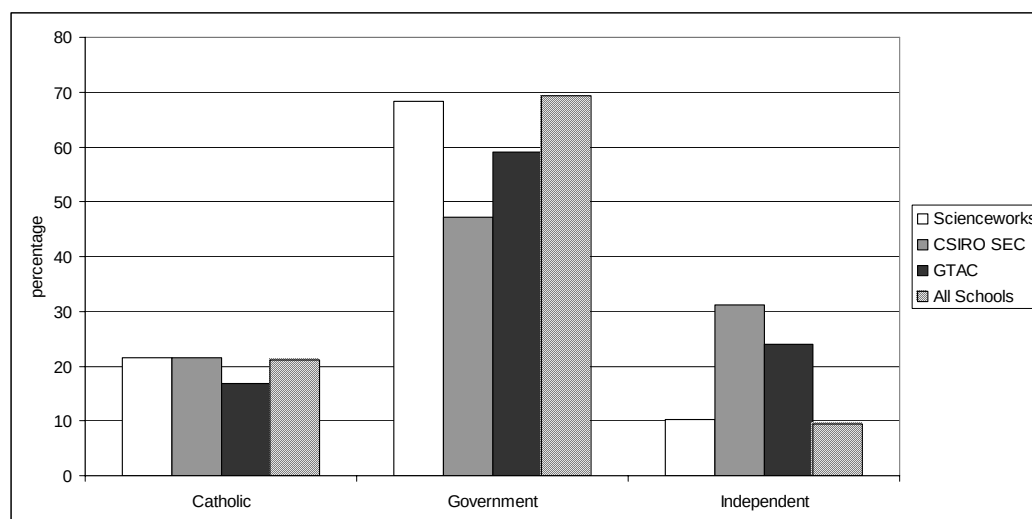
During the inquiry, the Committee visited three Melbourne-based science facilities that host excursions for school groups. These were Scienceworks Museum, the CSIRO Melbourne Science Education Centre and the Gene Technology Access Centre (GTAC). A description of these centres is contained at Appendix L.

Figure 6.4 shows the distribution of schools visiting these facilities in recent years.

All three school sectors are proportionately represented in visits to Scienceworks Museum in 2003 and 2004. This is perhaps due to the widespread knowledge among teachers, parents and the community about the facility and its product offerings. The Committee also notes that free entry to Scienceworks for children, together with a travel subsidy offered by the Victorian Government to assist Year 6 students to visit, make it the most accessible science centre in the State.

It was noted by the Committee that many government school students seem to miss out on opportunities to visit the other two Melbourne-based centres. The Committee considers that the programs offered by these centres are of very high quality and can have a significant influence in increasing student engagement and consolidating learning. The availability of resources among many independent schools perhaps accounts for their higher levels of attendance at these facilities. The Committee notes, however, comments by the manager of the GTAC programs indicating that the Centre aims to manage its bookings so as to ensure a fair representation by all school types.²³⁴

Figure 6.4: Profile of Schools Visiting Melbourne-based Science Facilities by School Sector (%) (2003 to 2005)^a



Note: ^a Data for Scienceworks and CSIRO Science Education Centre relates to 2003 and 2004. Data for GTAC relates to 2004 and 2005.

'All Schools' refers to the overall distribution of all schools in Victoria by sector.

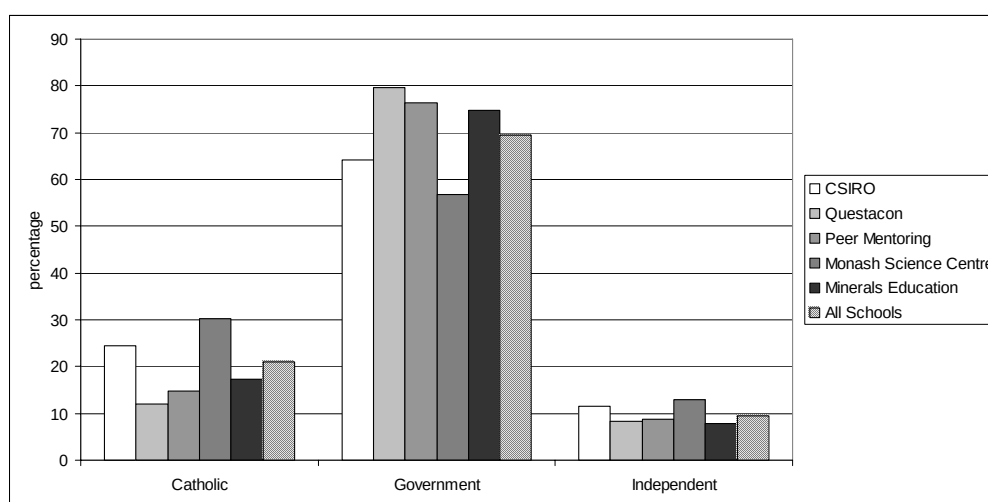
Source: Education and Training Committee analysis of participation in mathematics and science education and awareness programs.

Government schools were far better represented among outreach programs, including those offered by CSIRO Melbourne Science Education Centre (refer Figure 6.5). Indeed, government schools were over-represented among schools receiving outreach from Questacon

²³⁴ Mr B. Stevenson, in conversation with Committee members during visit to the Gene Technology Access Centre, 6 May 2005.

(Science Circus and Smart Moves), university-to-school mentoring programs and Minerals Education. This can be at least partially accounted for by the funding streams for some of these programs. Additionally, however, these types of programs may be less valued by independent schools for two reasons. First, outreach programs conducted by centres such as CSIRO and Questacon often involve mobile science lessons that involve equipment, consumables and specialised knowledge that may not be readily accessible to schools in the government and Catholic sectors. Independent schools often have better access to these resources. Secondly, the higher resource levels available in many independent schools mean that far more options are available, making an excursion a perhaps more attractive alternative than a school-based program.

Figure 6.5: Profile of Schools Receiving Science Outreach Programs by School Sector (%) (2002 to 2005)^a



Note: ^a CSIRO refers to Lab on Legs for the years 2003 and 2004. Questacon includes Smart Moves and Science Circus covering the period 2002 to 2005. Peer mentoring includes the In2Science (2004 and 2005), Monash University (2004 and 2005) and RMIT University (2002 to 2005) university-to-school mentoring programs.

'All schools' refers to the overall distribution of all schools in Victoria by sector.

Source: Education and Training Committee analysis of participation in mathematics and science education and awareness programs.

The Committee's analysis of participation in mathematics and science education and awareness programs by relative socioeconomic advantage/disadvantage reveals similar trends to those shown for school sector. Schools located in areas experiencing relative socioeconomic disadvantage are under-represented in nearly all programs, often substantially. It is of concern that schools in disadvantaged areas (which account for 58.1% of all Victorian schools) accounted for only 33.7 per cent of schools participating in the highly accessible Science Talent Search in 2004 and 2005. These schools were, however, reasonably represented among schools visiting Scienceworks Museum in 2003 and 2004, again demonstrating the

widespread accessibility of this facility due to its free entry status and the government travel subsidy offered for Year 6 students.

Schools in disadvantaged areas were also generally very poorly represented among outreach programs. The main exception to this was outreach conducted by Questacon. Schools in disadvantaged areas accounted for 82.1 per cent of schools participating in the Shell Questacon Science Circus and Questacon Smart Moves (over the period 2002 to 2005). There are a number of possible explanations for this, including possible deliberate targeting of these programs by Questacon and the regional focus afforded these programs: 48 per cent of government schools (which have lower socioeconomic profiles) are located in the non-metropolitan area, compared with only 28.5 per cent of independent schools. Another explanation may be the infrequency with which Questacon programs are offered in each region, making schools more likely to take advantage of the programs when they become available.

On the 'Like School Group' indicator used by the Committee, there are also identifiable trends in the profile of schools participating in mathematics and science programs. Scienceworks Museum was the only program that had a profile of participating schools that closely reflects that of government schools overall.

The 'Like School Groups' most likely to be under-represented in a range of excursions, enrichment activities and outreach programs were groups four, seven, eight and nine. Three of these groups have the highest proportions of students receiving the educational maintenance allowance or the youth allowance, with the other (LSG 4) having a medium proportion of students receiving these allowances. In contrast, the groups most likely to be over-represented in all three categories (excursion, enrichment and outreach) were groups two, three, five and six. These groups have a low or medium proportion of students receiving the educational maintenance allowance or the youth allowance (refer Appendix O).

Initiatives Aimed at Addressing Socioeconomic Inequities – Mentoring Programs

The Committee was unable to identify any mathematics or science initiatives or programs in Victoria that are specifically targeted at improving education outcomes among students experiencing socioeconomic disadvantage. In contrast, there are some university-to-school mentoring programs aimed at addressing socioeconomic inequities within the education system that have been implemented widely in international jurisdictions.

Israel's national Perach project is one of the most well known university-to-school mentoring programs worldwide. Perach was created in 1975 to ensure that as many young Israelis as possible fulfil

their potential. It achieves this through a two-pronged approach: providing tutorial help for children from disadvantaged backgrounds, while providing scholarships to university students in return for their work with under-privileged students. The stated goals of Perach include:

- giving every child and student an opportunity to fulfil their potential, [thereby] reducing social and educational differences between children in Israel;
- providing scientific and enrichment programs for needy children;
- making university students more aware of the social problems of the country by fostering relationships between themselves and disadvantaged families and children; and
- helping university students meet the cost of tuition.²³⁵

University-to-school mentoring programs have also been operating in the United Kingdom since 1975. More recently, these programs have grown rapidly and extensively, first through the government-funded National Mentoring Pilot Project (1994 to 2004) and now through the Aimhigher National Mentoring Scheme. In common with Perach, the key aims of the UK's National Mentoring Pilot Project were targeted at improving opportunities for students experiencing some type of disadvantage in their learning and life opportunities.²³⁶ An independent evaluation of the National Mentoring Pilot Project conducted by Warwick University in 2004, found significant improvement in academic achievement after just one year of quality mentoring.²³⁷ Mentoring is therefore very attractive in UK government policy terms, as it 'supports not only broader participation in higher education by under-represented groups, but also the raising educational standards agenda and young people's volunteering'.²³⁸

The Dutch Government recently released a policy paper, *Receiving Opportunities, Taking Opportunities*, which is aimed at improving the social and educational position of people from ethnic backgrounds, who represent ten per cent of the population. The paper recognises mentoring as a powerful tool in improving these students' social and educational prospects. An early evaluation of the Dutch program has shown very positive results. These include teachers learning more

²³⁵ A. Carmeli, 'The Perach project: lessons and results', *The Mentor*, Issue 7 Summer 2004, p.8.

²³⁶ For further information, refer to the National Mentoring Pilot Project website, <<http://www.nmpp.cf.ac.uk>>.

²³⁷ A. Evans, 'Quality mentoring: improving educational standards and raising aspirations', *The University Mentor*, Issue 1, Spring 2005, p.8.

²³⁸ A. Miller, 'Mentoring in Partnership', *The University Mentor*, Issue 1, Spring 2005, p.1.

about their students' background and problems, and parents becoming better informed and better equipped to support their children.²³⁹ Singapore, too, has a mentoring program aimed at disadvantaged students, although this program was initiated within the corporate sector by BP. Acting in partnership with participating local schools, the BP program identifies students who would most benefit from the positive effects of mentoring, including those who may not be performing well academically, those who have disruptive behaviours and those lacking positive role models in their life.²⁴⁰

University-to-school peer mentoring was pioneered in Australia by Murdoch University in Western Australia, which established the Science Technology Awareness Raising (STAR) program in 1994. STAR is modelled on the successful Pimlico Connection, which operates in the United Kingdom and, to some extent, on Israel's Perach project. It is now the biggest program of its type in Australia, with 60 science mentors/tutors regularly working in 19 high schools and two primary schools in the Perth metropolitan area.²⁴¹ Similar mentoring programs are now being run by La Trobe, Monash and RMIT universities (refer Appendix M for program descriptions).

Australian university-to-school mentoring programs have typically evolved within individual universities and, of key relevance to this inquiry, tend to operate through science, technology and engineering faculties. They seem to have been initiated due to concerns about the decline in participation (and standards) in these disciplines:

[tutoring and mentoring programs] have been spurred by predictions (and some disturbing evidence) of a drop in student demand for these disciplines, caused by a disproportionately heavy 80% increase in student fees. The fee 'hike' is seen by many observers in academe and industry as a strategic blunder at a time when Australia is trying to build on its international reputation for scientific and technological innovation.²⁴²

In contrast to the programs operating in other countries, university-to-school mentoring programs in Victoria (and Australia) are small and generally involve group tutoring or mentoring in the classroom (rather than one-to-one student tutoring).²⁴³ They are also often vulnerable

²³⁹ L. Brouwer-Vogel & Marloes de Bie, 'Mentoring and mediation in the Netherlands', *The Mentor*, Issue 7, Summer 2004, p.8.

²⁴⁰ BP Singapore website, <<http://www.bpmentoring.org>>, accessed on 20 October 2005.

²⁴¹ For further information, refer to the STAR website, <<http://about.murdoch.edu.au/star/navpage.html>>.

²⁴² STAR website, <http://about.murdoch.edu.au/star/peer_net/network.html>, accessed on 20 October 2005.

²⁴³ The Committee's analysis revealed that 102 students participated in university-to-school mentoring offered by Monash University, RMIT University and the In2Science Peer Mentoring Program during 2004 and/or 2005. Of these, 78 were government schools, 15 were Catholic schools and 9 were independent schools.

due to the lack of long-term, secure funding mechanisms. Mentor placements within Australian programs are generally of much shorter duration (often only 8 to 10 weeks). This limits the opportunities for establishing the strong relationships that are a key, valuable feature of the international programs examined by the Committee. These features mean that Australian mentoring programs are effectively, as the name of the STAR program indicates, targeted more towards science (and technology) awareness raising, than towards improved academic achievement among disadvantaged students.

The Committee believes that current inequities in mathematics and science education could be at least partially addressed through greater use and more effective targeting of university-to-school mentoring programs. In particular, the Committee believes that the following groups of students could benefit significantly from access to a mentoring program that includes one-to-one tutoring and mentoring, as seen in the international mentoring models:

- students in schools located in areas scoring lower on the index of relative socioeconomic advantage/disadvantage;
- students in primary and secondary schools that perform lower in national and/or international benchmarking studies;
- students in secondary schools that have lower levels of educational attainment, defined against variables such as successful post-compulsory education outcomes; and
- student groups that traditionally have lower levels of educational attainment, including Indigenous students, students from some language backgrounds other than English and students in rural communities.

The above represent key target groups who could benefit from mentoring programs and other mathematics and science education and awareness initiatives. However, an analysis of current university-to-school mentoring reveals a relatively narrow profile among participating schools, with virtually all being metropolitan schools that have a reasonably solid reputation either in terms of academic or other outcomes. For example, secondary schools with a high proportion of students with aspirations to attend university were over-represented in mentoring programs during 2004 and 2005.²⁴⁴ Schools achieving a mean VCE study score of 30 or over, schools with 15 per cent or more of study scores of 40 or over and schools with the highest proportions of successful VCE completions were similarly over-represented in

²⁴⁴ In 2004, 33.8% of secondary schools had over 90% of their student cohort applying for a university course. However, of secondary schools participating in peer mentoring programs during 2004 and/or 2005, 49.1% had over 90% of students applying for university.

mentoring programs, while schools with lower levels of academic achievement were under-represented.²⁴⁵

The Co-ordinator of In2Science, La Trobe University's mentoring program, explained the relatively narrow profile of participating schools as follows:

... the way we selected schools included the fact that because we were starting off we wanted it to work. So our first aim was to look at schools which we knew were interested in science and were actually looking forward. It is absolutely pointless just putting a mentor into a school where the teachers are not interested.²⁴⁶

The self-selecting nature of university-to-school mentoring programs offers an additional explanation as to why these programs do not easily reach those who could most benefit:

Teachers generally tend to select themselves in the sense that when we tell the school about what peer tutoring involves, we usually find that the more ... adventurous teachers will take up the option of having a peer tutor. Some teachers simply will not have a peer tutor under any circumstances. They do not want somebody else in their classroom.²⁴⁷

The Committee's analysis found that government schools were well represented in mentoring programs during 2004 and 2005, accounting for 76.0 per cent of participating schools. This reflects the funding conditions placed on some programs receiving government funding.

It should be noted that non-metropolitan schools were very poorly represented, accounting for only five per cent of participating schools. Further, enrolment and achievement trends suggest that students in the Western Metropolitan and Northern Metropolitan Regions could benefit from this type of program. However, these two regions were under-represented among schools participating in university-to-school mentoring programs during 2004 and 2005. This was particularly noticeable in the Western Metropolitan region, which accounts for 18.2 per cent of all metropolitan-based schools, but only 10.3 per cent of schools with mentor placements.²⁴⁸

Mentoring activity was also significantly skewed amongst 'Like School Group' categories, although there does not appear to be a consistent

²⁴⁵ Education & Training Committee analysis of schools participating in Victorian peer mentoring programs.

²⁴⁶ Mr J. McDonald, Program Director, In2Science Peer Mentoring Program, Transcript of Evidence, Public Hearing, Melbourne, 8 August 2005, p.22.

²⁴⁷ Mr R. Elsegood, Director, Science and Technology Awareness Raising Program, Murdoch University, Transcript of Meeting, Perth, 1 June 2005, p.7.

²⁴⁸ Calculated by the Committee based on data supplied by the In2Science Peer Mentoring Program, Monash Science Centre and RMIT University Peer Mentor Program.

pattern as to which 'Like School Groups' would be over-represented or under-represented. Of the two 'Like School Group' categories that were most substantially under-represented in mentoring programs, one had a medium proportion of students receiving either the educational maintenance allowance or youth allowance and the other had a high proportion of students receiving one of these allowances.²⁴⁹

The Committee acknowledges the arguments regarding the need to ensure programs are successful and recognises the importance of having both school and teacher support for university-to-school mentoring. However, it believes there remains scope to bring mentoring programs into a broader range of schools. Most programs in Victoria (and Australia) tend to rely heavily on government funding sources. Governments are therefore in a strong position to influence the implementation and outcomes of these programs. The Committee believes that the Victorian Government should take the opportunity to work with university-to-school mentoring programs to ensure they are better targeted towards achieving improvements in mathematics and science attainment levels, in addition to responding to their current role of raising awareness about mathematics and science education. Further, the Committee believes that future government funding should be dependent on the mentoring programs better targeting schools in greatest need. In order to achieve this, it may be necessary to develop materials and strategies that will assist teachers, students and parents to understand the benefits of mentoring and to participate fully in these programs.

The Committee also examined the growing use of e-mentoring in various interstate and international jurisdictions. The STAR program, run by Murdoch University in Western Australia includes an e-mentoring component targeted at rural and regional students. STARnet enables volunteer mentors to tutor/mentor students in rural and regional schools via desktop video conferencing.²⁵⁰ Students have (monitored) access to an internet-connected computer with video conferencing capability. This is made possible through a digital video camera supplied on loan by STARnet, together with free communication software that allows the tutor/mentor and the student to see one another and converse in real time. The role of the STARnet tutors/mentors is to assist the student in completing school assignments and to act as a valuable, non-judgmental sounding board, a positive role model and a source of first-hand information on where education should fit into their life after school.

Interestingly, e-mentoring in other countries, including the United States and the United Kingdom has been adopted in a broader range of contexts. Models vary considerably, with some e-mentoring offering

²⁴⁹ Education & Training Committee analysis of participation in peer mentoring programs.

²⁵⁰ Information on STARnet was obtained through the STAR website, <<http://about.murdoch.edu.au/star/intro.html>>, accessed on 7 November 2005.

one-to-one mentoring and/or tutoring and others operating more as a discussion board with a large number of participants. The involvement of representatives from the business, industry and/or research sectors is a common feature of many of the programs. While the purpose of the different programs may vary, they are generally aimed at one or more of the following:

- providing role models;
- raising the profile of science and scientific careers;
- offering career advice and guidance;
- providing tutorial support to help raise achievement levels; and
- addressing the special needs of various groups, such as girls, disadvantaged students and gifted or talented students.

The Committee supports e-mentoring to complement, rather than replace additional strategies aimed at addressing the needs of specific cohorts of students who could benefit from additional support in their mathematics and science studies. For example, the Committee believes that e-mentoring relationships could be established in conjunction with a visitation program such as RMIT University's Road Crew or participation in science enrichment programs such as Siemens Summer Science Experience. E-mentoring could also be supported with special networking events open to all participants. These types of activities would complement an e-mentoring strategy, by strengthening the mentoring relationships of participants.

The Influence of Gender Differences in Mathematics and Science Education

The following sections look at gender differences in participation and achievement in mathematics and science and the varying attitudes of males and females towards these subjects.

Trends in Participation by Gender

The Committee found that there are significant gender imbalances in participation in mathematics and science subjects, with females being under-represented in Mathematical Methods, Specialist Mathematics and Physics (refer Chapter 4). While there is a relative gender balance in Further Mathematics and also in Chemistry, females are significantly over-represented in Biology and Psychology. Similar gender biases

have been identified within the higher education sector.²⁵¹ Researchers have suggested many variables contribute to gender imbalances, including biological, sociological, attitudinal, institutional and affective factors, as well as curriculum, pedagogy and stereotyping.²⁵²

Gender differences in mathematics and science enrolments are of concern for two reasons. First, gender and diversity balance is critical for the sustainability of a broad range of professions and the communities they serve. The second reason relates to the inherent inequities in such gender imbalances in subject enrolments, which continue into future education, training, employment and lifestyle opportunities.

Cox's study on gender and socioeconomic differences in participation, performance and subject selection of Year 12 students at Bendigo Senior Secondary College was consistent with state-wide patterns. The school exhibited very similar enrolment trends to those seen at the state level, with a greater proportion of male students enrolled in the more advanced mathematics subjects and Physics and a greater proportion of female students enrolled in less advanced mathematics subjects, Biology and Psychology. Similar proportions of male and female students enrolled in Chemistry. Cox's study is therefore useful in helping to explain some of the factors leading to gender differences in participation in mathematics and science education.

Cox concluded that it is the different interests of girls and boys that lead them to differential subject selection, with boys apparently feeling less constrained than girls about studying mathematics and science.²⁵³ Cox found that students hold many sex-stereotyped beliefs about appropriate subjects, behaviour and jobs, which are often at odds with the norms of contemporary society.²⁵⁴ Teachers and parents were similarly reported to continue to have stereotyped beliefs of the appropriateness of subjects for each gender and to continue to communicate gender-specific subject selections.²⁵⁵ Cox further suggested that girls who are not interested in mathematics and science appear to receive less encouragement to follow these subjects than do equivalent boys.²⁵⁶

The Australian Institute of Physics similarly offered the differing interests among boys and girls, together with university pre-requisites, as an explanation for gender differences in subject enrolments.²⁵⁷ It

²⁵¹ See for example, Australian Council of Deans of Science 2003, *Is the Study of Science in Decline?*, ACDS Occasional Paper No. 3, ACDS, Melbourne, pp.12–13.

²⁵² Written Submission, Science Teachers' Association of Victoria, January 2005, p.10.

²⁵³ Written Submission, Mr P. Cox, La Trobe University, August 2005, p.3.

²⁵⁴ *ibid.* p 5.

²⁵⁵ *ibid.*

²⁵⁶ *ibid.*

²⁵⁷ Written Submission, Australian Institute of Physics, Victorian Branch, Education Committee, December 2004, p.3.

reported that there is a tendency for most paramedical courses, which traditionally attract girls, to specify Chemistry as a single prerequisite. In contrast, the tendency for most other courses is to specify a range of alternative pre-requisites that will satisfy entry requirements.

Trends in Achievement by Gender

At Year 12 level, there appears to be a general trend over the past four years for female students to slightly outperform male students, where performance is measured as successful completion of a VCE Unit 1–4 mathematics or science subject. Victorian Curriculum and Assessment Authority data shows that since 2000, females have consistently had higher successful completion rates in all mathematics subjects except Mathematical Methods (CAS) and in all science subjects except Environmental Science where males have outscored females in some units in some years (including Units 1–4 in 2004).²⁵⁸ The data available to the Committee did not allow for an analysis of the statistical significance of these apparent differences, or for differences in the range of scores achieved by each gender to be determined.

The study of 2,500 students at Bendigo Senior Secondary College revealed gender differences in performance in favour of females in all mathematics and science subjects, with larger gender differences present in the school-based assessments than in the examinations.²⁵⁹ When this data was analysed controlling for ‘ability’, however, very few of these gender differences in study scores were statistically significant. Rather, it was suggested that apparent gender differences are more likely to be caused by different ability groupings of males and females selecting mathematics and science subjects.²⁶⁰ That is, boys tend to enrol in a narrower combination of subjects than do girls. Therefore, the girls opting to undertake mathematics and science subjects tend to have a stronger background or level of ability in these subjects than the broader male cohort.

The two national benchmarking studies examined by the Committee revealed very few statistical differences in the achievement of males and females, either within Victoria or nationally. For example, the *National Report on Schooling in Australia* found statistically significant differences, though minor, for Victoria on the Year 3 numeracy benchmark (slightly in favour of girls) and for New South Wales on the Year 7 numeracy benchmark (also in slight favour of girls). The National Year 6 Science Assessment also found few significant differences in the level of scientific literacy between boys and girls. It reported that ‘[although] the differences were not statistically significant

²⁵⁸ Supplementary material provided to the Committee by the Victorian Curriculum & Assessment Authority, October 2005.

²⁵⁹ Written Submission, Mr P. Cox, La Trobe University, August 2005, p.3.

²⁶⁰ *ibid.*

in any particular State or Territory or overall, the tendency for males to perform better than females was consistent in all cases'.²⁶¹

Recent international benchmarking studies have also revealed few statistically significant gender differences in mathematics and science achievement among Australian students. In PISA 2003, there was no evidence of a gender gap in Australia for mathematical or scientific literacy or problem solving.²⁶² While there were almost twice as many Australian males as females achieving the highest PISA proficiency level in mathematical literacy, there were no significant differences in the mean scores for mathematical literacy.²⁶³ The Australian results are a stark contrast to findings for many other countries. Mathematics and scientific literacy is reportedly significantly higher for males than for females in a large number of participating countries and overall for the OECD.²⁶⁴

TIMSS also found significant gender differences in mathematics and science in many countries. In the case of TIMSS, however, these differences tended to be more evenly split between advantage for males and advantage for females. TIMSS found no significant gender differences in overall mathematics achievement at either Year 4 or Year 8 in Australia. In Year 8 science, however, Australia was one of many countries showing a significant gender difference in favour of males, with Australian males significantly outperforming Australian females in chemistry, physics, earth science and environmental science.²⁶⁵

The Australian Catholic University noted that although achievement in mathematics at the early and middle years on large-scale assessment measures shows no differences between genders, there are differences arising as early as Year 2 in the approaches and strategies students adopt in mathematics.²⁶⁶ The University suggested that girls tend to cling longer to less sophisticated learning approaches. The University further suggested that while the issues of gender are important to the teaching and learning of mathematics and science education, the complexities of cultural and language issues must also

²⁶¹ Ministerial Council on Education, Employment, Training & Youth Affairs 2004, *National Year 6 Science Assessment Report*, MCEETYA, Melbourne, p.25.

²⁶² Australian Council for Educational Research 2004, *PISA in Brief from Australia's Perspective*, ACER, Melbourne, p.10, reported that gender differences were found in the mathematical subscales of space and shape, and uncertainty, in which males scored higher than females, but not in quantity or change and relationships.

²⁶³ Australian Council for Educational Research 2004, *PISA in Brief from Australia's Perspective*, ACER, Melbourne, p.10.

²⁶⁴ *ibid.*

²⁶⁵ S. Thomson & N. Fleming 2004, *Highlights from TIMSS from Australia's Perspective: Highlights from the full Australian reports from the Trends in International Mathematics and Science Study 2002/03*, ACER, Melbourne, pp.6–7 & p.15.

²⁶⁶ Written Submission, Faculty of Education, Australian Catholic University, January 2005, p.3.

be considered.²⁶⁷ It stated that ‘in the interests of social justice, professional development is needed which specifically considers the impact of language, culture and gender on learning in mathematics and science’.²⁶⁸

Gender Differences in Attitudes to Mathematics and Science

Both PISA and TIMSS were able to link attitudinal factors with achievement in mathematics and science. These studies also revealed significant gender differences in attitudes toward mathematics and science education.

In PISA 2003, Australian females reported significantly more positive attitudes towards school, more positive student–teacher relationships and a greater sense of belonging to their school than did male Australian students.²⁶⁹ It is pleasing to note that overall, attitudes towards school, student–teacher relationships and teacher support are higher in Australia than the OECD average.²⁷⁰ However, of interest to this inquiry, Australia’s male students reported higher levels of interest and enjoyment in mathematics than females.²⁷¹ Furthermore, while Australian students scored higher on the instrumental motivation index than the OECD average, indicating stronger beliefs in the value of learning mathematics for external reasons such as getting a job in the future, Australian males had a much stronger sense of instrumental motivation than Australian females.²⁷²

Among the attitudinal and belief factors examined in PISA 2003, mathematics self-efficacy had the strongest association with mathematical literacy among Australian students. The average for Australian students was slightly higher than the OECD average, and the scores for males were significantly higher than the scores for females.²⁷³ Similarly, Australian students had a higher sense of self-concept in mathematics than the OECD average, and Australian males had significantly stronger self-concept than females. Mathematics self-concept had a moderately strong relationship with mathematics performance in Australia.²⁷⁴

According to TIMSS, Australian students had relatively high self-confidence in learning both mathematics and science. Consistent with the PISA study, males had higher self-confidence in learning mathematics than females at both Year 4 and Year 8 and higher self-

²⁶⁷ *ibid.*

²⁶⁸ *ibid.*

²⁶⁹ Australian Council for Educational Research 2004, *PISA in Brief from Australia’s Perspective*, ACER, Melbourne, p.12.

²⁷⁰ *ibid.*

²⁷¹ *ibid.*

²⁷² *ibid.*

²⁷³ *ibid.*

²⁷⁴ *ibid.*

confidence in learning science at Year 8.²⁷⁵ Males at both year levels also reported a higher degree of enjoyment of learning mathematics than females. In science there was no difference in enjoyment levels between the genders at Year 4, but at Year 8, males appeared to enjoy learning science more than females.²⁷⁶

The Bendigo Senior Secondary College study also examined students' beliefs and attitudes towards various subjects. The study found that the start of secondary school (Year 7) was rated as the year in which the greatest percentage of students first lost interest in science, with a similar trend occurring for mathematics.²⁷⁷ Furthermore, it was reported that a greater percentage of boys than of girls rated that they first lost interest in English in Year 7 and throughout secondary school, while a greater percentage of girls than of boys rated that they first lost interest in chemistry, physics and mathematics in Year 7 and throughout secondary school.²⁷⁸

It is important to recognise that gender differences in attitudes towards other factors in the education environment may also result in differences in participation and achievement in mathematics and science. Research about gender issues in the teaching and learning of mathematics has been on-going in Australia and the subject of a series of four-yearly reviews published by the Mathematics Education Research Group of Australasia over a 20 year period. In the most recent review, Vale et al concluded:

Gender differences in achievement and attitudes towards mathematics that have favoured males in the past now appear to be small or non-existent, and in some cases to favour girls. However these differences are not consistent across countries in Australasia, socioeconomic groups, level of education, assessment instruments, and mathematics content and skills being assessed or meanings given to the attitudes measured. It appears that whether boys or girls benefit most in classrooms depends on the mathematical discourse, the teaching methods, the use of technology, and the attitudes of teachers. Evidence was presented to show how these factors influence learning environments and gender identities, and how they disadvantage particular girls and boys.²⁷⁹

²⁷⁵ S. Thomson & N. Fleming 2004 *Highlights from TIMSS from Australia's Perspective: Highlights from the full Australian reports from the Trends in International Mathematics and Science Study 2002/03*, ACER, Melbourne, pp.14–15.

²⁷⁶ *ibid.*

²⁷⁷ Written Submission, Mr P. Cox, La Trobe University, August 2005, p.4.

²⁷⁸ *ibid.*

²⁷⁹ C. Vale, H. Forgasz & M. Horne, 'Gender and mathematics: Back to the future?', in B. Perry, G. Anthony and C. Diezmann (n.d.), *Research in Mathematics Education in Australasia 2000–2003*, MERGA, Flaxton, Queensland, p.94, cited in Written Submission, School of Education, Victoria University, December 2004, pp.5–6.

Victoria University noted that the above review ‘highlighted the complexities concerning gender and mathematics’ and ‘identified some particular issues that need to be the focus of teacher pre-service and in-service programs and further research’.²⁸⁰ The use of technology within mathematics was one such issue:

[the] results of studies in which gender issues associated with technology use for mathematics learning appear to contradict other trends. In these learning contexts gender differences in attitudes towards mathematics may be widening in favour of males rather than closing, teachers’ gender-stereotyped views of students’ ‘ability’ were evident, gender differences in spatial reasoning may be re-emerging, and girls may be rejecting the use of technology.²⁸¹

The studies referred to above included classroom studies of teachers’ practice, surveys of students’ attitudes and comparison of performance in Year 12 mathematics examinations.²⁸²

While the above studies focused specifically on mathematics education, the Committee notes that similar findings may be relevant to science education. The Committee therefore believes that educationalists must continue to monitor participation and performance differences among males and females in the context of changing education environments. They must also ensure that relevant findings of current and future gender research are incorporated into curriculum and assessment policies and processes.

The Influence of Geographical Differences in Mathematics and Science Education

The Committee’s evidence reveals there are some significant differences in levels of participation, and to a lesser extent, achievement, in mathematics and science education among students in different geographic locations. The following sections outline some of these differences and identify some of the innovative initiatives being implemented in other jurisdictions to address geographic inequities.

²⁸⁰ Written Submission, School of Education, Victoria University, December 2004, p.6.

²⁸¹ C. Vale, H. Forgasz & M. Horne, ‘Gender and mathematics: Back to the future?’ In B. Perry, G. Anthony & C. Diezmann (n.d.), *Research in Mathematics Education in Australasia 2000–2003*, MERGA, Flaxton, Queensland p.94, cited in Written Submission, School of Education, Victoria University, December 2004, p.6.

²⁸² Written Submission, School of Education, Victoria University, December 2004, p.6.

Differences in Participation and Achievement by Geographic Location

The Committee found that students in metropolitan areas have a greater tendency to undertake the more advanced mathematics and enabling science subjects than students in non-metropolitan areas (refer Chapter 4). *Australia's Teachers: Australia's Future* reported that for the three core science subjects, differences in participation rates between city and rural schools were small, with a slightly higher participation rate in chemistry and physics among city schools and a slightly higher participation rate in biology among rural schools.²⁸³

National and international benchmarking studies have reached varying conclusions about differences in the level of mathematical and scientific literacy attained by students in different geographic locations. PISA 2003 found that Australian students in metropolitan areas performed at a significantly higher level of mathematical and scientific literacy than students in a regional city, who in turn, performed at a significantly higher level than students in rural areas.²⁸⁴ TIMSS found that Year 8 students in remote schools scored at a significantly lower level in mathematics than Year 8 students in metropolitan and regional schools.²⁸⁵ It similarly found that science achievement among Year 8 students in remote schools was significantly lower than that of Year 8 students in metropolitan schools.²⁸⁶

National numeracy benchmark results show no significant differences in achievement among Victorian students by location at either Year 3 or Year 5 levels.²⁸⁷ In comparison, benchmark results for Australian students overall show significantly higher achievement for regional students compared with rural students. At Year 7, however, Victorian results mirrored those for Australia overall, with Victorian students in provincial areas achieving the benchmarks at a rate that was significantly lower than Victorian students in metropolitan areas.²⁸⁸ The 2003 *National Year 6 Science Assessment Report* found that there were no significant differences in mean scores by students in different

²⁸³ Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Background Data and Analysis*, Commonwealth of Australia, Canberra, p.11.

²⁸⁴ Australian Council for Educational Research 2004, *PISA in Brief from Australia's Perspective*, ACER, Melbourne, p.10.

²⁸⁵ S. Thomson & N. Fleming 2004, *Summing it up: Mathematics achievement in Australian schools in TIMSS 2002 (TIMSS Australia Monograph no. 6)*, ACER, Melbourne, p.vii.

²⁸⁶ S. Thomson & N. Fleming 2004, *Examining the Evidence: Science achievement in Australian Schools in TIMSS 2002 (TIMSS Australia Monograph no. 7)*, ACER, Melbourne, p.vi.

²⁸⁷ Ministerial Council on Education, Employment, Training & Youth Affairs 2003, *National Report on Schooling in Australia Preliminary Report, National Benchmark Results Reading, Writing and Numeracy Years 3, 5 and 7*, MCEETYA, Melbourne, p.9 & p.19.

²⁸⁸ *ibid.*, p.29.

geographic locations.²⁸⁹ It also found, however, that schools in major urban areas had the highest percentages of students in the top levels of proficiency in science.²⁹⁰

Victorian Curriculum and Assessment Authority data shows there are no significant differences in the rate of successful completion of VCE mathematics and science subjects by location. Overall, successful completion rates for the metropolitan and non-metropolitan areas were very similar over the period 2000 to 2004.²⁹¹ Within the metropolitan area, the Eastern Metropolitan and Southern Metropolitan Regions had a tendency to achieve slightly higher successful completion rates in most VCE Unit 4 mathematics and science studies, compared with the average for metropolitan regions overall. Conversely, Northern Metropolitan and Western Metropolitan Regions had successful completion rates slightly lower than the metropolitan average. Amongst non-metropolitan regions, successful completion rates were more mixed, with no region standing out as achieving successful completion rates that were either consistently below or consistently above the average for non-metropolitan communities.²⁹²

The Committee's analysis of participation in a variety of mathematics and science education and awareness programs shows similar regional differences (refer Figures 6.6, 6.7 and 6.8).

Not surprisingly, all metropolitan regions were over-represented and all non-metropolitan regions were under-represented among schools undertaking an excursion to a metropolitan-based science facility (Scienceworks, CSIRO Melbourne Science Education Centre or the Gene Technology Access Centre – refer Figure 6.6).

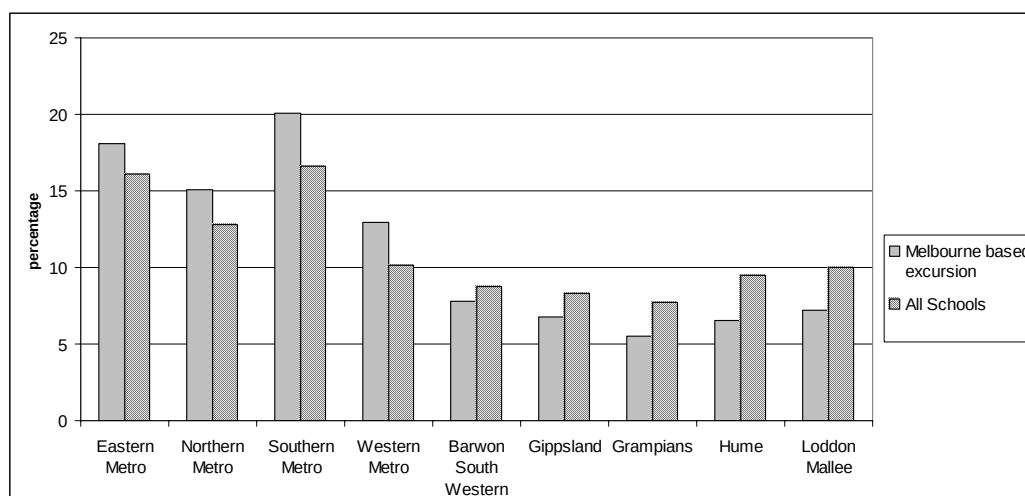
²⁸⁹ Ministerial Council on Education, Employment, Training & Youth Affairs 2004, *National Year 6 Science Assessment Report*, MCEETYA, Melbourne, p.46.

²⁹⁰ *ibid.*, p.47.

²⁹¹ Supplementary material provided to the Committee by the Victorian Curriculum & Assessment Authority, October 2005.

²⁹² *ibid.*

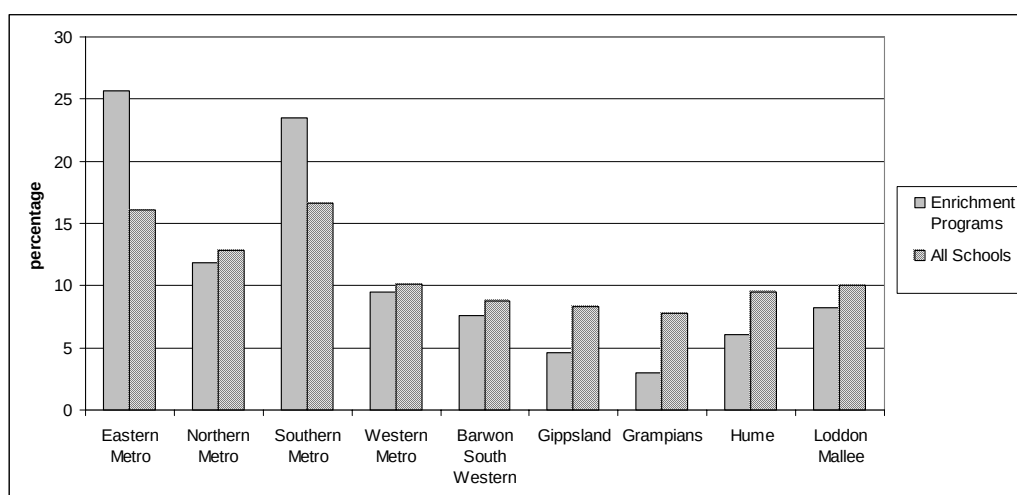
Figure 6.6: Profile of Schools Visiting Melbourne-based Science Facilities by Region (%) (2003 to 2005)^a



Note: ^a Includes excursions to Scienceworks (2003 & 2004), CSIRO Melbourne Science Education Centre (2003 & 2004) and GTAC (2004 & 2005).
 'All schools' refers to the regional distribution of all schools in Victoria.
 Source: Education and Training Committee analysis.

As shown in Figure 6.7, Eastern Metropolitan Region and Southern Metropolitan Region were substantially over-represented in mathematics and science enrichment programs. All other regions were under-represented, with some of the non-metropolitan regions substantially under-represented.

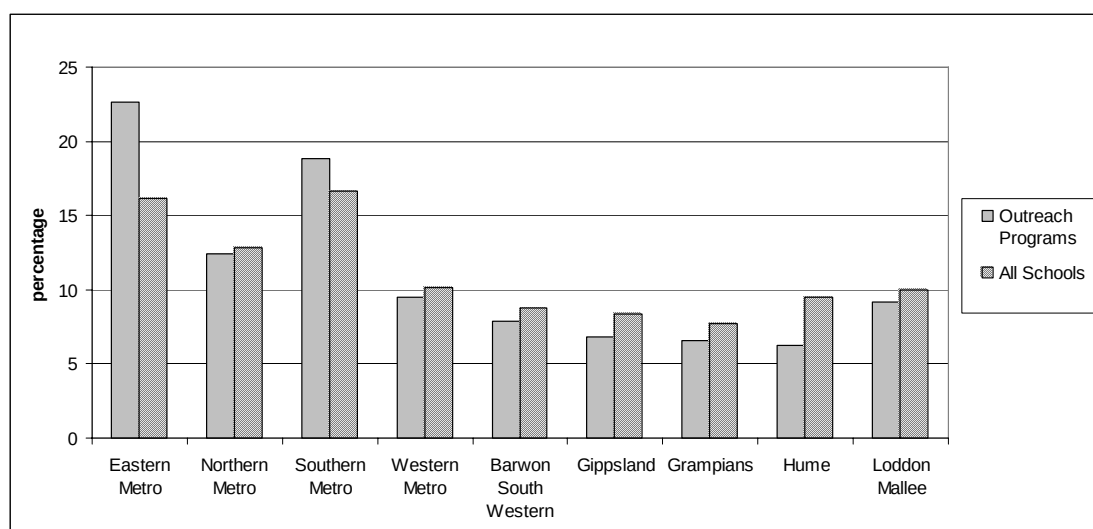
Figure 6.7: Profile of Schools Participating in Mathematics or Science Enrichment Programs by Region (%) (2003 to 2005)^a



Note: ^a Includes Science Talent Search (2004 or 2005), Maths Talent Quest (2003 to 2005), Australian Mathematics Trust Challenge (2003 to 2005), CSIRO Student Research Scheme (2003 or 2004) and Siemens Science Experience (2003 to 2005).
 'All Schools' refers to the regional distribution of all schools in Victoria.
 Source: Education and Training Committee analysis.

Participation in outreach programs showed similar trends, with Eastern Metropolitan Region and Southern Metropolitan Region both being over-represented and remaining metropolitan and non-metropolitan regions being under-represented (refer Figure 6.8). Non-metropolitan regions were, however, generally better represented among outreach programs compared with enrichment programs. This is largely accounted for by the inclusion of two Questacon programs (Smart Moves and Science Circus) that are only delivered in the non-metropolitan regions.

Figure 6.8: Profile of Schools Participating in Mathematics or Science Outreach Programs by Region (%) (2003 to 2005)^a



Note: ^a Outreach programs include CSIRO Lab on Legs (2003 & 2004), Questacon Science Circus (2004 & 2005), Questacon Smart Moves (2003 & 2005), In2Science Peer Mentoring Program (2004 & 2005), RMIT Peer Mentoring (2004 & 2005), Monash Peer Mentoring Program (2004 & 2005), Monash Science Centre outreach programs (2005) and Minerals Education student presentations (2003 & 2005).

'All Schools' refers to the regional distribution of all schools in Victoria

Source: Education and Training Committee analysis of participation in mathematics and science education and awareness programs.

The regional profile of schools participating in the Victorian Government's Science in Schools initiative was far more representative of the overall profile of schools in Victoria. Unfortunately, there were far greater variances in the profile of schools funded under the Commonwealth Government Australian School Innovation in Science, Technology and Mathematics (ASISTM) program. Eastern Metropolitan Region was the most over-represented among metropolitan regions (accounting for 28.1% of Victorian schools participating in the ASISTM program, compared with only 16.1% of all Victorian schools). The Hume Region was the most over-represented non-metropolitan region (accounting for 15.2% of ASISTM schools and 10.6% of all Victorian schools).

A national reference group comprising representatives of science and technology centres and various outreach programs recently conducted a study of the delivery of science, mathematics, engineering and technology (SMET) education and awareness programs to regional, rural and remote Australia. The key findings of the study, as reported in *Reaching all Australians* included:²⁹³

- Visiting SMET programs increase student interest and skills levels in the learning areas of science, mathematics and technology. Program presenters bring much needed new approaches, content, techniques and resources into the classroom, benefiting students and teachers alike.
- School students, their teachers and their supporting communities in many regional, rural and remote areas are unable to access SMET programs.
- The number of available SMET outreach programs, the frequency of their visits and the range of experiences they provide are insufficient to meet the needs.
- Time, transport and accommodation costs increase significantly the further the programs have to travel. Many providers are unable to offset the higher costs of visiting more distant communities and limit their outreach itineraries to less-distant locations.
- Schools and communities in rural and remote areas, with their lower population base, are not in a position to afford the higher costs and therefore are not adequately serviced by most SMET programs.
- It is more cost and time efficient for schools if outreach programs visit schools rather than have students travel to the nearest city or regional centre to experience SMET programs.
- The greater the distance from the capital cities, the greater the 'educational divide' becomes.

While acknowledging that the National Reference Group may have had a vested interest in the study, the Committee endorses its vision for equitable access to science, mathematics, engineering and technology outreach programs for all rural, regional and remote students and

²⁹³ National Reference Group 2003, *Reaching all Australians: A report on delivering science, mathematics, engineering and technology education and awareness programs to regional, rural and remote Australia*, compiled by R. Garnett, National Reference Group, Canberra, pp.ix–x.

teachers.²⁹⁴ The Committee considers the following aims of the National Reference Group to be reasonable:

- Every primary student will have the opportunity to participate, at least once every two years, in a visiting program that stimulates awareness and understanding of science, mathematics, engineering or technology.
- Every junior secondary student will have the opportunity to participate, at least once every two years, in a visiting program that provides experiential activity in science, mathematics, engineering or technology.
- Every senior secondary student will have the opportunity to participate in at least one visiting program that stimulates awareness and understanding of continuing study options and careers in science, mathematics, engineering and technology.
- Every teacher will have the opportunity to participate, at least once every two years, in a visiting program that provides professional development in enhancing the engagement of their students in science, mathematics, engineering or technology education, with an appropriate emphasis on emerging and cutting-edge developments and career opportunities.²⁹⁵

The Committee believes that the Victorian Government should assess the level of success within Victoria currently being attained against the above aims. The Committee further believes that where these objectives are not yet being met, the Victorian Government should develop strategies to fill the gaps in delivery.

Initiatives Aimed at Addressing Geographic Inequities

The Committee recognises the additional barriers faced by rural and regional communities in accessing many mathematics and science education and awareness programs, particularly those involving student excursions to a science facility or centre of excellence. Barriers for rural and regional students relate to three interrelated issues: distance, cost and the small size of the student cohort in some rural and regional schools. In summary:

- Rural and regional communities often find it too expensive to undertake excursions due to the cost of participation together with the added costs of transport.

²⁹⁴ *ibid.*, p.x.
²⁹⁵ *ibid.*, p.x.

- Small cohort sizes can exacerbate the problem of cost, as any group discount may not apply and the costs of travel may have to be shared among a smaller group of students.
- The need to travel long distances affects the time available to participate in programs once at the destination, perhaps limiting the value of some excursions for more distant schools.
- Decisions to undertake overnight trips in response to the above factors can further reduce accessibility for individuals or whole student cohorts due to the added financial burden.
- Similarly, decisions to increase the size of the cohort by integrating excursions across year levels or by partnering with neighbouring schools can increase the administrative burden on schools, again reducing the accessibility of rural and regional students to Melbourne-based programs.

In April 2005, the Minister for Education Services, Jacinta Allan, announced funding of \$750,000 over three years for an updated version of the STAR 6 program.²⁹⁶ This program will allow all Victorian Year 6 students in rural and regional areas to receive free transport to and from Scienceworks Museum. Metropolitan students will be eligible for a travel subsidy of \$3 per student. The Committee welcomes this initiative and encourages the Victorian Government to consider whether any expansion of this program is warranted. Potential options for expansion include:

- widening the eligibility criteria to cover additional year levels;
- widening the eligibility criteria to cover excursions for students across year levels to other appropriate Melbourne-based centres of excellence such as the Gene Technology Access Centre, Victorian Space Science Centre and/or CSIRO Melbourne Science Education Centre;
- offering a subsidy to rural/remote students to access appropriate regional-based facilities; and/or
- offering assistance to metropolitan-based facilities to deliver outreach programs to schools in rural/remote areas.

²⁹⁶ J. Allan, Minister for Education Services, 'Rural Schools Get Scienceworks Ticket to Ride', *Media Release*, 5 April 2005.

Barriers for rural and regional students may appear to be limited to reduced accessibility of excursions, particularly to world leading science facilities located in Melbourne. It should be noted, however, that many of the other programs examined by the Committee also have some type of barrier to access for rural and regional students. For example, entries to the Science Talent Search must be sent to Melbourne for judging, all participating schools must supply at least one judge per 12 participating students (or part thereof) and winning students will be expected to attend an exhibition and presentation day in Melbourne. These factors can represent a significant burden for rural and regional schools, particularly smaller schools where workloads are shared among a small number of staff. In the case of outreach programs, many specify a minimum required number of student participants, again making it difficult for smaller schools to qualify for participation.

The Committee examined how various jurisdictions have sought to overcome geographic disadvantage in mathematics and science education. Notable programs include the United Kingdom's Lab in a Lorry initiative and a range of initiatives being implemented by the Queensland Government including Science on Saturday, BioBus and QUT Smart Train (these programs are outlined as case studies in Appendix P).

The above initiatives are mainly targeted at secondary school students in their middle or senior years, although Science on Saturday targets children from seven years of age. The programs all visit regional and rural areas, with some also visiting metropolitan-based locations. Importantly, most of the initiatives aim to be accessible for the broader community by operating weekend and/or evening activities. Some programs are based in schools, while others utilise community facilities, including railway stations, festivals and other venues. The typical purpose of the program is to engage young people, their parents and the broader community in science and scientific careers and to increase awareness in the community of the role and importance of science in everyday living. Topics covered by the various initiatives include electronics, physics, forensic science, sustainability, health, tissue engineering, genetics, biotechnology, and ethical issues. All initiatives include interactive displays, a student laboratory program and/or talks by scientists/physicists and most initiatives also offer teacher professional development.²⁹⁷

The Committee believes that the experience of some of the above programs in overcoming geographic disadvantage could be useful within the Victorian context.

²⁹⁷ Refer Appendix N for further details of these science education and awareness programs that target rural and regional communities.

Summary of Findings and Policy Implications

As stated in previous chapters, the Committee found that overall Victoria performs well against national and international trends in mathematics and science education. Analysis of differences by socioeconomic status, gender and geographic location has, however, revealed some significant differences in levels of participation and performance in mathematics and science among different groups of students. In summary:

- Students from higher socioeconomic backgrounds have significantly greater levels of participation and achievement in the highest level mathematics and science subjects, compared with students from lower socioeconomic backgrounds.
- A range of socioeconomic indicators reveal that students from lower socioeconomic backgrounds also have reduced access to a range of mathematics and science enrichment activities, including excursions, competitions, university-to-school mentoring and outreach programs.
- There are significant gender differences in mathematics and science enrolments, and in attitudes towards mathematics and science education. Further, there may be emerging gender differences in student responses to various factors in the educational environment, including the rising use of technology in the classroom.
- Students in rural and regional Victoria have lower levels of participation in studies in the enabling sciences. However, evidence regarding differences in achievement levels among rural and regional students compared with their metropolitan counterparts is inconsistent.

Students in rural and regional Victoria face a range of barriers in accessing the full range of mathematics and science education and awareness programs readily available within most metropolitan regions. While there is a growing bank of data on comparative performance in mathematics and science at the national and international level, it remains very difficult to explain exactly why differences in performance occur and how these differences can be addressed effectively. This is due to a variety of factors including the vast differences in the educational contexts within which varying levels of performance occur; the huge number of variables that contribute to mathematics and science achievement (eg. student backgrounds; cultural context and influences; teacher training, skills and experience; school resources); and the continuing lack of longitudinal data. Nonetheless, international trends and benchmarking studies, together

with analysis of evidence to this inquiry, offer a number of policy implications.

The Committee's findings suggest that in seeking to reduce the gap between our higher and lower achieving students, policy makers and educationalists need to target the inequities among schools and specific groups of students. The Committee's analysis reveals that students of lower socioeconomic status and students in rural and regional Victoria could benefit from additional resources in their mathematics and science studies. Recent national and international benchmarking studies have further suggested that Indigenous students and students from some language backgrounds other than English could also warrant additional attention. The Committee believes that expansion and better targeting of existing university-to-school mentoring programs could be useful in addressing some of the needs of these groups of students.

Gender differences in participation in mathematics and science education suggest that an understanding of where boys and girls differ in their interests and attitudes needs to be allowed for in the delivery of these subjects. This requires an examination of the contexts used to teach and promote mathematics and science subjects so that a more equal uptake of subjects by boys and girls will occur.²⁹⁸ This Committee supports PISA's finding that approaches to reducing gender differences need to start at an early age in order to increase the engagement of female students in mathematics (and science) and to build their confidence in their abilities in these subjects. Research on the gender related views of mathematics and science education among teachers and parents would perhaps be timely.

As suggested throughout this inquiry, there is also scope to enhance the use of male role models in biological and health science and female role models in the physical sciences. Effective use of role models should be a priority within schools and within the broader community, with the aim to raise awareness among parents and the general public of the important role that either gender can play within the sciences. The Committee notes that the media could play a role here. The Committee also believes that improved teacher workforce planning that seeks to address gender imbalances in the teacher cohort in mathematics and science (for example, increasing the number of females teaching physical science and males teaching biological sciences and psychology) could be beneficial.

This inquiry found that socioeconomic status was a more important concern than gender in mathematics and science education. The Committee found that the percentage of enrolments in the high status subjects of chemistry, physics, mathematical methods and specialist mathematics increases with increasing socioeconomic level, with this

²⁹⁸ Written Submission, Faculty of Education, La Trobe University, January 2005, p.5.

effect more marked for girls than for the boys. Furthermore, students from higher socioeconomic backgrounds have a long-term history of outperforming other students in mathematics and science.

The Committee believes that improved communication of subject and career choices would be of great benefit in addressing such inequalities in the short term. This should include a targeted approach to communicating the implications of subject choices to students, teachers and parents within lower socioeconomic communities.

The Committee also believes consideration should be given to the development and funding of mathematics and science education and awareness programs that specifically target current socioeconomic inequities. In developing such programs, special consideration should be given to rural and regional students who also face unique barriers to full participation in mathematics and science education.

Recommendation 6.1: That the Victorian Government develop strategies aimed at improving the participation and performance of students from lower socioeconomic backgrounds in the enabling sciences (physics, chemistry and advanced mathematics) to that of the overall student cohort.

Recommendation 6.2: That the Victorian Government work with university-to-school mentoring programs to ensure they are better targeted towards achieving improvements in mathematics and science attainment levels, especially within schools:

- that are located in areas of relative socioeconomic disadvantage;
- that perform lower in national and/or international benchmarking studies;
- that have lower levels of educational attainment; and/or
- that have student groups that traditionally have lower levels of educational attainment, including students in rural communities, Indigenous students and students from some language backgrounds other than English.

Recommendation 6.3: That the Victorian Government review the specific needs of rural and regional students in gaining equitable access to a range of mathematics and science education, awareness and enrichment programs and devise strategies to overcome geographic disadvantage in mathematics and science education.

Recommendations continued over...

Recommendation 6.4: That the Victorian Government develop additional strategies to ensure that the mathematics and science curriculum and its implementation are gender inclusive. Particular areas of focus should include the use of gender inclusive content, language and role models within the curriculum and integration of learning technologies that respond to gender needs.

Recommendation 6.5: That the Victorian Government trial an e-mentoring program involving the industry, business and research sectors to complement existing mentoring programs.

7. Engaging Students in Mathematics and Science

Introduction

Student engagement is an essential element to the teaching and learning process. Teaching methodology has moved well beyond the once predominant approach of the transfer model or 'chalk and talk'. Students are no longer passively involved in their education, to learn effectively, they must now be engaged in the learning process and with the subject matter they are learning.

Student engagement was perhaps the strongest theme to arise from the evidence received by this Committee. Certainly, the need to increase levels of student engagement, along with improving teacher quality, was identified as a key factor that will support high quality teaching and learning of mathematics and science into the future.

The Committee heard that students are most likely to be engaged in learning mathematics and science if they enjoy their studies, see the relevance of these subjects to their own lives and are confident in their abilities. The concept of student engagement was well articulated by the Catholic Education Commission of Victoria:

Teaching practices and curriculum that are exciting, engaging, make links to relevant real life situations (for students), cater to different learning styles, inquiry based, promote discussion including that on ethical and controversial issues, are multidisciplinary and include sufficient practical work. The classroom environment values enjoyable learning which teachers and learners see as fun. Such practices and curriculum promote scientific literacy in all learners as well as promoting the passion of a science career for some.²⁹⁹

The Committee heard that many factors contribute to positive student attitudes towards mathematics and science. These factors include:

- the learning environment, including characteristics of the classroom and teaching style;
- focus of learning;

²⁹⁹ Written Submission, Catholic Education Commission of Victoria, December 2004, p.7.

- being able to relate mathematics and science to their current and future lives;
- depth of teacher knowledge and passion; and
- parents valuing success in mathematics and science and encouraging and supporting students in their studies.

The following chapter examines some of these issues in greater depth. Issues associated with teacher quality are covered in Chapter 9.

The Learning Environment

Many submissions and witnesses emphasised that the learning environment is central to student engagement. In doing so, they identified a variety of components of the learning environment, including teaching strategies, interpersonal relationships between student and teacher, student dynamics, classroom layout, availability of ICT and the quantity and quality of equipment.

Key stakeholders consistently emphasised that mathematics and science learning environments must promote an inquiry-based culture. The Victorian Government described this as a culture where:

... curiosity, creativity and questioning are valued, where resources and opportunities are made readily available, and where students can work like scientists and mathematicians engaged in the process of collective problem solving.³⁰⁰

Findings from the Science in Schools Research Project support a classroom model whereby student learning and engagement is maximised through promoting an inquiry-based culture.³⁰¹ The Victorian Government identified the following characteristics of a classroom that achieve effective learning through an inquiry-based culture:

- the learning environment encourages active engagement with ideas and evidence;
- students are challenged to develop meaningful understanding of content in the context of their current and future lives;
- science and mathematics is linked to students' lives and interests;

³⁰⁰ Written Submission, Victorian Government, June 2005, p.19.

³⁰¹ *ibid.*

- assessment of learning is an important component of a school's maths and science strategy and a range of assessment tasks is used to reflect different aspects of science and types of understanding;
- science is presented as a rich and varied enterprise with varied investigative traditions and constantly evolving understanding, that has important social, personal and technological dimensions;
- classroom learning is linked with learning experiences and issues in the local and broader community, including families, and frames the learning of science within a wider setting; and
- learning technologies are available and utilised successfully.³⁰²

The Committee notes that teaching and learning based on the above principles follows the international trend away from the transfer model of teaching, towards a greater emphasis on teaching for understanding and problem solving. As stated by the Victorian Government, the key outcome of high quality teaching and learning of mathematics and science is:

... the attainment of conceptual understanding of scientific and mathematical knowledge rather than mastery of scientific and mathematical content knowledge ...³⁰³

Despite general agreement among inquiry participants about the factors contributing to an engaging learning environment, the Committee observed that there is great variation in the quality of mathematics and science teaching across Victoria. Many students can access leading edge classrooms and equipment; highly passionate, knowledgeable and motivated teachers; and are involved in a range of mathematics and science education and awareness programs, excursions and enrichment activities. Other students, however, can access only a limited range of classroom resources in schools that provide inadequate emphasis on mathematics and science education. These students often have less opportunity to participate in the large variety of extracurricular programs and activities available.

Some of the specific issues and challenges associated with effective mathematics and science education for primary and secondary school students are outlined below.

³⁰² *ibid.*, pp.19–20.

³⁰³ *ibid.*, p.20.

Primary School Mathematics

As a foundation for all future learning, numeracy along with literacy is afforded special priority within the primary school curriculum. The *National Goals for Schooling* state that students should have:

... attained the skills of numeracy and English literacy; such that, every student should be numerate, able to read, write, spell and communicate at an appropriate level.³⁰⁴

As such, education authorities have invested significantly in numeracy over recent years. Both the Victorian Government's Early Years Numeracy Program (EYNP) and the Catholic Education Commission of Victoria's Success in Early Numeracy Education (SINE) program were identified as best practice models for the effective teaching of numeracy.

The EYNP is based on the Early Numeracy Research Project which was run from 1999 to 2001. The Mathematical Association of Victoria noted that the EYNP, along with Count Me in Too (NSW), First Steps (WA) and SINE, are examples of programs at the primary level that have 'produced marked improvements in numeracy learning and improved teacher knowledge and confidence'.³⁰⁵ An evaluation of EYNP found that the most common improvements to teaching practices observed were:

- more open-ended tasks and activities;
- more probing questions/asking why and how/ valuing children's thinking;
- challenging and extending children/higher expectations;
- more practical/hands-on activities; and
- greater emphasis on reflection/sharing.³⁰⁶

The EYNP also sought to address teachers' personal confidence with mathematics; the perceptions of children, teachers and parents regarding mathematics; the lack of understanding of the 'big ideas' of mathematics in the early years; and the lack of comprehensive

³⁰⁴ Ministerial Council on Education, Employment, Training & Youth Affairs 1999, *National Goals for Schooling in the Twenty-First Century*, MCEETYA, Melbourne, obtained from website, <<http://www.mceetya.edu.au/nationalgoals/natgoals.htm#nat>>, accessed on 1 February 2006.

³⁰⁵ Written Submission, Mathematical Association of Victoria, December 2004, pp.1–2.

³⁰⁶ Department of Education & Training 2002, *Early Numeracy Research Project: Summary of the Final Report*, DE&T, Melbourne, p.16.

assessment instruments and processes for the early years.³⁰⁷ The EYNP has spread the aims and approaches of the Early Numeracy Research Project, system wide. Crucially, the EYNP has institutionalised a daily one hour numeracy block in primary schools, which is generally held in the mornings.³⁰⁸

SINE is the major approach to the teaching and learning of numeracy being implemented in Victorian Catholic schools. It has a whole-school approach designed to assist teachers to identify the mathematical understanding of the students they teach and develop activities to help students progress at their relevant level of understanding.³⁰⁹ While SINE has not been resourced to the same level as the EYNP, improvements are still evident.³¹⁰ An evaluation of the SINE program conducted by the Australian Catholic University, found that the program resulted in:

- an increased profile of mathematics in Catholic primary schools;
- an increase in teachers reporting confidence and knowledge with mathematics; and
- an increase in student enjoyment, interest and confidence in mathematics.³¹¹

The Committee heard few concerns regarding the current status or quality of mathematics in the primary school curriculum. The concerns that were raised were generally related to the depth of knowledge and understanding of the mathematics discipline among primary school teachers. The Committee consistently heard that applicants for primary school pre-service teacher education often lack a solid background in senior mathematics. However, it is also evident that issues associated with gaps in knowledge and understanding and lack of confidence in teaching mathematics are a high priority within teacher education. Nonetheless, some participants continued to suggest that a lack of in-depth knowledge and conceptual understanding prevents some primary teachers from being able to adequately diagnose learning difficulties and/or address common misconceptions. The professional development needs of primary teachers are further considered in Chapter 9.

³⁰⁷ *ibid.*, p.2.

³⁰⁸ Information on the Early Years Numeracy Program, numeracy block obtained from SOFweb website, <<http://www.sofweb.vic.edu.au/eys/num/numscp.htm>>, accessed on 29 January 2006.

³⁰⁹ Information on the Success in Early Numeracy Education program obtained from the Catholic Education Office Archdiocese of Melbourne website, <<http://web.ceo.melb.catholic.edu.au/index.php?sectionid=57>>, accessed on 3 February 2006.

³¹⁰ Written Submission, Catholic Education Commission of Victoria, December 2004, p.2.

³¹¹ *ibid.*

Secondary School Mathematics

In contrast to primary school mathematics, a large number of witnesses and submissions raised concerns about the level of student engagement in secondary school mathematics, particularly in Years 7–10. The Committee found that a range of factors contribute to student disengagement during the middle years. In summary, the Committee's evidence revealed:

- a lack of continuity between primary and secondary mathematics for some students, due to lack of knowledge among some secondary school teachers about what has been covered in the primary school curriculum;
- considerable variation in students' prior knowledge and experience in mathematics, meaning some students find the transition too difficult while others find it too easy and repetitive;
- a focus of learning that is on repetitive problems and memorisation of mathematical facts and formula;
- a lack of linkages between mathematics problems and a real world context; and
- more textbook work and less engaging teaching strategies than used in primary schools.

A 1999 TIMSS video study found that Australian Year 8 mathematics classrooms were characterised by:

- a relatively high level of repetitive mathematics problems;
- the absence of mathematical reasoning; and
- the use of mathematical questions that procedurally, were relatively less complex, and required less time to calculate than those seen in other participating countries.³¹²

The Committee recognises that the above study was conducted some years ago and that many new education strategies and programs have since been implemented. However, the Committee heard that some Victorian mathematics classrooms continue to focus predominantly on repetitive mathematics problems.³¹³ Therefore, many students continue

³¹² National Center for Education Statistics 2003, *Teaching Mathematics in Seven Countries: Results From the TIMSS 1999 Video Study*, U.S. Department of Education, Washington, pp.72–77.

³¹³ See for example, Written Submission, Faculty of Education, Deakin University, March 2005, p.3.

to be involved in simply practising procedures, rather than engaging in more complex problem solving that challenges students to make connections between mathematics concepts and to utilise mathematical reasoning.

The Committee heard that some secondary students disengage from learning mathematics due to a lack of confidence in their own abilities. A Year 12 student at Balwyn High School shared her perspective with the Committee:

... [my year 8 teacher] put my performance down to a lack of confidence. Mr Hopkins understood that I was not naturally gifted but I had determination and the will to succeed. He took the time to teach me the basic concepts and worked through my difficulties with me. This helped change my negative, scared attitude into a positive and disciplined one and as a result I began to perceive maths not as a hard, tortuous subject, but a challenging and rewarding one ... Unfortunately, many students progress through their junior years without having a similar experience.³¹⁴

Other students shared similar experiences when speaking with Committee members and staff during visits to schools and the Science Talent Search exhibition event.

The Committee also heard examples of students becoming disengaged in mathematics (and science) arising from gaps in students' knowledge and understanding. As discussed in Chapter 3, the Committee believes it is important that teachers use diagnostic and summative assessment strategically, to identify students at risk of disengagement due to gaps in their knowledge and understanding.

Of concern to the Committee was the frequency with which submissions and witnesses identified negative parental influences as a factor contributing to student disengagement. 'Maths anxiety', a tendency to fear and avoid mathematics often stemming from a lack of success in mathematics, was an issue repeatedly raised during the inquiry. As noted by inquiry participant Numeracy Australia, 'maths anxiety' can be passed down from generation to generation, not through heredity, but unintentionally through parental attitude. Comments from parents such as 'I was never any good at maths at school so it is no wonder you are not as well' are commonplace and will undoubtedly impact a child's expectations of their own potential in mathematics.³¹⁵

³¹⁴ Ms M. Barr, Year 12 Student, Balwyn High School, Transcript of Evidence, Public Hearing, Balwyn High School, 25 July 2005, p.15.

³¹⁵ Written Submission, Numeracy Australia, December 2004, p.7.

The Committee heard that some parents find it difficult to assist their children with mathematics homework:

One of the difficulties – and I think it is something we need to address – is the parents who say: 'I cannot do maths and I cannot help my child'.³¹⁶

Conversely, the Committee heard that parents can have a significant positive influence on students' performance in mathematics. Students participating in this inquiry recognised the role of parents in their mathematics education:

I think parents are a very important part of learning. Not only do they help lead you in the right direction, but they help you with work and with understanding.³¹⁷

President of the Mathematics Education Research Group of Australasia, Professor Phil Clarkson, was supportive of 'community programs that bring parents into the equation' of mathematics education.³¹⁸ International research confirms the importance of this approach. According to the OECD:

An important objective for public policy may therefore be to support parents, particularly those whose own educational attainment is limited, in order to facilitate their interactions both with their children and with their children's schools in ways that enhance their children's learning.³¹⁹

Students are not the only beneficiaries of increased parental involvement in mathematics and science education. Greater parental involvement may also serve to raise mathematical and scientific literacy in the wider school community or at least emphasise that both fields are a high priority to the school, the education system and society beyond. This point is well recognised in many mathematics and science awareness initiatives operating in Australia and internationally.

³¹⁶ Mr C. Nielsen, Mathematics Co-ordinator, Kangaroo Flat Secondary College, Transcript of Evidence, Public Hearing, Bendigo, 1 August 2005, p.36.

³¹⁷ Mr A. Argyropoulos, Year 11 Student, Montmorency Secondary College, Transcript of Evidence, Public Hearing, Montmorency Secondary College, 1 September 2005, p.9.

³¹⁸ Transcript of Evidence, Public Hearing, Melbourne, 20 June 2005, p.14.

³¹⁹ Organisation for Economic Co-operation & Development 2004, *Learning for Tomorrow's World: First Results from PISA 2003*, OECD, Paris, p.162.

Primary School Science

Evidence received by the Committee regarding primary school science was consistent with findings from recent studies:

Where science is currently taught in primary schools, it is taught well and students enjoy the experience. However, in many Australian primary schools little or no science is taught and many primary teachers do not feel confident about their ability to teach it.³²⁰

The Committee believes that the lack of time and status afforded science within many primary schools is not conducive to broad engagement in scientific issues and the development of high levels of scientific literacy. As stated by the Prime Minister's Science, Engineering and Innovation Council (PMSEIC) Working Group on Science Engagement and Education:

To achieve a science-literate society, a strong foundation in primary school is essential. Australia needs primary teachers who are confident about teaching science, and have the time and resources to do so effectively.

Every Australian primary school classroom needs science, in its own right, to be taught using an investigative, hands-on approach which ensures students entering secondary school have an appreciation of scientific thinking.³²¹

The Committee notes the potential of a program such as Primary Connections to improve the status and quality of primary school science. Primary Connections is an innovative national initiative of the Australian Academy of Science, which links the teaching of science with the teaching of literacy in Australian primary schools. It is designed to help students question, investigate, gather and analyse information and make evidence-based decisions about themselves and their world.³²² As noted by the PMSEIC Working Group on Science Engagement and Education, linking science with literacy provides benefits to both learning areas:

³²⁰ D. Goodrum, M. Hackling & L. Rennie 2001, *The Status and Quality of Teaching and Learning of Science in Australian Schools*, report prepared for the Department of Education, Training & Youth Affairs, Commonwealth of Australia, Canberra, cited in Prime Minister's Science, Engineering & Innovation Council 2003, *Science Engagement and Education: Equipping young Australians to lead us to the future*, DEST, Canberra, p.12.

³²¹ Prime Minister's Science, Engineering & Innovation Council 2003, *Science Engagement and Education: Equipping young Australians to lead us to the future*, DEST, Canberra, p.12.

³²² For further information, refer to the Primary Connections website, <<http://www.science.org.au/primaryconnections>>.

Primary teachers are confident and competent at teaching literacy. Using literacy as a vehicle to teach science is an approach likely to appeal to teachers who lack confidence in science. It will also provide an enhanced perspective for experienced and confident teachers of science.

Doing science activities provides a stimulating context for literacy. Many aspects of quality science programs involve the learning goals of literacy programs. For example, a student studying the topic of flight would begin with related readings, followed by comprehending instructions that lead to an experiment on how planes fly. Students would then present oral and written reports describing their activities. Lessons presented this way are enjoyable and achieve both literacy and science-literacy goals.³²³

The PMSEIC Working Group further noted the potential for a program linking science with literacy to respond to the varying needs of different students:

It is likely that some boys may find literacy more engaging if it is presented in a science context linked to hands-on activities. It is also likely that some girls may find the physical sciences more engaging if they are introduced through a literacy context.³²⁴

Primary Connections was trialled by 106 teachers in 56 schools across Australia in 2005, including 17 Victorian schools. The trial received \$1.8 million funding through the Australian Government Quality Teacher Program. An evaluation of the trial reported that:

Research evidence from the trial of Primary Connections demonstrates that this program has had a large and positive impact on teachers' practice, students' learning and the status of science in schools and has the potential to have a significant impact on improving the teaching and learning of primary science throughout Australia.³²⁵

The evaluation reported that student survey data showed 'that a large majority of students enjoyed science and believed that they had learned more science using Primary Connections than previously'.³²⁶ More than 90 per cent of teachers indicated that Primary Connections

³²³ Prime Minister's Science, Engineering & Innovation Council 2003, *Science Engagement and Education: Equipping young Australians to lead us to the future*, DEST, Canberra, pp.12–13.

³²⁴ *ibid.*, p.13.

³²⁵ M. Hackling & V. Prain 2005, *Primary Connections Stage 2 Trial: Research Report. Executive Summary*, Australian Academy of Science, Canberra, p.1.

³²⁶ *ibid.*, p.3.

had a significant impact on their schools, 'increasing students' and teachers' interest in science, the profile of science within the school and local community, and increasing the amount of science being taught'.³²⁷

The Committee believes that Primary Connections represents a significant opportunity to achieve improvement in science teaching in primary schools throughout Victoria (and Australia). The program responds to many of the issues raised in the national review of the status and quality of science teaching in Australian schools, as well as the national review of teaching and teacher education. The Committee is pleased to note that Victoria has been heavily involved in the development and trial of this innovative program. Primary Connections is consistent with the philosophy and directions of the Victorian Government's Schools Innovation in Science (and SIT) initiative and the Principles of Learning and Teaching (PoLT). Participation in Primary Connections by Victorian schools has therefore been supported by the strong foundations developed through these programs, as well as the increasing interest and enthusiasm for science education among many Victorian teachers involved in these Victorian Government initiatives.

The Committee welcomes the continued commitment of the Commonwealth Government to Primary Connections, through to 2008. However, the Committee believes that this program should be complemented by a similar nationwide initiative for the junior secondary years. This will ensure that the benefits of Primary Connections in generating interest and enthusiasm for the study of science among a broad range of students can continue during the difficult middle years of schooling. Therefore, the Committee recommends that the Victorian Government pursue through the Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA), the development of a nationwide curriculum and teacher professional development initiative for secondary schools (see recommendation 7.1).

The Committee identified a wide range of other science education and awareness programs that could assist primary school teachers and students to become more engaged in science. Some of those identified as suitable for primary school students include:

- BHP Billiton Science Awards;
- CREativity in Science and Technology (CREST);
- CSIRO Double Helix Science Club;
- CSIRO Science Challenge;

³²⁷ *ibid.*, p.4.

- EngQuest;
- Science Program Exciting Children Through Research Activities (SPECTRA); and
- Science Talent Search.

A description of the above programs is contained at Appendix N.

Excursions also represent important opportunities for students to participate in engaging science activities in world-class centres such as Scienceworks Museum, Monash Science Centre and CSIRO Melbourne Science Education Centre. Further opportunities are made available through outreach programs (incursions) such as the Shell Questacon Science Circus and CSIRO Lab on Legs and other programs operated by a broad range of private companies.

The above represent just a sample of the science enrichment programs and activities available to Victorian students and teachers. Unfortunately, however, it seems that many students never have the opportunity to experience science through these innovative, engagement activities. As described in Chapter 6, students in rural and regional Victoria and those in areas experiencing socioeconomic disadvantage are less likely to experience these activities than other students.

The Committee also observed that many primary school teachers are unaware of the full range of science education and awareness programs available and/or are uncertain about how to participate. The Committee itself found it a relatively time-consuming and difficult task to identify these opportunities and their potential for integration into the primary school curriculum. The Committee sees that without a centralised online resource this task is all the more difficult for the new or inexperienced teacher.

The Committee heard evidence that Family Science programs (aimed at both primary and secondary schools) have been successful in the past in engaging school communities in exciting science activities. In 2000, 550 schools were funded under the Department of Education and Training's Family Science Program. Family Science programs were aimed at:

- helping parents to be actively involved in the science learning of their child;
- encouraging children and parents to work together;
- assisting in understanding the everyday role science plays in people's lives;
- engaging parents and students in thinking and working scientifically;

- assisting parents to encourage their child's interest in science in the home; and
- promoting a wider understanding of science in the community.³²⁸

The CSIRO Melbourne Science Education Centre and the Monash Science Centre currently run Family Science programs (refer to Appendix N). The Department of Education and Training website (www.sofweb.vic.edu.au) also represents a useful resource featuring many case studies and activities associated with the Department's Family Science program, although the site has not been updated in recent years. The Committee believes that as a low-cost strategy within a renewed science education policy, the Family Science program could be resurrected, with the current website being updated with new activities and more recent case studies and promoted within all Victorian primary schools.

Secondary School Science

Evidence before the Committee indicates that there are considerable challenges involved in maintaining student interest and enjoyment in science as students undertake the transition from primary into secondary school. The Committee heard that most students seem to enjoy science during their primary studies and enter secondary school excited about the prospect of undertaking more advanced experiments within school laboratories. However, it seems that the reality of secondary school science does not match many students' high expectations. The Committee's evidence appears consistent with TIMSS 2003 data, which revealed a marked decline in the levels of student enjoyment of science between Year 4 and Year 8. While 64 per cent of Australian Year 4 students strongly agreed that they 'enjoy science' (compared to an international average of 55%), only 29 per cent of Year 8 students strongly agreed that they 'enjoy science' (compared to the international average of 44%).³²⁹

The Committee acknowledges that some of this disengagement may be associated with general disengagement during the middle years. The Committee notes that student engagement in the middle years is being addressed through an increasing number of government initiatives and believes that as part of these initiatives, specific issues associated with disengagement from science should be considered.

³²⁸ Information on the Family Science program obtained from SOFWeb website, <<http://www.sofweb.vic.edu.au/science/famsci/aboutfs/index.htm>>, accessed on 3 February 2006.

³²⁹ M.O. Martin, I.V.S. Mullis, E.J. Gonzalez & S.J. Chrostowski 2004, *TIMSS 2003 International Science Report – Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades*, TIMSS & PIRLS International Study Centre, Boston, pp.170–173.

A number of themes associated with student engagement in secondary school science were raised in evidence to the Committee. Some of these parallel the issues seen in secondary mathematics, including:

- the need for teachers to be passionate and deeply knowledgeable about their subject area;
- the need for curriculum approaches that focus on open-ended scientific investigation, higher order thinking skills and relevance to students' lives;
- the need for greater awareness among students and parents about opportunities to pursue science-related education, training and career pathways; and
- student confidence in their abilities.

As noted in the previous section, the Committee believes that the extension of a program such as Primary Connections into secondary schools would be beneficial (refer Recommendation 7.1).

Students, too, identified for the Committee a broad range of factors influencing their level of engagement with secondary school science (and mathematics). Middle years students at Balwyn High School identified the following factors as contributing to a successful mathematics or science lesson:

- quality teachers who listen to their students and have open discussions with them;
- quality equipment and improved technology;
- hands-on activities;
- interesting topics;
- small class sizes; and
- incursions and excursions.³³⁰

Ms Dominique Grant, Balwyn High School student, reflected on her 'perfect lesson' in an effort to convey what makes an effective science class:

As soon as we walked into the classroom the teacher held our attention. He was surrounded by test tubes and beakers filled with an assortment of powders and

³³⁰ Ms L. Poor & Ms J. Dickenson, Year 10 Students, and Mr E. Kumar & Ms D. Grant, Year 11 Students, Balwyn High School, Transcript of Evidence, Public Hearing, Balwyn High School, 25 July 2005, pp.11–12.

acids. It was our introductory lesson on chemical reactions. We started the lesson by having a class discussion to brainstorm questions we had relating to the topic and on the facts we already knew. This opened up our minds to the new topic by making us compile what we had already learnt and think about what we wanted to learn. It also motivated us to find out more about chemical reactions and gave us the driving curiosity to answer the questions we had posed.

The next activities were experiments done by the teacher while we reported on the results and recorded our observations. Ordinarily this may have been boring, however, with a science teacher as passionate as my own and with students with a newfound thirst for knowledge, the activity was not only informative and productive but stimulating and enjoyable.

In the final part of our lesson that day we were divided into groups of three to investigate and answer one question ... using our textbooks and notebooks and conducting certain experiments relating to a specific question to not only complete the task but also justify our responses. The thing that motivated us even more, though, was when the teacher announced that the first group to answer the question would get a prize. This activity not only offered hands-on experience but also released our competitive spirit, gave us invaluable investigative skills and allowed us the freedom to explore science.³³¹

Students at other schools visited by the Committee presented many similar views. Teacher quality was a particularly important issue for many students. For example, Ms Kirstyn Heywood, Student, Montmorency Secondary College, stated:

In maths and science the teacher needs to have a strong knowledge of what they have to teach the students, especially in engaging their audience. They should be able to discuss things in class without help from a textbook.³³²

In responding to a question about what would make them return to science studies, students at Templestowe College gave a range of answers, including:

³³¹ Transcript of Evidence, Public Hearing, Balwyn High School, 25 July 2005, p.12.

³³² Transcript of Evidence, Public Hearing, Montmorency Secondary College, 1 September 2005, p.5.

I really think that it is definitely the teacher. You need to have a good teacher who can engage the class ... has a good nature and likes teaching ...³³³

I think if I was more confident with it. If I had a really good teacher ...³³⁴

If I found an area that I wanted to work in when I am older, or something that needed science ...³³⁵

Students at Parkdale Secondary College similarly made strong links between their intent to pursue studies in VCE science subjects and their future education and career pathways. This again emphasises the importance of linking science to real-world contexts and applications of these disciplines in the workplace, to enable students to recognise the relevance of science to their current and future lives. This needs to be taken a step further, however, through the implementation of effective career advisory programs for students, parents and teachers.

Effective careers and pathway advice was raised by participants as an important issue throughout this inquiry. A number of students at the schools visited by the Committee commented that a key reason for undertaking advanced mathematics and science subjects at VCE level is to achieve a high ENTER. While the Committee welcomes increased participation by a diverse range of students, the Committee believes that the primary motives for students choosing their subjects should be related to their interests and abilities and the relevance of subjects to their preferred future pathways.

The Committee was also concerned about the lack of advice to students and parents about the importance of mathematics and science related studies for those wishing to pursue a trade career. The Committee heard many comments from industry and employers on this issue.

Ms Sandy Roberts, General Manager, Central Victorian Group Training Company commented:

We find it extremely difficult attracting school leavers into the traditional trades. That is no news to anybody. In terms of maths and science, a lot of the recruitment really struggles in the electrical engineering areas ... The ones we are attracting tend to be the ones who

³³³ Mr J. Wilson, Year 9 Student, Templestowe College, Transcript of Evidence, Public Hearing, Templestowe College, 5 September 2005, p.10.

³³⁴ Ms G. Van Kalken, Year 8 Student, Templestowe College, Transcript of Evidence, Public Hearing, Templestowe College, 5 September 2005, p.10.

³³⁵ Mr C. Vine, Year 8 Student, Templestowe College, Transcript of Evidence, Public Hearing, Templestowe College, 5 September 2005, p.10.

have dropped maths quite early, so it is really difficult for them to try to do it in catch-up mode ...³³⁶

Ms Maxine Semple, Training Consultant, Victorian Employers' Chamber of Commerce and Industry similarly stated:

I believe a lot of kids at school do not see the relevance of maths and science until they are actually in the work force. They cannot translate what they are actually learning in school to what they are going to do on the job. They cannot see why they need maths to do cooking or engineering or even building. They cannot see the need for it until it is too late, and then they are really well behind.³³⁷

Mr Jim Crawshaw, Committee Member and Past Chairman of North-East Victoria Area Consultative Committee and Business Development Manager, The Factory, also expressed a view that a lack of foundation skills in mathematics can hinder a young person's future career opportunities:

We have found that the difficulties in people achieving just the basic things in mathematics have been a real hold-up to their career development and their progress in the workplace, and I think it is a shame that they do not really understand and they are not given an understanding early on in their careers of the need to progress in these sorts of areas.³³⁸

Given the above evidence, and the Victorian Government's commitment to pursue strategies to alleviate current skills shortages, the Committee believes that there is an urgent need for greater attention to be paid to effective career counselling and subject advice for all students, and particularly those pursuing vocational pathways and careers.

Recommendation 7.1: That the Victorian Government pursue through the Ministerial Council on Education, Employment, Training and Youth Affairs, the development of a nationwide curriculum and teacher professional development initiative for secondary schools.

Recommendation 7.2: That the Victorian Government pursue strategies to improve the quality of advice to young people and their parents to ensure that those pursuing vocational pathways undertake appropriate mathematics and science studies.

³³⁶ Transcript of Evidence, Public Hearing, Bendigo, 1 August 2005, p.4.

³³⁷ *ibid.*

³³⁸ Transcript of Evidence, Public Hearing, Shepparton, 2 August 2005, p.43.

Scientific Investigations, Laboratories and Equipment

The importance of investigative approaches in science (and even mathematics) was consistently emphasised by students, teachers and other participants throughout this inquiry. Investigative approaches include various forms of practical work, including demonstrations, experiments, fieldwork and open investigations. Unfortunately, the variety and frequency of science investigations varies greatly throughout Victorian schools. The following sections look first at the importance of scientific investigations and then at some of the resource requirements for effective investigations.

The Importance of Scientific Investigations

Hands-on experimentation should be central to the science curriculum for both primary and secondary students. As stated by the Victorian Model Solar Vehicle Challenge Committee, experimentation is at the very core of science:

We see science as a process of designing and carrying out experiments, making observations and interpreting those observations in terms of current laws or theories and at advanced levels, using those observations to challenge existing theories.³³⁹

The reasons given for the inclusion of practical work in science are many and varied. They include:

- language development;
- learning to work co-operatively;
- concrete experiences of natural phenomena;
- stimulating curiosity and creativity;
- motivation and enjoyment of science;
- developing investigation and problem-solving skills;
- developing techniques and manipulative skills associated with using scientific equipment;
- experiencing and developing an understanding of the nature of science; and

³³⁹ Written Submission, Victorian Model Solar Vehicle Challenge Committee, Monash University, August 2005, p.1.

- conceptual development.³⁴⁰

As noted by Hackling, the emphasis on practical work varies according to year level. Primary teachers tend to place more emphasis on the first half of the above list and secondary teachers tend to place more emphasis on the second half of the list.³⁴¹

The Committee received submissions and heard evidence from witnesses that similarly identified a range of reasons why practical work is essential in the study of science. Dr Raimund Pohl acknowledged the importance of both laboratory work and fieldwork:

Chalk and talk or the didactic method is not an appropriate method as it just dogmatises concepts. The concept 'I do and I learn' about the real world is vital. Laboratory work is useful but it should not be perceived as the be all and end all. Doing fieldwork, collection of data, analysing, evaluating and synthesising it, is vital. Learning needs to be fun and any teaching method needs to be built around the skills that are being learnt.³⁴²

Other evidence to the Committee also stressed the importance of experimentation as a means of engaging a variety of intelligences; such as spatial, kinaesthetic and interpersonal intelligences. In her submission to this inquiry, Ms Mandy Kirsopp, a parent, stressed the importance of providing students with teaching strategies that 'incorporate a variety of sensory modes' to engage the learner.³⁴³ In this way, practical classes act to 'aid cognitive development'.³⁴⁴ Ms Julie Sheppard, of the Science Teachers Association of Western Australia, emphasised the value of practical experiments as an ideal means to integrate kinaesthetic learning practices into the curriculum:

For a lot of kids the hands-on stuff is important because it helps them consolidate what they are learning.³⁴⁵

Furthermore, hands-on learning through experimentation can be particularly beneficial to students who are less academically orientated. This was explained in the submission from the Victorian Model Solar Vehicle Challenge Committee:

It is our contention that many students will be more motivated by experimentation than learning abstract

³⁴⁰ M.W. Hackling 1998, *Working Scientifically: Implementing and Assessing Open Investigation Work in Science – A resource book for teachers of primary and secondary science*, Education Department of Western Australia, Perth, p.2.

³⁴¹ *ibid.*

³⁴² Written Submission, Dr R. Pohl, July 2005, p.1.

³⁴³ Written Submission, Ms M. Kirsopp, November 2004, p.1.

³⁴⁴ Written Submission, Science Teachers' Association of Victoria, January 2005, p.6.

³⁴⁵ Transcript of Meeting, Perth, 2 June 2005, p.39.

theory, and that lower achievers, especially the middle year boys who appear disinterested in much of the current curriculum, are more motivated by an active learning approach.³⁴⁶

Student engagement in learning, not just of mathematics and science, but all subjects, is widely recognised as being particularly challenging in the middle years. The University of Melbourne also stressed the importance of practical work, as well as fieldwork, during the middle years, as a way of engaging students and teaching the scientific method:

The inclusion of practical laboratory and fieldwork is key to encouraging students to develop interest and passion with the disciplines ... This is also the time to inculcate the fundamental principles of the scientific method: hypothesis testing, reproducible experimentation, quantitative analysis, logical deductions and communication of results and implications.³⁴⁷

Students participating in this inquiry also expressed their enjoyment and the value of experimentation. The Committee heard from middle years students at Templestowe College that practical lessons provide a change from the usual learning and teaching practices of science classes and that of many other subjects. Year 8 student Ms Georgia Van Kalken stated:

My favourite year is this year for science, because we are doing more experiments and it is not just copying things off the board and listening to the teacher speak. We do more experiments and I think that helps us learn more.³⁴⁸

Mr David Craze a Year 12 student of Montmorency Secondary College shared this perspective:

I think practical sessions are very important. They give you that visual element that is missing in a lot of the writing and the things that you get in a lot of science and maths classes. It helps you remember things a lot more. It is also a bit of fun – a change, a break from the sort of stuff you have been doing in the theory work and with equations and things like that.³⁴⁹

³⁴⁶ Written Submission, Victorian Model Solar Vehicle Challenge Committee, Monash University, August 2005, p.1.

³⁴⁷ Written Submission, Faculty of Education, Faculty of Engineering & Faculty of Science, The University of Melbourne, January 2005, p.4.

³⁴⁸ Transcript of Evidence, Public Hearing, Templestowe College, 5 September 2005, p.3.

³⁴⁹ Transcript of Evidence, Public Hearing, Montmorency Secondary College, 1 September 2005, p.3.

Given that experimentation is a central pillar to science education, some stakeholders suggested that it should also have greater prominence in post-compulsory assessment. Associate Professor Kieran Lim recommended that an extended experimental investigation be included in the first semester of Year 12 VCE sciences, replacing the mid-year examination as the assessment.³⁵⁰

While experimentation has a multitude of advantages, the Committee notes that teachers need to be wary of how they approach and run laboratory classes. It is important to ensure that students do not see 'every experiment as a recipe and ticking things off in a list because of the time frame'.³⁵¹ Montmorency Secondary College Year 11 mathematics and science student, Mr Andrew Argyropoulos, similarly stressed the importance of explicitly linking experimentation with the science it is intended to explore:

[Teachers] have to make us think more when we do the practical activity instead of, 'Put two drops of that, mix it with that'. We have to start thinking about what we are doing instead of just doing it.³⁵²

While the importance of scientific investigations cannot be questioned, the Committee heard that a range of barriers to effective delivery exist in both primary and secondary schools. As discussed further in Chapter 9, some of these barriers are associated with the depth of knowledge, understanding and skills among science teachers. Often, primary school teachers do not have the depth of content knowledge and conceptual understanding required to be confident in delivering a range of engaging practical science activities. In the case of secondary school teachers, there are two issues: content knowledge may be an issue for those teaching 'out of field' while, for others, developing effective pedagogies that successfully engage diverse students in learning throughout the difficult middle years can be challenging.

In addition to the above challenges, the Committee received evidence highlighting concerns regarding the variability of science facilities and equipment in Victorian schools, as outlined below.

³⁵⁰ Written Submission, Associate Professor K. Lim, January 2005, p.5.

³⁵¹ Mr J. McDonald, Program Director, In2Science Peer Mentoring Program, La Trobe University, Transcript of Evidence, Public Hearing, 8 August 2005, p.18.

³⁵² Transcript of Evidence, Public Hearing, Montmorency Secondary College, 1 September 2005, p.3.

Science Laboratories and Equipment

The Committee heard that the quality of laboratory facilities and scientific equipment has a direct, significant influence on the quantity and variety of practical work undertaken in secondary schools. Mr Bruce Carpenter, Science Co-ordinator at Bendigo Senior Secondary College, stated, for example:

... student attitude, motivation and engagement [have been identified] as the key factors for supporting high quality science education. The way to do that: enthusiastic teachers who have an excellent depth of knowledge in their specific teaching area are absolutely crucial ... You need high quality resources and equipment. We have got students walking around our classes with iPods, digital cameras, computer gaming consoles at home, mobile phones, PDAs ... and we find sometimes the equipment in teaching science is a little bit dated in comparison ... that is where an image problem comes in for science and maths... The kids come in with certain expectations of science and I think fairly often they are disappointed ... the science laboratories and maths classrooms need to be of a higher standard.³⁵³

Ms Karen Utber, Science Learning Area Leader, Wanganui Park Secondary College, similarly noted:

The schools around here are older and I would love to have all the up-to-date technology and lovely science labs. I have taken kids on excursions to places and you should see their faces when they walk into a properly equipped science laboratory ... There is no way that you could not engage kids if you have funding for that stuff.³⁵⁴

Students, too, highlighted the importance of quality science equipment and laboratories:

Having good equipment and aids enhances the teachers' skills. Improved technology, which includes overhead projectors, DVDs and PowerPoint presentations, broadens the way in which a teacher is able to present material, which is beneficial to different student learning styles. Hands-on activities also engage the students' attention by positively involving them in

³⁵³ Transcript of Evidence, Public Hearing, Bendigo, 1 August 2005, p.37.

³⁵⁴ Transcript of Evidence, Public Hearing, Shepparton, 2 August 2005, p.34.

the subject, creating a pleasant work environment for both students and teachers.³⁵⁵

Participants throughout the inquiry agreed that the provision of a range of quality facilities and equipment is a crucial element for modern science education. While some Victorian schools have exemplary, state-of-the-art facilities and equipment, others find their facilities and equipment limited.

Mr Bill Porter, Assistant Principal at McGuire College, noted for example, some of the limitations of the dated facilities at his school:

McGuire College has four science rooms, all of which are 30-plus years old. One room has a new fume cupboard. That was installed two years ago. The other three science rooms have condemned fume cupboards. All four science rooms are in their original configuration. The rooms are neat but in a poor state for delivery of a modern science curriculum. None of the rooms have modern scientific equipment and they are under-resourced. The rooms are uninspiring, with antiquated troughs and benches and a poor layout.³⁵⁶

Students, too, sometimes highlighted the limitations of their school laboratory facilities. For example:

... you do prac reports and experiments which are all basically done pretty well, but sometimes you get a bit behind with the pracs because the benches are around the outside and it gets hard. We just did a sound experiment in physics which is a bit of trouble in the classroom with everyone else's interference.³⁵⁷

The Committee heard that due to limited facilities and equipment, the number and range of experiments in some schools may be reduced. This, of course, can have negative consequences for student engagement and learning in science. Further, teachers who are hindered in their ability to deliver exciting practical lessons often resort to less engaging teaching strategies, including relying heavily on the use of textbooks.

The Committee observed interesting and innovative approaches by various schools in overcoming some of the limitations of existing science facilities. St Helena Secondary College, for example, has built a \$3.7 million Science and ICT Centre. The Victorian Government provided \$3 million in funding for the Centre, as one of an increasing

³⁵⁵ Ms J. Dickenson, Year 10 Student, Balwyn High School, Transcript of Evidence, Public Hearing, Balwyn High School, 25 July 2005, p.11.

³⁵⁶ Transcript of Evidence, Public Hearing, Shepparton, 2 August, 2005, p.23.

³⁵⁷ Mr R. Campbell, Year 12 Student, Parkdale Secondary College, Transcript of Evidence, Public Hearing, Parkdale Secondary College, 12 September 2005, p.3.

number of centres of excellence within Victorian schools. The facility is state-of-the-art, rich in ICT and is one of Victoria's leading centres of its kind. In contrast, Eltham High School has adopted a lower cost, yet equally effective approach to ensuring that students have first-class opportunities to engage in practical science. By re-configuring its laboratories and preparation rooms into a central core that is easily accessible via adjacent classrooms, Eltham High School has been able to significantly improve the opportunities for students to engage in science and experimentation.

Many other schools across Victoria are making similar decisions to redesign, redevelop or create new science facilities. The Committee was somewhat surprised, however, that although schools undertaking these projects each face similar design considerations they continue to address these issues relatively independently. While most will seek opportunities to tour various best practice facilities and gain feedback about other projects, the Committee heard that there are not any best practice guidelines available. Consequently, many teachers and school administrations are required to make design decisions within the limits of their own knowledge and experience. The Committee therefore believes that materials outlining successful renovations or redevelopments, including low-cost options for optimising existing facilities, would be of significant benefit to a number of schools.

Evidence received by the Committee also highlighted occupational health and safety (OHS) and duty of care considerations associated with the design of science laboratories and preparation rooms and the delivery of practical lessons to students. A written submission from Mr Neil Champion offered a good summary of these considerations. Mr Champion was concerned that many science teachers are finding it difficult to convince administrators that there is a difference between 'risk management' and 'no risk' when it comes to the operation of science laboratories and OHS concerns.³⁵⁸ According to Mr Champion, OHS and duty of care concerns are hindering practical classes in some schools, limiting the variety of experimentation teachers can undertake and consequently affecting student engagement in science:

There is a need to expose students to meaningful experiments that have an element of risk, to manage that risk and to induct students into the ways that we can minimise risk.³⁵⁹

Mr Champion also proposed a number of solutions to the above issues. He suggested there is a need for:

- development and dissemination of advice on OHS and duty of care laws and regulations specifically tailored for

³⁵⁸ Written Submission, Mr N. Champion, January 2005, p.3.

³⁵⁹ *ibid.*

schools to ensure important and engaging science activities can continue;

- regular induction and training of system and school administrators, school science co-ordinators and/or laboratory administrators on how to work within OHS and duty of care constraints while minimising any negative impact on worthwhile science activities; and
- availability of micro-chemistry kits for schools to allow the use of small quantities of interesting chemicals for a range of activities that cannot be conducted with conventional equipment due to cost, safety and waste minimisation considerations.³⁶⁰

The Committee believes that there is a need to re-think the design of some school science facilities, taking into account the need to address OHS and duty of care requirements, while also facilitating opportunities for students to experience exciting scientific investigations. The Committee notes that the most effective laboratory facilities have the following characteristics:

- an appropriately sized preparation room, located centrally and on the same level (step and stair free) to the laboratories it supports, allowing access to those laboratories without the use of student thoroughfares and allowing for the appropriate separation of chemicals;
- island benches in laboratories to facilitate effective group work and minimise the number of students working with their back to the teacher and the rest of the class;
- integration of ICT facilities;
- the inclusion of infrastructure such as fume cupboards that widen the scope and diversity of experimentation that can be undertaken;
- space to store extended student experiments in progress; and
- space to exhibit student work and scientific displays.

The Committee believes that there is a case for some additional government funding for science laboratories and equipment in secondary schools. It would be unrealistic, however, to expect that every school, regardless of student population size or number of science enrolments, could have the fully equipped science laboratories

³⁶⁰ *ibid.*

seen in an increasing number of larger Victorian schools. Nonetheless, the Committee firmly believes that all Victorian students should have opportunities to experience an appropriate range of practical and investigatory science. Therefore, opportunities for the sharing of laboratories and equipment and various centres of excellence must continue to be expanded. This can be achieved through programs such as the Leading Schools Fund, which facilitate joint projects between school clusters, or neighbouring schools, as well as continued investment in large-scale community facilities.

The Committee notes the investment the Victorian Government has made in various centres of excellence. These include the Australian Mathematical Sciences Institute, Bacchus Marsh Science and Technology Innovations Centre (trading as Ecolinc), Gene Technology Access Centre (GTAC), Scienceworks Museum, Victorian Space Science Education Centre and Victorian Institute of Chemical Sciences. A description of these centres is contained in Appendix L. The Committee observed that many of these centres present opportunities to either undertake scientific investigations, or to extend activities in the classroom. The centres therefore represent a significant opportunity for all schools, particularly those with limited on-site facilities, to make mathematics and science more engaging for students. Science centres achieve this through a variety of strategies, including:

- hosting school groups for site tours and/or hands-on experimentation;
- delivering expert presentations and/or careers sessions, either on-site or in regional centres around the state;
- conducting mathematics and science education and awareness (outreach) programs in rural and regional communities;
- producing quality educational resources, including curriculum materials, careers information and internet resources; and/or
- delivering teacher training and/or professional development.

A key asset shared by most, if not all, Centres of Excellence, is highly motivated, energetic and experienced educators who are effective in engaging students in their field. Additionally, many of these centres are able to facilitate direct contact between high-end working scientists and school students and teachers.

Additional strategies should also be developed to ensure students in areas experiencing socioeconomic disadvantage and those in rural and regional Victoria have similar opportunities to other students. Such strategies may include assistance in forming partnerships across

schools to facilitate access to appropriate facilities, assistance with travel costs, assistance in bringing outreach programs into schools and/or additional funds for an 'equipment boost', where required. These schools should also be encouraged to participate in school, industry and community partnership programs that arise from time-to-time, such as the new Australian School Innovation in Science, Technology and Mathematics (ASISTM) Project (refer Appendix N).

Science equipment in primary schools is likely to be less expensive than the equipment required by secondary schools. Further, primary science consumables are generally more easily acquired and are more likely to be sourced locally by the classroom teacher than through a specialist provider that supplies secondary schools. The Committee nonetheless heard evidence suggesting that a greater number and range of interesting and challenging science experiences could be offered to primary school students if the availability and quality of equipment were improved. Generally, it was only a modest boost to science funding that was seen as having the potential to make a significant difference:

You have to have money to teach science ... You cannot teach a unit on electricity unless you can buy the wires and the batteries. Primary schools are very much in the situation where they might have a budget of \$500 for the whole year and might be expected to have 11 classrooms teach hands-on science. It is only through the goodwill of teachers who purchase equipment out of their own pockets that gets hands-on things going ... [So] ongoing funding at a reasonable level, not for Van de Graaff machines but for the paper clips and the balsawood – the things that you consume in science – or a bag of potting mix. It sounds trivial, but it just cannot happen unless teachers have ... the funding to put those ideas into practice.³⁶¹

The Committee recognises that the Department of Education and Training has committed additional resources for science equipment over recent years. In 1999, small equipment grants were provided to primary schools for science equipment and for a complementary teacher professional module. This was followed in 2000, with a similar grant for secondary schools. In 2002, further grants were made available to primary schools, to be used either for the purchase of additional science equipment, or to assist in the delivery of Family Science activities. While these modest funding boosts have proved very useful in supplementing science equipment in Victorian schools, the Committee believes that now is the time to provide a more substantial equipment boost. A major equipment boost would assist the capacity of schools to embrace the expansion of new and innovative

³⁶¹ Ms R. Morley, Teacher, Sherbourne Primary School, Transcript of Evidence, Public Hearing, Montmorency Secondary College, 1 September 2005, pp.20–21.

sciences in their introduction and consolidation of the new Victorian Essential Learning Standards (VELS). It would allow for the purchase of innovative yet expensive science equipment that could be shared among school clusters and would also recognise that consumables represent a significant cost in the delivery of engaging science activities.

In summary, the Committee observed that there is considerable variation in science facilities and equipment throughout Victorian schools. Many schools have newly equipped state-of-the-art science laboratories that facilitate an exciting array of experiments. Others, however, have facilities that are inadequate for the needs of a modern science curriculum.

The Committee recognises that it will take some time before all Victorian students have equitable access to a full range of exciting science facilities and experimental opportunities. To assist in the process, however, the Committee believes that the Department of Education and Training should develop a five-year strategic plan that addresses the need for primary and secondary schools to have access to appropriate science facilities and equipment. The strategic plan should include:

- best practice guidelines for the design of laboratory facilities;
- best practice guidelines for the delivery of the school science curriculum within OHS and duty of care requirements;
- partnership strategies to facilitate appropriate sharing of science facilities and equipment;
- strategies to facilitate public-private partnerships for the provision of laboratory equipment; and
- strategies for ensuring students in rural and regional Victoria and in areas of socioeconomic disadvantage can access appropriate facilities and experiences.

The Committee believes that the strategic plan for science laboratories and equipment in schools should be linked to a broader mathematics and science education policy, as recommended in Chapter 2, as well as to strategies aimed at raising levels of participation and achievement in the enabling science disciplines. Additionally, the Committee believes the strategic plan should be supplemented by an 'equipment boost' complementary to those seen over recent years.

Recommendation 7.3: That the Department of Education and Training, as part of a strategic statement for mathematics and science education (refer recommendation 2.1) develop a five-year plan for science laboratories and equipment in primary and secondary schools. The strategic plan should include:

- best practice guidelines for the design of laboratory facilities;
- best practice guidelines for the delivery of the school science curriculum within occupational health and safety and duty of care requirements;
- partnership strategies to facilitate appropriate sharing of science facilities and equipment;
- strategies to facilitate industry support for the provision of some specialised laboratory equipment; and
- strategies for ensuring students in rural and regional Victoria and in areas of socioeconomic disadvantage can access appropriate facilities and experiences.

Recommendation 7.4: That the Victorian Government fund a science 'equipment boost' for primary and secondary schools to encourage greater innovation, scientific practice and experimentation as part of the consolidation of the Victorian Essential Learning Standards in Victorian schools.

Mathematics and Science Enrichment Programs

Many submissions and witnesses highlighted the important role mathematics and science education and awareness programs can play in engaging students. Opportunities include excursions and incursions (outreach), partnership programs such as the Commonwealth Government's ASISTM Project and various competitions, awards programs and other enrichment activities.

Excursions and Incursions

Excursions and incursions, especially those involving centres of excellence, can be of enormous benefit in mathematics and science education. The benefit of excursions and incursions include:

- access to expertise, facilities and resources beyond the capacity of the school community;

- exposing students to different learning environments or approaches to learning and teaching; and
- exposing students to leaders in the field and other potential role models.

Crucially, it is the capacity of excursions or incursion programs to engage, and often entertain students in mathematics and science, that is one of their most valuable assets. Mr Chris Krishna-Pillay, Manager, CSIRO Science Education Centre, referring to the science curriculum, stated:

I think what you have to do is ask, 'Okay, how do we engage kids in this stuff?' and then, 'How do we make them see the useful links to it?' ... I think that one of the ways you achieve that is by giving moments. You give moments to students and teachers ... If you go to Sovereign Hill you get moments. If you go to the planetarium you get moments. If you go down to the beach and collect molluscs you get moments. It does not matter whether you are five-years-old or 25-years-old; those things never go away.³⁶²

Providing memorable moments and encouraging teachers to draw the link to those moments for students is a challenge faced by excursion and incursion program operators. Teachers need to be aware of both the power and limitations of excursions or incursion programs.

Ms Pennie Stoyles, Education Officer with Scienceworks Museum, stated:

These days kids are often doing two-dimensional activities. With their television, their computer, their X-boxes, whatever, their experience is in two dimensions ... so we do hands-on and bodies-in experiences for them, because if you actually do something it is the old saying, 'I hear it, I can do it, I see it, I remember and I do it and I understand'.³⁶³

There is, of course, a need to clearly structure any excursion (or incursion) so that it offers some direction to the students' learning process without detracting from the benefits of the informal or unique learning environment. A study of research relating to school visits to science centres concluded that teachers should integrate a visit to the science centre into their teaching program, so that the visit complements the classroom activities. In particular, the researchers emphasised the importance of both teacher and student preparation for

³⁶² Transcript of Briefing, CSIRO Science Education Centre, Melbourne, 9 May 2005, p.10.

³⁶³ Transcript of Evidence, Public Hearing, Scienceworks Museum, Melbourne, 19 August 2005, p.3.

a visit and the need for both structured as well as free-choice exploration during the visit.³⁶⁴

The CSIRO's Lab on Legs program, for example, offers a range of science education programs covering topics suitable from Years P–12 and can be run as either an incursion or as an excursion onsite at the Melbourne Science Education Centre. Programs are closely linked to the curricula for the targeted year levels. Importantly, the programs are designed to enable teachers to repeat the activities and experiments undertaken during the sessions.³⁶⁵

Scienceworks Museum has exemplary curriculum resources that link directly to exhibits and shows. Resources are available to teachers through the museum's website. The site provides student activities as well as teacher notes linked to the exhibits and displays at the museum. Additional extension exercises are available that can be conducted onsite, at home or in the classroom.³⁶⁶ Both the exhibits and curriculum resources can be targeted to a range of year levels and scientific fields. Ms Pennie Stoyles stated:

We provide education support materials for all the schools so that they have school-based activities that they can do before and after they visit. It is not a one-off visit to Scienceworks. It is part of unit of work that may go for four or six weeks, and it is integrated into that so that we provide all the hands-on activities that they might like to do at school. Resources are also available with descriptions of what they are going to see, which aims to make them well prepared and to have a positive educational experience.³⁶⁷

Some students reported to the Committee that excursions are not always integrated into the school curriculum.³⁶⁸

The *Education Times* recently published an article on how schools can select excursions and use them to maximise student learning. A common theme in the article was that the main focus when selecting and organising an excursion is the need to enhance programs within

³⁶⁴ L.J. Rennie & T.P. McClafferty 1995, *Don't Compare, Complement: Making the best use of science centres and museums*, cited in Written Submission, Discovery Science and Technology Museum, December 2004, p.6.

³⁶⁵ Mr C. Krishna-Pillay, Manager, CSIRO Melbourne Science Education Centre, Transcript of Briefing, CSIRO Science Education Centre, Melbourne, 9 May 2005, p.3.

³⁶⁶ Information on Scienceworks curriculum resources was obtained from the Scienceworks Museum website at <<http://scienceworks.museum.vic.gov.au/education/resources.asp>>, accessed on 19 January 2006.

³⁶⁷ Transcript of Evidence, Public Hearing, Scienceworks Museum, Melbourne, 19 August 2005, p.3.

³⁶⁸ Mr A. Argyropoulos, Year 11 Student, Montmorency Secondary College, Transcript of Evidence, Public Hearing, Montmorency Secondary College, 1 September 2005, p.6.

the school, while also capturing students' attention and imagination in a fun and exciting way. Some of the keys to success are:

- selecting excursions that allow students to process information, challenge and extend ideas, develop big picture understandings and draw the threads of integrated studies together;
- providing opportunities to experience learning in different ways not possible within the context and confines of the classroom;
- involving students in the planning and organisation of the excursion (particularly secondary students);
- timing the excursion to integrate with what is happening in the classroom;
- tapping into experts in the field of study;
- using local events, facilities and experts where possible;
- evaluating the success of the excursion and using findings to enhance future excursions; and
- co-ordinating excursions across the school.³⁶⁹

Further dissemination of the above points, through an online or printed resource may serve as useful guidelines to teachers planning excursions or incursions. While Victorian students have access to a diverse range of centres of excellence, take-up of these opportunities by many schools is low.

Education and Awareness Programs

The Committee investigated a considerable variety of mathematics and science education and awareness programs available across primary and secondary levels of schooling. Programs considered by the Committee include:

- mathematics and science competitions and awards programs;
- holiday or weekend science and mathematics programs; and
- school, community and industry partnership initiatives.

³⁶⁹ J. Penson, 'Classroom Conundrum: Testing questions for teachers and principals', *Education Times*, 11 August 2005, p.13.

A description of the mathematics and science education and awareness programs investigated by the Committee, including contact details is included as Appendix N.

An important element of some of the enrichment programs examined by the Committee is the opportunity for students to engage in the program through numerous mediums and different approaches. The Science Talent Search, for example, gives students and teachers the freedom to enter a number of categories including research, class (group) project, creative writing, models and inventions, posters, board games, computer programs, photography and videos. Importantly, this approach widens the program's appeal and accessibility, simultaneously engaging students who are academically focused, as well as those who prefer a more hands-on approach.

Committee representatives attended the Science Talent Search exhibition and presentation day, and were impressed by the diversity, standard and creativity of participants' work. It was clear from discussions with participating students that they had enjoyed the program, and generally demonstrated a thorough understanding of the concepts related to their own projects. The Committee therefore encourages other schools and students to explore opportunities to participate in these types of programs.

The Science Talent Search is obviously a large-scale event facilitating participation among a large and diverse cohort of students.³⁷⁰ Other programs are far smaller and, therefore, can reach only a small number of students each year. For example, the Siemens Science Experience runs at 30 university campuses across Australia, with an annual participation of around 2,700 students.³⁷¹ Siemens Science Experience aims to introduce students to a wide range of sciences, stimulate interest in science activities and provide information on study and career opportunities in science. A typical three-day program includes experiments in university laboratories, short lectures from high profile lecturers, visits to local places of special scientific interest and information about study and career opportunities in science and technology, often delivered by a successful young person in science. The Committee believes that programs such as Siemens Science Experience, which offer in-depth immersion in science related activities, albeit over a short timeframe, are particularly valuable for students who do not have frequent opportunities to engage in these experiences.

³⁷⁰ The Science Teachers' Association of Victoria provided information to the Committee in October 2005 showing that, in 2003, there were 2,563 entries in the Science Talent Search, involving participation by 202 schools and 3,334 individual students. In 2005, the corresponding figures were 2,282 total entries, involving 164 schools and 2,909 students.

³⁷¹ Mr J. Sonnemann, National Director, Siemens Science Experience, provided information to the Committee in November 2005, showing that in 2003, 364 Victorian students, representing 160 schools participated in the Siemens Science Experience. In 2005, 306 Victorian students from 138 different schools participated.

This includes students who are disadvantaged due to location or socioeconomic status. The Committee believes that given only a small number of students can access these types of programs each year, priority should be given to specifically targeted groups of students.

The Committee's analysis of participation in a large number of mathematics and science education and awareness programs reveals significant variation in the profile of participating schools (refer Chapter 6). Some schools obviously experience some form of barrier to participation, including location or socioeconomic disadvantage. However, the Committee believes that lack of information about the availability of these programs and how to access them is a simple explanation for the lack of participation by many schools. The identification of suitable programs and information about access represented a significant challenge to the Committee. The Committee also found there was little material available to explain the comparative benefits of various programs. The Committee therefore believes that a central online resource detailing excursions, incursions, and other enrichment programs would be beneficial. The capacity to include as part of the database, teacher and student feedback as an ongoing review mechanism, could also be of assistance to teachers choosing between programs. Furthermore, the Committee considers that there is considerable value in making such an online resource publicly accessible. Students, parents and families should be encouraged to utilise mathematics and science education programs and centres of excellence independently of their schools.

Recommendation 7.5: That the Department of Education and Training develop and maintain an online resource detailing mathematics and science related excursions, incursions, competitions and award programs and other enrichment activities that are available to Victorian students.

The Integration of Technology in the Classroom

Every young person will need to use ICT in many different ways in their adult lives, in order to participate fully in a modern society ... Investment in this technology can give competitive advantage in global markets.³⁷²

While information and communication technology (ICT) is a product of the enabling sciences, it is also a powerful tool within mathematics and science education.

It is clear to the Committee that the effective incorporation of ICT into the classroom presents considerable opportunities to engage students in mathematics and science education. Importantly, some stakeholders recognised the changing nature of the student cohort and their increasing familiarity with ICT. Mr Alby Freijah, Assistant Principal, Mooroopna Secondary College, commented:

We are trying to engage visual learners – they are on the computers all the time. They use DVDs. There is interaction. If you are talking about maths/science, we are competing with the hands-on subjects. We have to engage our students quickly in the early years with some of these resources ...³⁷³

Australian students are some of the most ICT literate in the world. PISA investigations into usage of ICT by 15-year-old students revealed that:

- 94 per cent of Australian students reported that they have access to a computer at home for school work (compared to the OECD average of 79 per cent);
- 100 per cent of Australian students reported having access to a computer at school;
- 70 per cent of Australian students reported that they use a computer frequently for word processing (compared to an OECD average of 48 per cent);
- 74 per cent of Australian students reported frequent use of the internet to look up information about people, things or ideas (compared to the OECD average of 55 per cent); and

³⁷² Organisation for Economic Co-operation & Development 2005, Program for International Student Achievement, *Are Students Ready for a Technology-Rich World? What PISA Studies Tell Us*, OECD, Paris, p.8.

³⁷³ Transcript of Evidence, Public Hearing, Mooroopna Secondary College, 2 August 2005, p.38.

- 90 cent of Australian students reported being confident users of the internet.³⁷⁴

Clearly, ICT is an important tool in education systems in Australia. However, just 10 per cent of Australian students reported frequent use of educational software such as a mathematics program. This was just below the OECD average of 13 per cent.³⁷⁵ Nevertheless, it is evident efforts are being made to better incorporate ICT into Victorian classrooms:

We have just spent a lot of time in planning the upgrade of our ICT resources and redesigning classrooms because the use of computer software will be a big thing in the future. As a cluster we have subscribed to a resource called maths 300, which is run by the Curriculum Corporation.³⁷⁶ It [Maths 300] contains lots of interactive material that students can use on the computer, and there are also lots of lesson plans that teachers can use.³⁷⁷

Video and display technologies are also enhancing the educational opportunities in the classroom. The 'explosion' in high-quality display technology including plasma screens and digital projectors for the mass entertainment market has been substantial and can be an engaging tool in the classroom, as Mr Carpenter, Science Co-ordinator at Bendigo Senior Secondary College highlighted:

If you are just presenting videos on a little TV screen at a distance of about 20 metres, it is not particularly engaging. A lot of the stuff that we have to go through in senior college is fairly involved. You cannot really get the concept out of a book. You need to see things moving; you need to interact with it a little bit, and once again that feeds into how valued the kids feel. They need to feel this is something new and vibrant they are doing in science and maths as well.³⁷⁸

³⁷⁴ Australian Council for Educational Research 2006, *Australian students among the highest users of computers at school and in the home: OECD report*, Media Release 25 January 2006, ACER, Melbourne.

³⁷⁵ *ibid.*

³⁷⁶ The Curriculum Corporation is an independent education support organisation owned by all Australian education ministers established to assist education systems in improving student learning outcomes. The Corporation is a major provider and publisher of print and digital curriculum products, provide educational project management services, deliver assessment and testing services to education systems, provide a model for online delivery and nurture strategic partnerships. Obtained from website <http://www.curriculum.edu.au/who_are_we/whoarewe.php>, accessed on 21 February 2006.

³⁷⁷ Mr C. Nielsen, Maths Co-ordinator Kangaroo Flat Secondary College, Transcript of Evidence, Public Hearing, Bendigo, 1 August 2005, p.33.

³⁷⁸ Transcript of Evidence, Public Hearing, Bendigo, 1 August 2005, p.37.

As the Committee's previous report, *Step Up, Step In, Step Out* outlined, there is often a considerable divide between the technological skills of students and those of their teachers. Students of the 21st century are 'digital natives', fluent with digital technologies, while many teacher educators and current teachers are 'digital immigrants', often lacking the technology skills of school students and new entrants into teacher education.³⁷⁹ Therefore, ICT is not a 'cure all' to the challenges facing student engagement in mathematics and science. It is vital that teachers are equipped with ICT pedagogies so that they can utilise ICT effectively in the classroom:

You can provide resources, you can provide time, you can provide computers and technology, but unless teachers have a background in the discipline, particularly in secondary schools, and an understanding of how to bring that alive within the classroom and engage students, then it is not going to happen. That is why the resources and the effort needs to be put into helping teachers to be effective.³⁸⁰

Mr Gary Simpson shared this perspective:

More or better facilities in the form of laboratory and classroom space are helpful, access to ICT and other technologies are great, but if the teacher does not have the capacity to use the facilities well or the knowledge of how to use software and hardware with students, then they are worthless.³⁸¹

In integrating ICT into the classroom, teachers need to be aware of the tendency of some girls (more so than some boys), to reject technology and that inappropriate deliveries of ICT can be disengaging for either males or females.³⁸² It is therefore important, as with all approaches to teaching, that teachers consider the gender and cultural implications of the strategies they are employing.

Mr Gary McLean, Assistant Director of School Services, Catholic Education Office, Catholic Education Commission of Victoria, outlined an example of effective use of ICT within the classroom:

There were experiments related to dye ... There was a tremendous teacher working with a third of the group doing the actual experiment. Another third of the group were following it up and writing it up, having taken part

³⁷⁹ Education & Training Committee, *Step Up Step In Step Out: Report on the inquiry into the suitability of pre-service teacher training in Victoria*, February 2005, p.186.

³⁸⁰ Mr B. Armstrong, Principal, Balwyn High School, Transcript of Evidence, Public Hearing, Balwyn High School, 25 July 2005, p.25.

³⁸¹ Written Submission, Mr G. Simpson, Co-ordinator of Independent Learning, Woodleigh School, August 2005, pp.1–2.

³⁸² Refer to Chapter 6 *Student Differences* for further details on girls' rejection of technology.

in the experiment. The other group—which I thought was just brilliant—were working around a group of three computers because the teacher had downloaded, from The Le@rning Federation, an ICT science activity that was directly related ... again, it came down to the quality of the teacher, who was able to set up three really challenging activities for those students to be involved in ...³⁸³

The Le@rning Federation is an organisation at the leading edge of the development of online curriculum material in Australia. The Le@rning Federation reports to MCEETYA, whose member governments own and fund the initiative. The Le@rning Federation's role is 'to create online curriculum materials and the necessary infrastructure to ensure that teachers and students in Australia and New Zealand can use these materials to widen and enhance their learning experiences in the classroom'.³⁸⁴ One of the Le@rning Federation's key objectives is to support growing innovations, enterprise and knowledge priorities of MCEETYA member governments. Science and mathematics and numeracy are two of the six priority content areas. The curriculum materials are designed to engage students and support teachers and will be freely available to all schools in Australia and New Zealand. The Committee hopes that continued work by the Le@rning Federation will assist in increasing the use of educational software in Australian classrooms.

Educational authorities, such as the Department of Education and Training and the Catholic Education Commission of Victoria, are also using ICT to assist in school-based decision making. Mr Paul Sedunary, Manager of Curriculum and Innovation at the Catholic Education Commission of Victoria, spoke of the power of ICT used in this manner:

Another avenue for effective use of ICT in supporting learning and teaching in maths and science is having access to data so that schools and teachers can make informed decisions when planning their numeracy and science programs.... One of the achievements within our sector has been that, as we have had a greater reliance on and use of data, our teachers have become more data-literate. Schools are becoming more data-literate as organisations and have access to data that assists in their planning. We see that the data we collect through assessments needs to be diagnostic, which enables the teachers and schools to focus on the

³⁸³ Transcript of Evidence, Public Hearing, Melbourne, 20 June 2005, p.9.

³⁸⁴ Information on the Le@rning Federation obtained from website, <<http://www.thelearningfederation.edu.au/tlf2/showMe.asp?md=p&nodeID=1>>, accessed on 27 January 2006.

students' strengths and weaknesses and to plan for necessary learning interventions ...³⁸⁵

The Committee therefore reiterates the recommendations of its previous report, which called for ICT to be a compulsory and key focus of pre-service teacher education and to require universities to detail a strategic plan for the incorporation of ICT into teacher education programs.

The Integration of Business, Industry and Research Applications

The integration of business, industry and research applications into mathematics and science education has considerable value. By relating mathematics and science to the real world and making it more relevant to students, students are likely to become more engaged in these disciplines. A review of the supply of science and engineering skills in the United Kingdom reported that the benefits of improved links between schools and the industry and research sectors are:

- increased engagement;
- improved student learning; and
- improved participation and retention rates.³⁸⁶

Therefore, the integration of business, industry and research applications into school and learning communities could contribute to two key goals of government: raising levels of scientific literacy across the community and addressing skills shortages in the economy.

Business, industry and research applications of mathematics and science education can be integrated into school and learning communities either directly, or indirectly. Direct integration requires business and industry to have a strong, direct linkage with students, working with them and demonstrating real world applications of mathematics and science. The Minerals Council of Australia spends approximately \$300,000 a year on its education program in Victoria, creating a direct link to classrooms. Employing 10 educators, Minerals Education Victoria (the state education arm of the Minerals Council of Australia) runs incursions, targeting years P–10, focusing on the science and technology associated with the mining and minerals industry.³⁸⁷

³⁸⁵ Transcript of Evidence, Public Hearing, Melbourne, 20 June 2005, p.2.

³⁸⁶ Ms J. Niall, Deputy Secretary, Business Development, Department of Innovation, Industry & Regional Development, Transcript of Briefing, 29 April 2005, p.2.

³⁸⁷ Written Submission, Minerals Council of Australia, Victorian Division, August 2005, p.5.

The national professional body for engineers, Engineers Australia similarly runs a number of activities in schools. The aim of its program is to get students passionate and motivated at a young age about the concept of engineering. One of its key programs is EngQuest (refer Appendix N). Although EngQuest appears to the Committee to be an effective model for generating interest and understanding about engineering, the Committee notes the comments from Engineers Australia indicating that it has been challenging to achieve widespread take up of the program in schools.³⁸⁸ This could reflect a number of issues, including the view noted below that some industry groups do not fully understand how to effectively access the school sector. The Committee notes, however, that some schools and teachers could also become more proactive in seeking out engaging opportunities that have real world relevance for students.

Indirect integration of industry and research applications of mathematics and science can involve a variety of activities. These include working with teachers to upgrade their professional knowledge and skills, or working with curriculum authorities to influence future curriculum changes or assist in the development of curriculum resources. In developing the new Chemistry Study Design the Victorian Curriculum and Assessment Authority consulted a variety of industry and research stakeholders. The Authority conducted a symposium seeking input from representatives from industry, professional education associations, the research sector, teachers and tertiary educators.³⁸⁹ According to the Authority, the new course will incorporate new science, such as nanotechnology, the synchrotron, biotechnology and green chemistry.³⁹⁰

The Committee sees that a combination of direct and indirect involvement of the industry and research sectors is essential in improving the quality and relevance of mathematics and science education in Victoria.

The Committee notes there are a reasonable number of mathematics and science education and awareness programs involving industry. Nonetheless, direct industry involvement within schools and learning communities appears to be quite limited. Often, industry investment in education and awareness programs is limited to sponsorship of various events.³⁹¹ The Committee considers this disappointing, given the

³⁸⁸ Ms G. Graham, Accreditation and Industry Manager, Engineers Australia, Transcript of Evidence, Public Hearing, Melbourne, 31 August 2005, p.15.

³⁸⁹ Information provided to the Committee by the Victorian Curriculum & Assessment Authority, 2 February 2006.

³⁹⁰ Mr M. White, Chief Executive Officer, Victorian Curriculum & Assessment Authority, Transcript of Briefing, Melbourne, 18 April 2005, p.17.

³⁹¹ Examples of industry-sponsored mathematics and science education and awareness programs include Siemens Science Experience, BHP Billiton Science Awards and Shell Questacon Science Circus. In Western Australia, the STAR peer tutor program has been continually sponsored by industry.

interest industry has in ensuring education systems produce students with the knowledge and skills required for continued innovation and advancement. Schools cannot, and should not be expected to solve the problems associated with current skills shortages. While schools can strive to prepare students to meet the needs of industry, they cannot achieve this without a much stronger and ongoing involvement from industry. While increased sponsorship of various programs would be most welcome, the Committee also supports the calls of key stakeholders, including the Australian Science Teachers Association, for industry to make greater efforts to become more directly involved in mathematics and science education in schools:

Groups, including industry associations of an engineering or technical nature, seek endorsement or assistance in promoting the 'enabling' sciences and maths in schools as a vehicle for ensuring provision of their future technical employees. But these groups tend to have little idea of current school culture, or how to effectively impact on it, and they often operate in isolation rather than in a coordinated way.³⁹²

Effective linkages between the education, research and industry sectors ensure that best practice and new learning in the mathematics and science disciplines can be shared with students and teachers. Governments play an important role in facilitating the establishment of cross-sectoral linkages, which can often become self-sustaining once the various partners see the benefits. The Victorian Government highlighted in its submission to this inquiry that, consistent with its *Growing Victoria Together* policy, it is committed to:

- increasing networking, collaboration and interaction between academia and industry at all levels of education and training; and
- developing policies and programs that encourage mobility of staff between research, education and industry.³⁹³

The above mechanisms have been shown internationally to improve skill and knowledge transfer between sectors and more closely align the interests and expectations of education systems and industry.

To facilitate better integration of business, industry and research applications of mathematics and science into mathematics and science education, the Committee believes more regular industry–education 'events' would be worthwhile. The Committee therefore recommends

³⁹² Australian Science Teachers Association 2005, *Response from the Australian Science Teachers Association to the Discussion Paper Audit of Science, Engineering and Technology Skills*, ASTA, Canberra, provided as supplementary materials to the Committee by Ms A. Forbes, August 2005.

³⁹³ Written Submission, Victorian Government, June 2005, p.8.

that the Department of Innovation, Industry and Regional Development, in conjunction with the Department of Education and Training, host a triennial conference involving high-level representatives of the business, industry, research and education sectors. These conferences should be focused on showcasing recent advancements in the application of mathematics and science within the economy and developing approaches for the effective integration of these applications into schools and learning communities.

Recommendation 7.6: That the Department of Innovation, Industry and Regional Development, in conjunction with the Department of Education and Training, host a triennial conference involving high-level representatives of the business, industry, research and education sectors. The conferences should focus on:

- showcasing recent advancements in the application of mathematics and science within the economy; and
- developing approaches for the effective integration of these applications into schools and learning communities.

8. Teacher Supply and Demand

The Committee received a considerable amount of evidence regarding the supply and demand of mathematics and science teachers. Evidence focused on the profile of the current mathematics and science teacher workforce, the attractiveness of a teaching career relative to other career options and the adequacy of the number of teacher education places currently being allocated to the mathematics and science disciplines.

Profile of the Victorian Teaching Workforce

As at 2003, there were over 58,000 teachers employed in Victorian schools. Figure 8.1 shows a breakdown of the number of full-time equivalent (FTE) primary and secondary teachers employed within the government and non-government sectors.

Figure 8.1: Employment of (FTE) Teachers in Victoria (2003)

Sector	Primary	Secondary	Total
Government	19,509	18,155	37,664
Non-Government	8,427	12,118	20,545
Total	27,936	30,273	58,209

Source: Adapted from MCEETYA 2004, *Demand and Supply of Primary and Secondary Teachers in Australia*, p.9

The profile of the teacher workforce has been documented over recent years, in key studies such as:

- *Teacher Supply and Demand Report for Victoria*, an annual report commissioned by the Teacher Supply and Demand Reference Group.
- *Demand and Supply of Primary and Secondary School Teachers in Australia*, a biennial report published by the Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA).
- *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics*, published by the Committee for the Review of Teaching and Teacher Education, October 2003.

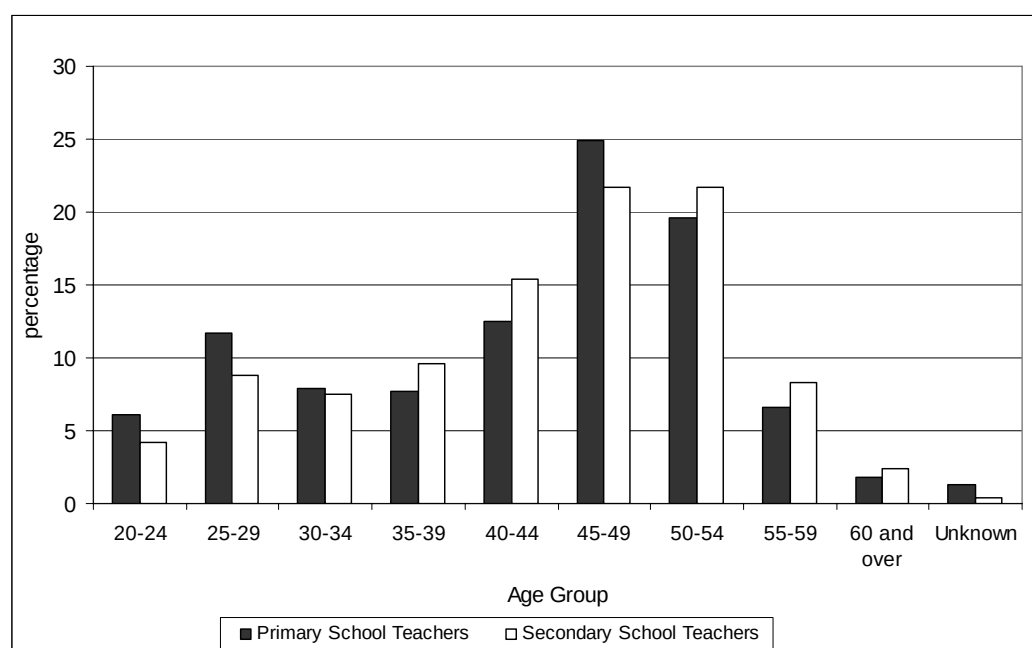
The following section provides a snapshot of the current Victorian teaching workforce, based on the above studies.

Age Profile of the Teaching Workforce

Census data reveals that the teacher workforce is generally older than the rest of the professional workforce, with the highest proportion of teachers aged in their middle to late 40s.³⁹⁴

Figure 8.2 shows the age profile of government primary and secondary school teachers in Victoria in 2003. One quarter of government primary teachers were in the 45–49 age range in 2003 and a further 28.0 per cent were aged 50 or older. The secondary school sector exhibits an older workforce profile compared with the primary school sector. In 2003, 21.7 per cent of Victorian government school secondary teachers were aged 45–49 and a further 32.4 per cent were aged over 50. *Australia's Teachers: Australia's Future* reported that male teachers are concentrated much more heavily in the older age groups and that this trend is set to continue.³⁹⁵

Figure 8.2: Proportion of Victorian Government School Teachers by Age Group (2003)



Source: Compiled by the Education and Training Committee from MCEETYA 2004, *Demand and Supply of Primary and Secondary Teachers in Australia*, pp.11-13.

³⁹⁴ Ministerial Council on Education, Employment, Training & Youth Affairs 2004, *Demand and Supply of Primary and Secondary School Teachers in Australia*, MCEETYA, Melbourne, p.10.

³⁹⁵ Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Agenda for Action*, Commonwealth of Australia, Canberra, p.15.

The 2004 *Teacher Supply and Demand Report* also highlighted the ageing teacher workforce in the Victorian government school sector. For mathematics teachers, it reported:

The age profiles of Mathematics teachers in a sample survey of Government secondary schools shows a significant shift in the peak age group from 40–44 years in 1995 to 50–54 years in 2004. Even more dramatically the percentage of surveyed Mathematics teachers in the 50–54 year age group has grown from 9.7 per cent in 1995 to 23.7 per cent in 2004. More broadly the proportion of mathematics teachers aged 45 years and over has grown from about one third to well over half.³⁹⁶

The same report also found an ageing of the workforce among science teachers in Victorian government secondary schools over the period 1995 to 2004. The largest single age group of science teachers shifted from the 40–44 year cohort to the 50–54 year cohort, and the 45–49 year cohort remained almost unchanged.³⁹⁷ These trends suggest a 'large-scale generational change in the profession resulting from expected retirements at unprecedented rates is likely in the next few years'.³⁹⁸ The ageing profile of mathematics and science teachers therefore has implications for future supply and demand in these disciplines. It also suggests that a significant proportion of teachers are many years past their initial teacher education. Therefore, unless these teachers have continued to engage in professional development within their discipline, many current secondary teachers may not have in-depth knowledge about the rapidly advancing applications of the mathematics and science disciplines in areas such as biotechnology, laser technology, nanotechnology or synchrotron science. This issue is discussed in Chapter 9.

Gender Profile of the Teaching Workforce

Female teachers dominate the primary teaching workforce across Australia and, in Victoria, accounted for 79.9 per cent of primary teachers in 2003.³⁹⁹ In the secondary sector, the balance between female teachers and male teachers is more even, with females accounting for 56.8 per cent of Victorian secondary teachers in

³⁹⁶ Teacher Supply & Demand Reference Group 2004, *Teacher Supply and Demand Report*, DE&T, Melbourne, p.4.

³⁹⁷ *ibid.*, p.5.

³⁹⁸ Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Agenda for Action*, Commonwealth of Australia, Canberra, p.15.

³⁹⁹ Ministerial Council on Education, Employment, Training & Youth Affairs 2004, *Demand and Supply of Primary and Secondary School Teachers in Australia*, MCEETYA, Melbourne, pp.9–10.

2003.⁴⁰⁰ As reported in *Australia's Teachers: Australia's Future*, however, male teachers are better represented in secondary schools in the learning areas of science, technology and mathematics (and in more senior/promotion positions within schools).⁴⁰¹ The policy implications of this gender bias were raised in that report:

The role messages these phenomena may be sending to students are concerning, as are the possible effects of a profession unrepresentative of the composition of broader society.

It is therefore desirable that the number of male teachers, especially in primary schools, increase in coming years. It is also desirable that more females become teachers of science, technology and mathematics, and more female teachers aspire to, and obtain, formal positions of leadership within the profession.⁴⁰²

Discussion about gender differences in mathematics and science education is contained in Chapter 6. The Committee believes that male and female role models could be used more effectively, to assist in addressing some of these issues. Professor Sue Stocklmayer of the Centre for the Public Awareness of Science at the Australian National University in Canberra, for example, offered evidence that the effective use of role models, combined with relevant course content and assessment processes that reflect gender awareness, can assist in achieving a better gender balance in the sciences:

At the ANU, physics has a very atypical gender balance, due in part to the presence of several women lecturers (fulfilling a range of gender research recommendations including role modelling) and in part to young and enthusiastic men who have introduced courses which are cross-disciplinary and open-ended in their style. The courses do not patronize by being less rigorous, but they do allow for debate and speculation and creative assessment through portfolios and discussion boards. Such courses at school level are very rare.⁴⁰³

This may mean actively targeting male recruits into the areas of biological and health science and female recruits into the physical sciences. Other strategies may include the strategic use of either

⁴⁰⁰ *ibid.*

⁴⁰¹ Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Agenda for Action*, Commonwealth of Australia, Canberra, p.15.

⁴⁰² *ibid.*

⁴⁰³ Written Submission, National Centre for the Public Awareness of Science, Australian National University, September 2005, p.4.

gender in government and industry publications and case studies and in media promotion.

Australia's Teacher's: Australia's Future also noted that while Australia is one of the most ethnically and culturally diverse countries in the world, that this diversity is not reflected in the composition of the teaching profession.⁴⁰⁴ It therefore reported the need for the teaching profession to become more representative of the cultural and social diversity of the Australia community, if the education sector is to remain inclusive.⁴⁰⁵

The Committee found that there are some significant differences in the levels of participation and achievement in mathematics and science among students from different socioeconomic backgrounds. Additionally, Indigenous students and students from a language background other than English tended to achieve at a lower standard compared with other students in the National Numeracy Benchmarks and the National Year 6 Science Assessment (refer Chapter 5). International studies such as PISA and TIMSS have similarly found lower levels of achievement among these groups of students. The Committee therefore believes that strategic use of role models and active recruitment into the teaching profession should not only be aimed at addressing gender imbalances, but also at making mathematics and science education more inclusive for culturally and linguistically diverse students and those from lower socioeconomic backgrounds.

Demand for Mathematics and Science Teachers

Across Australia, most education authorities have generally reported an adequate supply of generalist teachers for the primary school sector, although recruitment difficulties are experienced in some locations. In 2003, Victoria was 'just able to satisfy demand' for primary teachers.⁴⁰⁶

In the secondary school sector, states and territories have commonly reported difficulties in filling vacancies located in rural, remote and 'difficult to staff' metropolitan locations and for particular specialisations.⁴⁰⁷ MCEETYA reported that mathematics, science and technology continue to present the greatest recruitment difficulties Australia wide, within both the government and non-government school

⁴⁰⁴ Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Agenda for Action*, Commonwealth of Australia, Canberra, p.15.

⁴⁰⁵ *ibid.*

⁴⁰⁶ Ministerial Council on Education, Employment, Training & Youth Affairs 2004, *Demand and Supply of Primary and Secondary School Teachers in Australia*, MCEETYA, Melbourne, p.25.

⁴⁰⁷ *ibid.*, p.29.

sectors.⁴⁰⁸ Professor John McKenzie, Dean of the Faculty of Science at the University of Melbourne further noted that government schools experience more recruitment difficulties than those in the non-government sector:

If you look at the difficulty that schools have in attracting and retaining teachers in science generally, but particularly teachers in physics and chemistry, if you are in a government school you have a much greater challenge than if you are in a Catholic school, which in turn has a greater challenge than if you are in a private school. If you are in a government school in a regional area your probability of attracting a physics teacher is very low indeed.⁴⁰⁹

The 2004 *Teacher Supply and Demand Report for Victoria* reported that the number of mathematics vacancies that were difficult to fill was higher in 2004 compared with 2000. However, the number of difficult to fill science vacancies was lower.⁴¹⁰ Victoria also reported to the MCEETYA study that approximately 30 per cent of teaching vacancies in non-metropolitan secondary schools were reported as difficult to fill, compared with 14 per cent of those in metropolitan secondary schools.⁴¹¹ Included in the top ten most difficult to fill subjects in that study were mathematics, science and physics.⁴¹²

The Victorian Government's *Skills in Demand List* also reports teacher shortages in a range of secondary disciplines in outer metropolitan and non-metropolitan regions.⁴¹³ As at June 2005, the List included mathematics and physics teachers (refer Figure 8.3 showing local government areas experiencing difficulty recruiting mathematics teachers in government secondary schools). The recruitment difficulties being experienced in non-metropolitan areas are of particular concern to this Committee, in the context of the tendency for lower levels of participation and achievement in mathematics and science among rural and regional students, compared to their metropolitan counterparts (refer Chapter 6).

⁴⁰⁸ *ibid.*, p.29 & p.34.

⁴⁰⁹ Transcript of Evidence, Public Hearing, Gene Technology Access Centre, Melbourne, 6 May 2005, p.15.

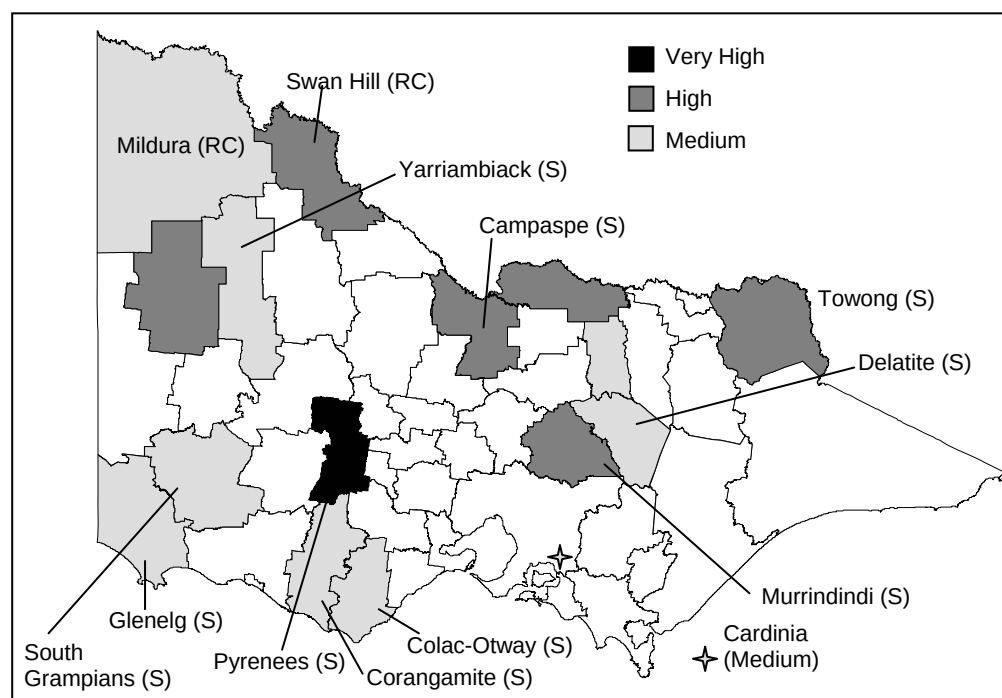
⁴¹⁰ Teacher Supply & Demand Reference Group 2004, *Teacher Supply and Demand Report*, DE&T, Melbourne, p.11.

⁴¹¹ Ministerial Council on Education, Employment, Training & Youth Affairs 2004, *Demand and Supply of Primary and Secondary School Teachers in Australia*, MCEETYA, Melbourne, p.139.

⁴¹² *ibid.*

⁴¹³ Victorian Government 2005, *STNI – Skills in Demand* July 2005, accessed on the Skilled Migration Program website, <<http://www.liveinvictoria.vic.gov.au>> on 10 January 2006.

Figure 8.3: Government Secondary Schools Experiencing Difficulty Recruiting Mathematics Teachers by Local Government Areas (2002 to 2004)



Source: Teacher Supply & Demand Reference Group 2004, *Teacher Supply and Demand Report*, p.12.

Although research consistently reports mathematics and science teacher shortages, it is very difficult to quantify these shortages. This is partly due to the lack of consistent, reliable data regarding existing teacher qualifications, allocation among disciplines within teacher education institutions and the difficulties in projecting future needs for teachers in specific disciplines. It should also be noted that where teachers are teaching 'out of field', this can cause an under-estimation of the extent of recruitment difficulties or teacher shortages.⁴¹⁴

The Department of Education and Training advised the Committee that it does not currently hold data relating to the subject specific qualifications of teachers in Victoria.⁴¹⁵ The Victorian Institute of Teaching similarly reported that its register of Victorian teachers does not currently incorporate this information, although the Institute has a responsibility to develop a public register that identifies the full qualifications of teachers.⁴¹⁶ Therefore, with the requirement for

⁴¹⁴ The 2002 TIMSS suggested that 10% of Australian Year 8 science teachers did not have science or science education as their major area of previous study. The equivalent figure for Year 8 mathematics teachers was significantly larger, at 30%. Refer S. Thomson & N. Fleming 2004, *Summing it up: Mathematics achievement in Australian schools in TIMSS 2002 (TIMSS Australia Monograph no. 6)*, ACER, Melbourne, p.81.

⁴¹⁵ Correspondence from the Department of Education & Training, 27 June 2005.

⁴¹⁶ Ms S. Halliday, Chairperson, Victorian Institute of Teaching, Transcript of Evidence, Public Hearing, Melbourne, 8 August 2005, p.27.

teachers to provide full details of their qualifications upon re-registration (commencing 2007), it will be possible in the future to obtain a far clearer picture of the range of specific subject qualifications held by Victorian teachers.⁴¹⁷ This information should be provided to the Commonwealth Government and to universities, to assist in the process of allocating teacher education places among universities and specific disciplines (refer to discussion below).

The Committee recognises the Victorian Government's efforts in seeking to address teacher shortages within specific geographic locations and targeted curriculum areas. The Government's initiatives were outlined in its response to this Committee's previous report, *Step Up, Step In, Step Out: Report on the inquiry into the suitability of pre-service teacher training in Victoria*.⁴¹⁸ The initiatives include:

- Teaching scholarships, which have been available each year since 2001 to attract the best and brightest teacher graduates to employment in government schools in hard to staff curriculum and geographical areas across Victoria.
- The Graduate Recruitment Program, which provides employment opportunities to recent high quality graduates, particularly in targeted geographic/curriculum areas.
- The Career Change Program, under which schools can employ an experienced professional (such as an engineer, IT professional or tradesperson) as a trainee teacher.
- The Student Teacher Practicum Scheme, which offers financial incentives to student teachers to undertake practicum placements in rural and outer metropolitan schools.
- Rural Retraining, allowing current staff to retrain in subject areas of recruitment difficulty.
- Refresher Training, which offers a professional development course for returning teachers and experienced teachers seeking to re-enter the teaching workforce.

⁴¹⁷ Detailed information on qualifications has already been collected for around 20,000 new teacher registrations since 2001.

⁴¹⁸ Department of Education & Training 2005, Government Response to the Education and Training Committee's Report on the Suitability of Pre-Service Teacher Training in Victoria, DE&T, Melbourne, p.2.

The Committee believes that the above initiatives will go some way towards addressing the recruitment difficulties being experienced in certain geographic and curriculum areas. Additional work aimed at making a teaching career more attractive, which is being undertaken by the Victorian Government and the Commonwealth Government, complements the above initiatives. The Committee also believes however that the Commonwealth Government should offer more university places for teachers training in the mathematics and science disciplines, as well as incentives for potential entrants to access these places. A Commonwealth Government response to these issues will become increasingly critical as the Committee's vision for increased levels of participation in mathematics and science education in schools is realised.

Attracting and Recruiting the Teaching Workforce

Teacher demand arises from a number of sources, including the number of student enrolments, staff attrition rates and leave arrangements and government policy associated with factors such as student to teacher ratios, school start and leaving age and the range of subjects taught. Taking into account such factors, the Teacher Supply and Demand Reference Group projected that over the five years to 2008, an average estimated 2,500 new (FTE) teachers would be required each year in government schools.⁴¹⁹ Demand was expected to be greater for secondary teachers, with the number of new secondary teachers required rising to 1,450 by 2008.⁴²⁰ This has implications in areas such as mathematics and science, where there are already some areas of recruitment difficulty.

According to *Australia's Teachers: Australia's Future*, new graduates constitute around 70 per cent of the new supply of teachers.⁴²¹ The *Teacher Supply and Demand Report for Victoria* reports, however, that the 'estimated supply of teacher graduates alone will be insufficient to meet forecast total demand for Victorian schools, resulting in an estimated need to recruit an additional 650 teachers on average each year to staff government and non-government schools'.⁴²² Given this, the Victorian Government must look to alternative sources of supply, including previous years' graduates not working in the profession, teachers returning from leave, former teachers returning to teaching,

⁴¹⁹ Teacher Supply & Demand Reference Group 2004, *Teacher Supply and Demand Report*, DE&T, Melbourne, p.21.

⁴²⁰ *ibid.*

⁴²¹ Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Background Data and Analysis*, Commonwealth of Australia, Canberra, p.66.

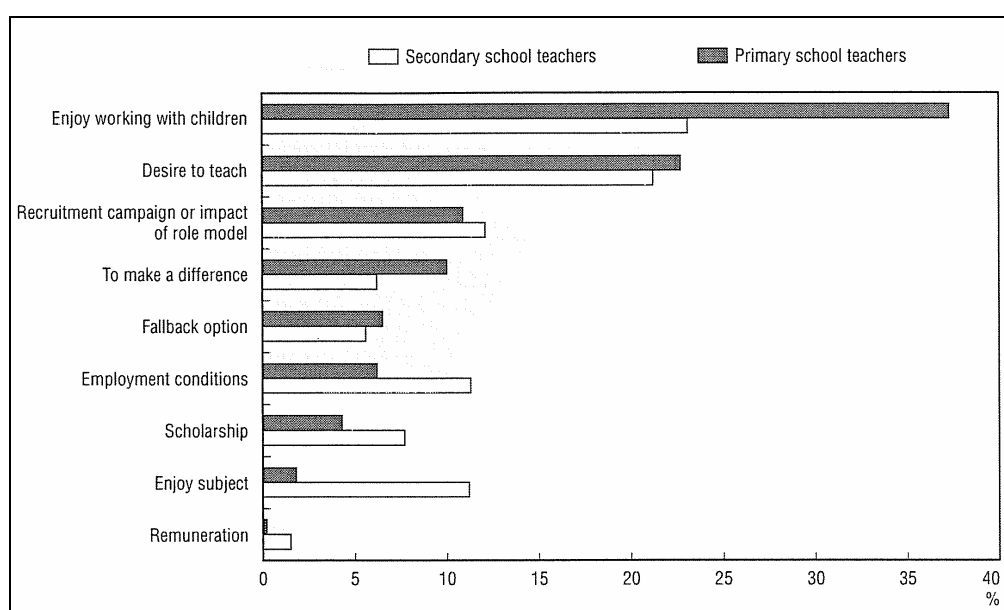
⁴²² Teacher Supply & Demand Reference Group 2004, *Teacher Supply and Demand Report*, DE&T, Melbourne, p.30.

the pool of casual and relief teachers and interstate and overseas migration.

Attractiveness of a Teaching Career

The Victorian Government, like many other governments worldwide, has given increased attention over recent years to the need to attract, recruit and retain high quality teachers within the profession. A recent study by the OECD found there are many different motivations for becoming a teacher. Within Australia, a survey of 2,500 primary and secondary teachers found that 'enjoying working with children' and a 'desire to teach' were the top two motivations (refer Figure 8.4). Attractive salaries were found to be important, however teachers also placed a lot of emphasis on the quality of their relations with students and colleagues, on feeling supported by school leaders, on good working conditions and on opportunities to develop their skills.⁴²³

Figure 8.4: The Most Important Motivations for Becoming a Teacher (Australia) (2002)



Source: OECD 2005, *Teachers Matter: Attracting, developing and retaining effective teachers*, p.55.

The above findings demonstrate that there are many factors that make teaching an attractive career option for people. The Committee believes that the key factors making teaching a highly attractive option in Victoria include:

- having the opportunity to significantly influence the lives and future of young people;

⁴²³ Organisation for Economic Co-operation & Development 2005, *Teachers Matter: Attracting, Developing and Retaining Effective Teachers*, OECD, Paris, p.55.

- being able to achieve a better work-life balance compared with other careers;
- relative security of tenure;
- being able to develop readily transferable skills and qualifications; and
- a highly competitive beginning teacher salary.

The Committee also recognises, however, that for some people, teaching is seen as a less attractive career option than some other professions. The review of the status and quality of teaching and learning science in Australian schools found that 'many teachers feel under valued, under-resourced and overloaded with non-teaching duties'.⁴²⁴ The Committee similarly found that some stakeholders believe that the teaching profession holds a low status within the broader community. This is a trend that has been identified across a number of OECD nations:

Teaching is a profession in long-term decline. As societies have become wealthier and educational qualifications have increased and employment opportunities have expanded, teaching's appeal as a path to upward social mobility and job security does seem to have diminished. Widespread concerns about the difficulties faced by many schools, fuelled by often negative media reporting, have damaged teaching's appeal.⁴²⁵

The Committee noted that the Association of Principals of Catholic Secondary Schools in Australia has suggested that many teachers actively discourage secondary students from pursuing a career in teaching.⁴²⁶ The Committee therefore suggests that while governments can continue to promote the attractiveness of teaching as a career, teachers themselves must also play an increasing role in promoting their profession. This perspective was shared by some participants in this inquiry, including Associate Professor Sue Stockmayer of the Centre for the Public Awareness at the Australian National University:

I was asked by a science teacher how [science teaching careers could be promoted] and my reply to him was to ask how much HE promoted it amongst his high-achieving boys [students]. He was silent –

⁴²⁴ D. Goodrum, M. Hackling & L. Rennie 2001, *The Status and Quality of Teaching and Learning of Science in Australian Schools*, report prepared for the Department of Education, Training & Youth Affairs, Commonwealth of Australia, Canberra, p.viii.

⁴²⁵ Organisation for Economic Co-operation & Development 2005, *Education Policy – Teachers Matter: Attracting, Developing and Retaining Effective Teachers – Overview*, OECD, Paris, p.5.

⁴²⁶ D. Wroe, 'Teachers urge bright students not to teach', *The Age*, 18 May 2005, p.7.

confirming that we encourage our best and brightest into research careers without thought that for some, teaching might be much more fulfilling.⁴²⁷

In order to encourage more students to consider a teaching career, Professor Stockmayer suggested that secondary school students should be given opportunities to experience teaching as a career in the senior years of schooling:

This has two advantages – natural talent for teaching will emerge, and the experience of explaining their science to other, younger students will benefit both the senior student who has to clarify ideas in their own mind, and the younger student who has a role model to follow. The idea is not new, but is once again rare, especially in prestigious schools where the focus is on passing the examinations – that is, getting through the overloaded curriculum.....!⁴²⁸

The Minerals Council of Victoria similarly suggested that existing teachers, especially teachers of mathematics and science, should be ambassadors for their profession:

We would suggest that we encourage the active promotion of teaching as a valuable and worthwhile profession by teachers and the wider community. We believe there is a very neglected opportunity with teachers who have the first call to our work force — in that they are sitting in front of them — and that they should be promoting their own careers to those students. That is a missed opportunity ... if we have a problem with attracting maths and science teachers, they are the best marketing tool we have.⁴²⁹

Australia's Teachers: Australia's Future also highlighted the role of the existing profession in raising awareness and appreciation of teaching:

Realistic and positive advice about teaching as a career needs to be offered through careers advisers and teachers themselves in all secondary schools.⁴³⁰

Professor Stockmayer's point about allowing secondary students opportunities to experience aspects of teaching was also highlighted in *Australia's Teachers: Australia's Future*:

⁴²⁷ Written Submission, National Centre for the Public Awareness of Science, Australian National University, September 2005, p.4.

⁴²⁸ *ibid.*

⁴²⁹ Mr C. Fraser, Executive Director, Victorian Division, Minerals Council of Australia, Transcript of Evidence, Public Hearing, Melbourne, 31 August 2005, p.28.

⁴³⁰ Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Agenda for Action*, Commonwealth of Australia, Canberra, p.23.

All schools ought to provide secondary students with opportunities to help younger students with their learning. In addition to its recognised two-way educational value, such opportunities help older students form early, informed judgements about their interest in and suitability for teaching.⁴³¹

The Committee believes that it is not only secondary school students that should be encouraged and supported to consider and experience a future teaching career. Governments, employment authorities and universities could also do more to actively promote a teaching career among existing university students undertaking mathematics and/or science related degrees. The Committee is aware of models internationally where university students in disciplines such as science, are actively targeted and encouraged to complete relevant teacher education units that can be fully credited against a teacher education qualification if they subsequently elect to take that pathway. This allows existing university students who may not have previously considered a teaching career, to experience that option before having to fully commit to a teacher education qualification.

Teacher Salaries and Career Structures

Not surprisingly, some submissions and witnesses suggested that higher teacher salaries and a changed career structure could result in increased attractiveness of teaching as a career. While there is widespread recognition that the commencing salary for graduate teachers in Victoria is relatively competitive, there is also some concern that teachers' salaries reach a plateau relatively early in a teacher's career. Some submissions also suggested that the salary plateau does not compare favourably with the salary and career potential of other careers requiring a mathematics and/or science background.⁴³²

The Committee acknowledges the policy implications of current salary and career structures in the context of a rapidly modernising teaching profession. Teaching is not immune from the changing workforce patterns across industries, whereby there is increasing movement of individuals between roles, organisations and professions. The skills and knowledge developed through a teaching career are often very attractive to employers in other industries, making it relatively easy for a teacher to work within an educational role within a broad range of organisations or even to make a total career change into a new industry.

The reverse is not always true. It seems that relevant skills and knowledge of a broad range of career-change professionals are not as

⁴³¹ *ibid.*, p.23.

⁴³² See for example, Written Submission, Mathematics Education Research Group of Australasia, February 2005, p.5.

readily recognised by education authorities. This Committee's previous report outlined in depth the barriers faced by career-change entrants into teaching and the need to facilitate entry through more flexible design and delivery of teacher education.⁴³³ The Committee recommended that the Victorian Institute of Teaching, in conjunction with the universities, develop a comprehensive framework for relevant knowledge, skills and previous experience to be formally recognised. It further recommended that an accelerated postgraduate teacher education program be developed.⁴³⁴ The Victorian Government's response to the Committee's report indicated that the first element of the recommendation will be incorporated into the Victorian Institute of Teaching standards and guidelines. Further, the Institute will work with universities during 2006 to develop and implement the second element of the recommendation.⁴³⁵

In Victoria, teacher salaries are generally structured to reflect length of tenure, as well as teaching experience. New entrants are therefore required to commence their teaching career on the base salary. The Committee believes, however, there are many career-change professionals with highly valued skills and experience that should perhaps be recognised through a salary that is higher than that offered to a new graduate entering teaching with an undergraduate qualification. The Committee therefore believes that as an additional incentive to attract highly qualified and experienced people with relevant mathematics and science backgrounds, the Victorian Government could consider a revised career and salary framework that better recognises the relevant skills and experience such teachers bring into the classroom.

Governments could also consider the merits of incentives such as the 'Golden Hellos' used in the United Kingdom, which Committee Member, the Hon Helen Buckingham MLC investigated during a study tour in 2005. 'Golden Hellos' were introduced in 2003 as an incentive aimed at addressing teacher shortages. 'Golden Hellos' are part of a comprehensive incentive package that includes fee-free tuition for postgraduate teacher education studies, a training bursary of £9,000 for those training in mathematics or science teaching and a £5,000 'Golden Hello' upon completion of the teacher induction requirements.⁴³⁶ Similar incentives are offered for other subject areas

⁴³³ Education & Training Committee 2005, *Step Up, Step In, Step Out: Report on the inquiry into pre-service teacher training in Victoria*, Parliament of Victoria, Melbourne, pp.69–98.

⁴³⁴ *ibid.*, p.93.

⁴³⁵ Department of Education & Training 2005, *Government Response to the Education and Training Committee's Report on the Suitability of Pre-Service Teacher Training in Victoria*, DE&T, Melbourne, p.8.

⁴³⁶ Department for Education & Skills website, <<http://www.dfes.gov.uk/go4itnow/>>, accessed on 27 January 2006.

of shortage, while reduced incentives apply for remaining postgraduate entrants into either primary or secondary teaching.⁴³⁷

Recommendation 8.1: That the Victorian Government consider offering additional incentives to attract postgraduate entrants into teaching in the mathematics and science disciplines.

Teacher Education Places

The 2003 MCEETYA report, *Demand and Supply of Primary and Secondary School Teachers in Australia* estimated that, depending on the success of government policy initiatives to attract and retain teachers, shortages of up to 20,000 to 30,000 teachers Australia wide may occur later in the decade. Projections for Victoria also reveal that future demand for teachers, particularly in hard to staff curriculum or geographic areas, may be difficult to satisfy. The Committee therefore welcomes the declaration under the *Commonwealth Grant Scheme Guidelines* that 'increasing the number of persons undertaking teaching' is a national priority. Measures applied to National Priorities (teaching and nursing) include increased Commonwealth Government course contributions, lower student contribution charges and provision of additional teacher education places in public and private institutions.⁴³⁸

Allocation of Teacher Education Places

Despite designation of teacher education as a National Priority, it is still not evident to the Committee that the Commonwealth Government has been able to fully address issues regarding the supply and demand for secondary teachers. Concerns about the allocation of teacher education places between primary and secondary teaching and between subject disciplines were raised during a recent inquiry conducted by the NSW Parliament Legislative Council Standing Committee on Social Issues into the recruitment and training of teachers:

The [NSW Department of Education and Training] expressed concern that in some instances, universities were allocating course places in response to student demand, as opposed to workforce need. Decisions regarding curriculum do not always correspond with the

⁴³⁷ *ibid.*

⁴³⁸ Department of Education, Science & Training 2004, *Commonwealth Grant Scheme – National Priority Areas*, Fact Sheet March 2004, DEST, Canberra, accessed on Backing Australia's Future website, <<http://www.backingaustraliasfuture.gov.au>> on 27 January 2006.

need of employers, for example NSW universities continue to train large numbers of primary school teachers despite well-documented projections of an oversupply. The Department was particularly concerned about the large number of primary teaching places being offered by universities, compared with secondary teacher education places.⁴³⁹

The above concern was also reported by MCEETYA in 2004:

The composition of new entrants to teaching is also of interest ... a large proportion of new teaching graduates enter primary sector teaching, while the composition of demand is shifting more towards secondary teaching. Moreover, recent trends in the composition of new supply of secondary teachers considered by specialisation are not encouraging.⁴⁴⁰

The MCEETYA report went on to outline the policy challenges associated with balancing teacher supply and demand over the coming decade:

Beyond raw numbers of teachers, workforce planners will increasingly be faced with the challenge of finding the teachers with the right skill sets in the right location – or prepared to move there. To achieve this, they need to obtain the right mix of teaching graduates from universities, and to tap into sources beyond new graduates. Not all graduates of teaching courses go into teaching. This suggests a need for greater liaison between university education faculties and teacher employers, to ensure that the supply of teachers reflects employment needs.⁴⁴¹

Australia's Teachers: Australia's Future also reported that 'in some States and Territories and for some education authorities, projected teacher workforce needs do not formally inform teacher education enrolment targets in programs run by higher education institutions'.⁴⁴² The review called for sufficient teacher education places to be allocated, and for these places to be allocated appropriately:

Teacher education places should be allocated by number and discipline mix in order to meet future workforce needs. Specifically, the allocation of places

⁴³⁹ Standing Committee on Social Issues 2005, *Recruitment and Training of Teachers*, NSW Parliament Legislative Council, Sydney, p.26.

⁴⁴⁰ Ministerial Council on Education, Employment, Training & Youth Affairs 2004, *Demand and Supply of Primary and Secondary School Teachers in Australia*, MCEETYA, Melbourne, p.129.

⁴⁴¹ *ibid.*, p.130.

⁴⁴² Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Agenda for Action*, Commonwealth of Australia, Canberra, p.17.

will need to take account of the shift in demand from primary to secondary, for specialist fields, particularly physics, chemistry, technology, mathematics and LOTE, and for specific geographic regions.⁴⁴³

Reforms to higher education in 2003 saw the replacement of the previous block grants system of funding with the new Commonwealth Grant Scheme (CGS). Through the CGS, the Commonwealth Government provides a contribution, set by discipline, towards the cost of an agreed number of commonwealth supported places. Each higher education institution that receives funding under the CGS enters into a Funding Agreement with the Commonwealth Government, with annual negotiations taking place over the number of places and the discipline mix that the Commonwealth Government will support.⁴⁴⁴ The Committee calls upon the Commonwealth Government to ensure that the CGS is utilised effectively for the appropriate allocation of teacher education places in the future. The Committee suggests that the Victorian Government can contribute to this process, by supplying detailed information regarding teacher qualifications (after the 2007 Victorian Institute of Teaching teacher re-registration process is complete) and projections of future demand for teachers across subject disciplines to the Commonwealth Government and to teacher education providers.

Recommendation 8.2: That the Victorian Government pursue through the Ministerial Council on Education, Employment, Training and Youth Affairs, strategies that result in sufficient teacher education places being allocated within priority disciplines such as mathematics and science.

⁴⁴³ *ibid.*, p.18.

⁴⁴⁴ Department of Education, Science & Training website, <http://www.dest.gov.au/sectors/higher_education/programmes_funding/general_funding/cgs/>, accessed on 27 January 2006.

Student Contribution Charges

The Committee notes that in working towards a more balanced subject mix among new teacher graduates, the Commonwealth Government will also need to review student contribution charges (formerly known as HECS), which currently act as a disincentive to qualify as a mathematics or science teacher (refer Figure 8.5).

Figure 8.5: Comparison of the Student Contribution Charge to Qualify as a Secondary Teacher (2006)

Secondary Teaching Qualification	Monash University [#]	La Trobe University*	University of Melbourne*
Humanities Disciplines	\$18,512	\$18,695	\$18,930
Science Disciplines	\$23,052	\$24,857	\$24,060

Note: * Student contribution charges are based on the cost to students of a commonwealth supported place in a science or arts undergraduate degree, combined with a commonwealth supported place in a diploma of education.

[#] Student contribution charges are based on the cost of combined bachelor of education/bachelor of arts or bachelor of education/bachelor of science.

Source: Constructed by the Education and Training Committee, using data obtained from the Department of Education, Science & Training website <<http://www.goingtouni.gov.au/CourseAdvancedSearch.htm>>, accessed 14 February 2006.

Indeed, the Committee is somewhat surprised that this issue has not already been addressed, given that the Committee for the Review of Teaching and Teacher Education covered the issue in depth in 2003:

... those qualifying to teach through completion of a Bachelor of Science degree followed by a graduate teacher education award accrue a higher HECS debt than other teachers, but receive the same pay once employed as teachers. The great majority of newly qualifying science and mathematics teachers are in this category. A number of submissions to the Review commented that the higher HECS liability faced by teachers of science, technology and mathematics, combined with teacher pay rates that do not distinguish between specialist areas such as science and mathematics, acts as a disincentive for graduates in those fields to take up teaching.⁴⁴⁵

⁴⁴⁵ Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Agenda for Action*, Commonwealth of Australia, Canberra, p.20.

The Review proceeded to state that teachers of science, technology and mathematics should not pay more HECS than other teachers:

New secondary and primary teachers of science, technology and mathematics should not pay more HECS than teaching colleagues. Similarly, those teachers who enrol in higher education units in science, technology and mathematics for the purpose of enhancing their professional expertise should not pay more HECS than colleagues enrolled in units in other disciplines.⁴⁴⁶

The Committee received many comments outlining concerns about the inequities and disincentives inherent in current Commonwealth Government student contribution charges. As evidenced by the following comments, participants in the inquiry were not necessarily advocating for significant advantages for mathematics or science teachers, over and above teachers of any other discipline. Rather, they were often simply highlighting the unfairness of current student contributions.

As Professor John McKenzie, The University of Melbourne, commented:

The circumstances at the moment are that Kaye has done an arts degree and Rod has done a science degree. They are both teaching in the same classroom or the same school and they are both being paid the same salary. Rod has a significantly higher HECS debt than does Kaye. I understand the reality of removing the HECS debt completely, but equalisation of HECS debt would have a huge symbolic impact.⁴⁴⁷

Mr Neil Champion similarly stated:

... science graduates these days have HECS debts that are higher than those of arts graduates. Why would they come into teaching if they are not going to get the equivalent take-home pay of their colleagues? How do you fix that? Obviously one way of doing it is to subsidise the difference. I think that is a very simple way of making sure that they come out with a take-home pay that is the same as every other person. That is quite different from then saying that science teachers ... ought to get more.⁴⁴⁸

Other participants, however, felt that the importance of mathematics and science within an innovation economy warranted additional

⁴⁴⁶ *ibid.*

⁴⁴⁷ Transcript of Evidence, Public Hearing, Gene Technology Access Centre, Melbourne, 6 May 2005, p.22.

⁴⁴⁸ Transcript of Evidence, Public Hearing, Melbourne, 8 August 2005, p.10.

incentives for those studying to become mathematics and science teachers.

Professor Kerry O. Cox, Vice-Chancellor, University of Ballarat:

Promoting greater interest by suitably qualified people to undertake maths and/or science teaching careers will require incentives for maths and science graduates to join the teaching profession. Incentives might include the waiving of student contribution amounts, a market loading, and for the regions, an area allowance.⁴⁴⁹

While the Committee does not advocate for a complete waiver of student contribution charges, the Committee agrees that the current situation appears counterproductive to the goal of raising levels of mathematical and scientific literacy within the community and of increasing industry competitiveness. The Committee is concerned not only that some potential mathematics and science teachers may be lost to other disciplines but also that those studying in other disciplines may be less likely to broaden their education by undertaking units of study from within the science disciplines. The Committee therefore believes that the Victorian Government should work with the Commonwealth Government, to ensure that student contributions do not act as a disincentive for teacher education students undertaking studies within the mathematics or science disciplines. Specifically, the Committee believes that debt arising from university studies should be equalised where mathematics and science graduates subsequently enter the secondary teaching workforce.

Recommendation 8.3: That the Victorian Government pursue through the Ministerial Council on Education, Employment, Training and Youth Affairs a review of student contribution charges, which currently act as a disincentive to qualification as a secondary mathematics or science teacher.

⁴⁴⁹ Written Submission, Vice-Chancellor's Office, University of Ballarat, December 2004, p.1.

9. Teacher Quality

Introduction

Teacher quality was identified as one of the most important factors supporting the high quality teaching and effective learning of mathematics and science. A major theme associated with teacher quality was the ability of teachers to create an engaging mathematics and science learning environment for students. For primary teachers, the main issues related to their knowledge, conceptual understanding and background in these two subjects and their level of confidence in delivering engaging mathematics and science lessons. It was seen as crucial for primary teachers to not only set in place the knowledge foundations for continued studies in these subjects, but also to engender in students a passion and understanding for the central importance of these subjects in modern society. For secondary teachers, the main issues focused on effective teaching strategies, making sure mathematics and science are relevant and engaging in the context of students' own lives and that industry and other real world applications are integrated into the curriculum. The rapidly advancing body of knowledge in areas of new science was also an important issue, particularly for secondary science teachers. In the context of these varied issues, a second theme associated with teacher professional development and professional communities arose within the Committee's evidence.

Teacher Qualifications

The Victorian Institute of Teaching is responsible for determining the qualifications required for teaching in Victorian schools. Aside from pre-service teacher training, teachers must have fulfilled a range of requirements to be considered formally qualified. Such requirements include pre-requisites for pre-service course entry and induction requirements for beginning teachers.

Current Victorian Institute of Teaching guidelines specify that primary teachers are expected to have good skills in numeracy and in oral and written communication. The guidelines specify that a desirable target is 'that entrants should have reached the standard equivalent to a "C" in VCE English Units 3 and 4 and *at least* satisfactory completion of VCE mathematics Units 1 and 2'.⁴⁵⁰

For secondary teachers, current guidelines set out what might be regarded as the *minimum* level of study applicable for preparation as a

⁴⁵⁰ Standards Council of the Teaching Profession 1999. *Guidelines for the Evaluation of Teacher Education Courses*, Department of Education, Melbourne, p.3.

subject area teacher in Victorian government schools.⁴⁵¹ Specialist area teachers are expected to have a sound understanding of the constructs of the discipline area, to be well versed in the knowledge and concepts required for teaching students in Victorian schools and to provide a variety of methodologies for addressing the needs of individual students.⁴⁵² Those teaching at VCE level may need a higher level of study than the minimum set out below:

- Mathematics teachers should have completed a sub-major in mathematics (statistics is accepted as mathematics provided it is taken within a mathematics department).⁴⁵³
- Generalist science teachers should have completed at least a sub-major in General Science, which includes studies in at least two of biology, chemistry, earth science/geology and physics *or* a sub-major in one of biology, chemistry, earth science/geology and physics, *together with* a part⁴⁵⁴ in another of these areas of study.⁴⁵⁵
- Specialist science teachers should have a sub-major study in the specialist science area.⁴⁵⁶

It should be noted that while the Institute sets out the above guidelines, it is not a requirement for employers to insist that a teacher hold particular specialist area qualifications in order to teach in a particular area. The reality of the school system means that it is sometimes necessary, or even preferable, for a teacher to be allocated to a subject that was not one of the main subjects in which they qualified as a teacher. *Australia's Teachers: Australia's Future* outlines a number of reasons for this: teachers need to fit into the requirements of the school in which they find themselves; changing curriculum patterns over the years; changing patterns of student subject choice; and changing

⁴⁵¹ Under the Victorian Institute of Teaching *Specialist Area Guidelines*, a major is defined as a total of three-quarters of a year of successful full-time tertiary study, usually comprising sequential discipline study taken over three years. A sub-major is defined as a total of half a year of successful full-time tertiary study, usually comprising sequential discipline study taken over two years.

⁴⁵² Victorian Institute of Teaching 2003, *Specialist Area Guidelines*, VIT, Melbourne, p.1.

⁴⁵³ *ibid.*, 4.

⁴⁵⁴ Under the Victorian Institute of Teaching 2003, *Specialist Area Guidelines*, VIT, Melbourne, a part is defined as successful tertiary study in a subject having the weighting of at least one quarter of a year of full-time study in the course from which it is derived.

⁴⁵⁵ Victorian Institute of Teaching 2003, *Specialist Area Guidelines*, VIT, Melbourne, p.5.

⁴⁵⁶ Examples of study areas applicable to each commonly taught science subject are: Biology – includes physiology, microbiology, botany, zoology; Chemistry – including biochemistry; Environmental Science – includes areas such as environmental science, environmental engineering, natural resource management, environmental management, biological sciences, chemistry, geography and earth science; Geology – includes earth science; Psychology – includes behavioural science; and Physics – includes electronics. Refer Victorian Institute of Teaching 2003, *Specialist Area Guidelines*, VIT, Melbourne, p.7.

teacher interests and expertise.⁴⁵⁷ Therefore, the significance of teaching 'out of field' varies:

... there are sometimes different priority needs between a Year 12 class where the teacher's depth of subject knowledge is vital, and a Year 8 class where encouraging student interest may be the prime objective. There are both positive and negative aspects to out-of-field teaching. [It] is a way for many teachers to extend their professional expertise and re-energise their teaching by taking on a new challenge. However, to the extent that teachers are being required to teach in disciplines for which they have inadequate expertise, out-of-field teaching is problematic ... Teachers regularly teaching in areas in which they lack adequate background must therefore be offered opportunities, support and incentives to acquire appropriate expertise.⁴⁵⁸

The Committee received some evidence highlighting concerns about teachers delivering secondary mathematics or science lessons 'out of field'. The Committee is aware that this has been a long-term debate, although what constitutes 'out of field' teaching and how widespread the practice is are difficult matters to determine.⁴⁵⁹ As noted in *Australia's Teachers: Australia's Future*, at the heart of the 'out of field' issue is the use of such terms as 'qualified teacher', 'adequately qualified teacher' and 'well qualified teacher'.⁴⁶⁰

Professor Peter Johnston, Discipline Head, Physics, RMIT University, suggested that one of the most significant factors inhibiting participation in mathematics and physics includes 'bad experiences in secondary schools because of a lack of properly qualified and enthusiastic staff'.⁴⁶¹

The Australian Catholic University National similarly highlighted concerns about the impact of 'out of field' teaching on student engagement in mathematics, noting:

[studies have] indicated that there had been a reduction of mathematics qualifications of secondary teachers in recent years with those over 45 having strong

⁴⁵⁷ Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Main Report*, Commonwealth of Australia, Canberra, p.83.

⁴⁵⁸ Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Agenda for Action*, Commonwealth of Australia, Canberra, p.41.

⁴⁵⁹ Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Main Report*, Commonwealth of Australia, Canberra, p.82.

⁴⁶⁰ *ibid.*

⁴⁶¹ Written Submission, Applied Physics, RMIT University, December 2004, p.1.

mathematics degrees mostly with majors in mathematics but those under 40 having mostly only minors in mathematics. Anecdotal evidence suggests that many who are teaching mathematics have never studied mathematics pedagogy. Similarly in Science there is a real shortage of those who have studied the physical sciences (as opposed to the biological sciences) teaching at the junior secondary school levels.⁴⁶²

The Australian Institute of Physics highlights its concern about the teaching of physics 'out of field' in its 2004 Policy Document. In that document, the Institute promotes the BEng/BSc plus DipEd model as the preferred option for training physics teachers, particularly those who are involved in teaching the senior secondary years, stating:

It is important the Physics teachers have a strong understanding of Physics at levels significantly higher than the level they teach. This is necessary for a clear understanding of concepts and the ability to take the more advanced students further.⁴⁶³

The Institute's policy is also 'strongly opposed to overcoming shortages in Physics teacher numbers for senior levels by the retraining of non-science teachers unless this retraining involves a program recognised by a professional body':

The AIP is strongly opposed to band-aid approaches that may have a deleterious effect on student knowledge, understanding and appreciation. Furthermore there is anecdotal evidence that poor teaching of Physics at secondary school results in fewer students taking Physics at the tertiary level.⁴⁶⁴

Ms Ruth Tideman, former principal and teacher of secondary science and senior biology for 35 years, similarly recommended that the minimum requirement for a teacher of secondary science be the completion of a Bachelor of Science (or its equivalent), with some courses in the pure sciences (chemistry, physics and supporting mathematics), followed by a teacher education qualification.⁴⁶⁵ Professor David Finlay, Dean, Faculty of Science, Technology and Education, La Trobe University advocates for teachers of senior secondary science and mathematics having a degree containing at least a university major (study to third year) in their first teaching area

⁴⁶² Written Submission, Faculty of Education, Australian Catholic University, January 2005, p.1.

⁴⁶³ Australian Institute of Physics, *The Australian Institute of Physics Science Policy*, Version 1.0, 2004, p.6.

⁴⁶⁴ *ibid.*

⁴⁶⁵ Written Submission, Ms R. Tideman, December 2004, p.5.

and at least a minor (study to second year) in their second teaching area.⁴⁶⁶

The Catholic Education Commission of Victoria also highlighted concerns about the extent of 'out of field' teaching in mathematics and the potential effects this can have on student learning:

Many Year 7 and 8 mathematics teachers in CECV schools are not mathematically trained. This does have an effect on student performance as the teacher knowledge of mathematics is lower than anticipated.⁴⁶⁷

While many submissions and witnesses focused on the need for mathematics and science teachers to have sound university qualifications in the relevant discipline, many others also emphasised the need for teachers to have a solid grounding in student learning and effective mathematics and science pedagogy. Therefore, some questioned whether the current predominant model of teacher education, involving a three-year undergraduate degree followed by a DipEd is sufficient as preparation to be an effective secondary mathematics or science teacher. For example:

... three-quarters of the preparation of teachers is in the hands of the university science departments, which continue to focus on the training of future research scientists, and only one quarter is devoted to the practice of teaching, the psychology of learning and child development, the social purposes of education, its history, and the administration and functioning of schools. It is not realistic to imagine that much change will occur soon in the focus of science departments, nor to propose reducing the amount of time given to acquisition of science content, but nor is it realistic to consider that a single year is enough time to fully prepare people for teaching.⁴⁶⁸

The Committee believes that the dichotomy created between effective pedagogy and detailed content knowledge in the 'out of field' debate is not helpful in improving student outcomes. Evidence before the Committee indicates that both pedagogy and content knowledge are crucial for effective teaching in any subject area. The Committee takes the view that it is not necessarily the level of formal qualification obtained by a teacher that is crucial to the debate but, rather, the nature of their knowledge, which can be developed through a variety of approaches and not only through formal education. The key debate should therefore be about how we ensure all mathematics and science teachers, regardless of their pathway into teaching, have the necessary

⁴⁶⁶ Written Submission, Faculty of Science, Technology & Engineering, La Trobe University, December 2004, p.2.

⁴⁶⁷ Written Submission, Catholic Education Commission of Victoria, December 2004, p.6.

⁴⁶⁸ Written Submission, Emeritus Professor R. White, December 2004, p.2.

skills, knowledge and qualifications to be effective teachers. Thus, the following sections look at what makes for an effective mathematics or science teacher and how professional development can be utilised to meet this ideal.

Professional Standards

The Victorian Institute of Teaching has developed standards of professional practice for the full registration of teachers in Victoria. The standards, which describe the characteristics of effective teaching and establish the essential components of teachers' knowledge and practice, were developed by teachers, for teachers.⁴⁶⁹ As outlined in *Australia's Teachers: Australia's Future*, professional standards can take on a variety of roles:

For the broader community, professional standards can provide a window in to the profession, building confidence and sometimes correcting perceptions. For potential new entrants to a profession, standards provide information about, and give rise to, more realistic understandings of collegial expectations. Professional standards help define teaching roles, and can be refined over time. Standards provide direction for promoting and sharing good practice. For the profession as a whole, standards signpost, showcase and make transparent the extent and scope of members' core competencies and responsibilities. From the perspective of society's needs and expectations, standards indicate targets, quality and achievement.⁴⁷⁰

As noted by the Australian Science Teachers Association, however, teachers' knowledge and expertise is largely specific to the particular subject areas and year levels that they teach. What accomplished teachers of one area know and do is different from what accomplished teachers in other fields do.⁴⁷¹ Therefore:

If standards are valid – if they capture what good teachers know and do – they must reflect these differences. What an expert primary teacher knows about how to help students develop their reading and writing skills is different from what a high school science teacher knows about how to engage students

⁴⁶⁹ Victorian Institute of Teaching website, <http://www.vit.vic.edu.au/content.asp?Document_ID=23>, accessed on 27 January 2006.

⁴⁷⁰ Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Main Report*, Commonwealth of Australia, Canberra, p.112.

⁴⁷¹ National Science Standards Committee, Australian Science Teachers Association 2002, *National Professional Standards for Highly Accomplished Teachers of Science*, ASTA, Canberra, p.5.

in a productive discussion about cloning ... If methods for assessing teacher performance against the standards are to be valid they must also be sensitive to these differences in what teachers are expected to know and be able to do in different subjects and different levels.⁴⁷²

With the above in mind, the Australian Association of Mathematics Teachers and the Australian Science Teachers Association have each developed professional standards for excellence in their respective disciplines. The Committee notes that both sets of subject specific standards complement the standards for the teaching profession developed by the Victorian Institute of Teaching.

The Australian Association of Mathematics Teachers *Standards for Excellence in Teaching Mathematics in Australian Schools* are organised into three domains: professional knowledge, professional attributes and professional practice. The professional knowledge domain sets out expectations for excellent teachers of mathematics to have a strong knowledge base to draw on in all aspects of their professional work.⁴⁷³ Their knowledge base should include knowledge of students, how mathematics is learned, what affects students' opportunities to learn mathematics and how the learning of mathematics can be enhanced. It also includes sound knowledge and appreciation of mathematics appropriate to the Year level and/or mathematics subjects they teach.⁴⁷⁴ The second domain, professional attributes, states that excellent teachers of mathematics are 'committed and enthusiastic professionals who continue to extend their knowledge of both mathematics and student learning.'⁴⁷⁵ The professional practice domain covers aspects such as the learning environment, planning for learning, teaching in action and assessment.⁴⁷⁶

The Australian Science Teachers Association *National Professional Standards for Highly Accomplished Teachers of Science* similarly set out standards along the three domains of professional knowledge, professional practice and professional attributes. In summary, the standards state that highly accomplished teachers of science:

- have a broad and current knowledge of science and science curricula, related to the nature of their teaching responsibilities;
- have a broad and current knowledge of teaching, learning and assessment in science;

⁴⁷² *ibid.*

⁴⁷³ Australian Association of Mathematics Teachers 2002, *Standards for Excellence in Teaching Mathematics in Australian Schools*, AAMT, Adelaide, p.2.

⁴⁷⁴ *ibid.*

⁴⁷⁵ *ibid.*, p.3.

⁴⁷⁶ *ibid.*, p.4.

- know their students well and understand the influence of cultural, developmental, gender and other contextual factors on their students' learning in science;
- design coherent learning programs appropriate for the students' needs and interests;
- create and maintain intellectually challenging, emotionally supportive and physically safe learning environments;
- engage students in generating, constructing and testing scientific knowledge by collecting, analysing and evaluating evidence;
- continually look for and implement ways to extend students' understanding of the major ideas of science;
- develop in students the confidence and ability to use scientific knowledge and processes to make informed decisions;
- use a wide variety of strategies, coherent with learning goals, to monitor and assess students' learning and provide effective feedback;
- analyse, evaluate and refine their teaching practice to improve student learning; and
- work collegially, within their school community and wider professional communities to improve the quality and effectiveness of science education.⁴⁷⁷

All of the above Australian Science Teachers Association standards are supported by a detailed description of what it means to be highly accomplished. The Committee therefore notes that the standards provide a sound basis for improving the effectiveness of professional development, by clarifying what the profession expects its members to improve with experience and establishing a standards-guided system for continuing professional learning across the profession.⁴⁷⁸ Further, the Committee notes that the standards represent a useful mechanism for employing and/or registering authorities to offer teachers the opportunity to seek assessment and accreditation against a demanding level of teaching excellence.

⁴⁷⁷ National Science Standards Committee, Australian Science Teachers Association 2002, *National Professional Standards for Highly Accomplished Teachers of Science*, ASTA, Canberra, pp.12–25.

⁴⁷⁸ *ibid.*, p.4.

Professional Development Needs of the Current Teacher Workforce

The Committee received a considerable amount of evidence about the importance of teacher professional development. A submission from the Victorian Government identified teacher professional development as one of five key factors supporting high quality teaching and learning of mathematics and science:

High quality teaching and learning of science and mathematics requires teachers to have up to date knowledge of developments of the subject matter and pedagogy, including the use of new technologies. Timely, accessible, effective professional development programs are valuable in ensuring the teachers' disciplinary and pedagogical knowledge is up to date, particularly in the science domain where rapid advancements in subject matter occur.⁴⁷⁹

The other key employing authority contributing to the inquiry, the Catholic Education Commission of Victoria, also emphasised the importance of professional development for mathematics and science teachers. It identified three continuing issues in that sector which could be at least partially addressed through improved delivery of teacher professional development:

- insufficient suitably qualified and trained teachers as well as a number of teachers who are teaching 'out of field' with insufficient support;
- the need for additional support to allow classroom teachers to incorporate innovative practices and cutting edge science in their programs; and
- a culture in some science teachers trained some years ago that further improvement in their knowledge and skills is not necessary.⁴⁸⁰

The above comments well encapsulate the general themes of the Committee's evidence covering professional development for mathematics and science teachers. The following sections outline some of the identified professional development needs of Victorian mathematics and science teachers.

⁴⁷⁹ Written Submission, Victorian Government, June 2005, p.21.

⁴⁸⁰ Written Submission, Catholic Education Commission of Victoria, December 2004, p.7.

Primary School Teachers

As generalist teachers, primary school teachers were recognised throughout this inquiry as being very good at pedagogy, teaching across subjects and engaging students in a wide variety of learning experiences. The Committee also heard, however, that the nature of the school experience and teacher education of many primary school teachers means that they do not always have the in-depth content knowledge required to teach mathematics and science effectively.

Commenting on primary school mathematics, Ms Janine McIntosh, International Centre of Excellence for Educational Mathematics, noted:

... they are coming in with year 11 mathematics and mathematics probably was not their favourite subject at school. They were probably one of those students who did not think they were going to need mathematics when they started working ... it is difficult to teach something when you are not feeling very comfortable in the area.⁴⁸¹

The Faculty of Education, La Trobe University, similarly noted the lack of mathematics and science backgrounds among many primary teaching entrants:

... it is recognised that many students entering teacher education especially at the primary level do so with a less than adequate understanding of the basic principles in mathematics and science. More importantly these students generally display a reluctance to improve their understandings ...⁴⁸²

Ms Sue Gunningham, Victorian Schools Innovation Commission, was another of the many participants raising similar concerns:

We have again, across the research, a number of our teachers whose maths content knowledge is an issue for our students. I do not want to label across the board, but it is a well-known fact that many of our primary school teachers have more of an emphasis on their literacy skills than on their numeracy skills and that there is a significant gap in the content knowledge for many of our primary school teachers.⁴⁸³

The above comments represent just a snapshot of the evidence emphasising a lack of deep mathematics and science content knowledge and understanding among many current primary school teachers. Significantly, the evidence reveals concerns not only about

⁴⁸¹ Transcript of Evidence, Public Hearing, Melbourne, 18 April 2005, p.6.

⁴⁸² Written Submission, Faculty of Education, La Trobe University, January 2005, p.3.

⁴⁸³ Transcript of Evidence, Public Hearing, Melbourne, 20 June 2005, p.25.

potential gaps in teacher knowledge and conceptual understanding, but also regarding an initial lack of interest and confidence among some teachers in improving their skills in these disciplines or in teaching them in the classroom. Dr Norman Webb, a former mathematics teacher with 10 years' experience, who had previously worked for 11 years in chemistry research and development, and now private tutor, suggested that this lack of teacher expertise can sometimes have a negative effect on students' future learning of mathematics and science at secondary school:

Students entering high-school lack the very basis upon which to begin teaching secondary curriculum content. This basis – were it present – would consist of a solid grasp of a few fundamental concepts upon which the added complexities of problem solving, creative thinking, comprehension of theory and analysis depend. This basis needs to become a top priority ... of primary teaching and all who seek to contribute to the early years of a child's education.⁴⁸⁴

Dr Webb continued by stating that the secondary school teacher's job becomes more difficult, if not impossible, if primary school teachers have failed to instil the basics during the primary school years:

There is little point in a teacher attempting to explain advanced mathematics to a class of students who have not accurately conceptualised addition, subtraction, multiplication and division or have formed erroneous conceptions that are an obstacle to proper comprehension ... The mathematics taught in the early years of secondary school is not complex. The more complex mathematics taught in later years will, however, be near impossible if year seven and eight must be spent trying to catch up on primary school arithmetic and erasing misconceptions and negative attitudes erroneously instilled during primary schools.⁴⁸⁵

The Committee observed, however, that given its central importance within the primary curriculum, most primary teachers do master the skills of effective numeracy teaching. They achieve this through their teacher education, professional practice, ongoing professional development and with the support of curriculum materials developed by the various employing authorities. The Committee heard, however, that these aspects of a teacher's professional life often do not emphasise to the same extent the importance of continuing to develop knowledge and skills in science education.

Most of the evidence relating to primary school science was concerned not with the quality of science teaching that takes place; rather, it was

⁴⁸⁴ Written Submission, Dr N. Webb & Mr D. Webb, Think Time Tutoring, January 2005, p.4.

⁴⁸⁵ *ibid.*, p.6.

the quantity of primary science taking place and the breadth of topics covered that was of greater concern. In particular, the Committee observed that primary school science often tends to focus on environmental science, with less emphasis on chemistry and physics.

Mr Paul Sedunary, Manager, Curriculum and Innovation, Catholic Education Commission of Victoria commented on the above perspectives:

Primary teachers do tend to get into their comfort zone ... for many primary schools their experience is, 'Well it's year 3, we'll do the solar system. Year 6, we'll do earthquakes or natural disasters,' for example. It is comfortable; it is known; there are a lot of resources that they can easily get their hands on ... It is nice and safe ... Now, with the release of the essential learning standards, where it focuses on the nature of the scientific inquiry as well as the nature of the scientific content, it will be a stretch initially for many primary teachers. They do need support in developing engaging programs...⁴⁸⁶

In the context of the above evidence, a variety of submissions and witnesses suggested that the professional development needs of primary teachers tend to be around mathematics and science content, rather than pedagogy. However, it should be noted that content specific pedagogy is also relevant to the current discussion.

Secondary School Teachers

In contrast to primary school teachers, those teaching in secondary schools were recognised for their in-depth knowledge in their subject area. Nonetheless, witnesses and submissions emphasised the importance of secondary teachers also continuing to develop their knowledge in mathematics and science. Two features of the current environment underlie the importance of this: the requirement for some secondary teachers to teach 'out of field'; and the rapidly advancing nature of current knowledge and applications within the mathematics and science disciplines.

The relatively high average age of Victorian mathematics and science teachers indicates a rich source of teaching experience for our young people. However, it also suggests that many secondary school teachers are themselves two decades or more past the time they completed their initial education and teacher training.⁴⁸⁷ Some of the areas of new science that current secondary teachers may not have studied include biotechnology, laser technology, nanotechnology, the

⁴⁸⁶ Transcript of Evidence, Public Hearing, Melbourne, 20 June 2005, p.8.

⁴⁸⁷ Written Submission, Faculty of Science, Australian National University, August 2005, p.2.

human genome project and synchrotron science.⁴⁸⁸ These are also just some of the fields that are currently at the cutting edge of innovation in Victoria.

A submission from the Faculty of Science, Australian National University, demonstrated not only the rapid advancement of knowledge in key areas of science over the past ten years but also the sheer volume of scientific material in cutting-edge areas being published internationally each year.⁴⁸⁹ For example, a review of the use of the key words *genomics*, *biotechnology*, *bioinformatics*, *proteomics* and *phenomics* revealed a 95.1 per cent increase in published papers over the ten years from 1993 to 2002.⁴⁹⁰ A second search of the key words *photonics*, *fibre optics*, *electro-optics* and *opto-electronics* showed a 60.8 per cent increase over a decade.⁴⁹¹

As outlined by the Faculty of Science, Australian National University, the emergence of new science poses a challenge of significant proportions to those who are expected to convey this knowledge, in clear, simple and engaging forms, to school students.⁴⁹² It is unrealistic to expect science teachers to develop an intricate and technical understanding of even small compartments of this evolving knowledge. Yet, both teachers and students need to have at least a basic understanding of these fields if they are able to comprehend the landscape of scientific advancement in Victoria. Of course, that understanding must be much deeper if we also wish our current students to be Victoria's future innovators. The Committee therefore believes that the most significant and inevitable pressure on the content knowledge of secondary teachers is the rapid pace at which new knowledge evolves. As stated by the Faculty of Science, Australian National University:

[It is apparent] that if the emerging generations of school students are to be attracted into science they must have access to this knowledge as it evolves, presented in ways which allow understanding and encourage engagement ... it would be irresponsible of a community so conspicuously dependent on the progress of science to neglect the obvious needs of science teachers, the importance of whose educational roles have been so clearly highlighted, in maintaining credible currency in their own areas of contemporary science.⁴⁹³

Content specific pedagogy progresses in unison with evolving areas of new science. Therefore, science teachers must also ensure that they

⁴⁸⁸ Written Submission, Associate Professor K. Lim, January 2005, pp.11–12.

⁴⁸⁹ Written Submission, Faculty of Science, Australian National University, August 2005, p.2.

⁴⁹⁰ *ibid.*

⁴⁹¹ *ibid.*

⁴⁹² *ibid.*, pp.2–3.

⁴⁹³ *ibid.*, p.3.

maintain the pedagogy connected with emerging new sciences. They must also be willing to stay abreast, if not drive, relevant curriculum and assessment of such new science. This, of course, necessitates further professional development opportunities for our secondary school teachers.

Mathematics content knowledge is not subject to the same advancement pressures as science. However, the Committee believes that it is highly beneficial for students if mathematics teachers are able to incorporate contemporary applications of the mathematics they teach into the classroom. With knowledge of recent and exciting applications of mathematics, teachers may have greater success in engaging students and encouraging them to pursue advanced mathematics studies. Therefore, professional development offering teachers a better understanding of real life applications of mathematics and science would be beneficial. Additionally, mathematics specific pedagogy continues to evolve as it remains the subject of research undertaken within the academic and policy environments. Teachers must keep up-to-date with this evolution to ensure their practice is providing students with the best opportunities for success. Professional development aimed at achieving this therefore should also be a priority for teachers.

Many submissions and witnesses suggested that there is considerable room for improvement in teaching approaches among some secondary school teachers. Mr Tony Cook, General Manager, Student Learning Division, Department of Education and Training, commented:

... secondary teachers may have very strong content knowledge but in terms of turning that into something that the kids want to do in the classroom there might be challenges.⁴⁹⁴

The Committee believes it very important that secondary teachers be assisted to continue developing effective pedagogies. Many students enter secondary schooling with high expectations and high levels of motivation surrounding science studies, in particular. In mathematics, there seems to be greater variation. Many students have been highly engaged in mathematics throughout their primary school years and are actively seeking the next level of challenge in this discipline. Others, however, arrive at secondary school without a sound grasp of the building blocks so essential to success in a cumulative subject such as mathematics. It is the responsibility of secondary school teachers then, to either capitalise on the positive attitudes that junior secondary students bring to school, or to respond to the confidence and knowledge requirements of those students needing to be re-engaged. If teachers can achieve this during the important 'middle years' of schooling, there will be a far greater likelihood of students pursuing

⁴⁹⁴ Transcript of Briefing, Melbourne, 29 April 2005, p.12.

mathematics and science related education, training and employment pathways.

Current Delivery of Professional Development

Governments and employing authorities Australia wide have prioritised and extended their teacher professional development programs over recent years. It was therefore somewhat of a surprise to the Committee that contributors to this inquiry continued to identify additional professional development as a major priority.

Australia's Teachers: Australia's Future identified the upgrading of subject knowledge and pedagogy as at the core of future professional learning.⁴⁹⁵ It also identified, however, the need for teachers to further strengthen their capacities for the leadership, mentoring, curriculum development, knowledge management, planning, marketing, community relationships, workplace health and safety and other roles they assume in schools.⁴⁹⁶ Further, teachers need to continually update their expertise in the use of ICT as an indispensable tool for their professional roles and to ensure they keep abreast of the full range of learning opportunities for their students.⁴⁹⁷

The Victorian Government outlined its strategies for professional development of mathematics and science teachers in its submission to this inquiry. Professional Development is Flagship Strategy 5 of the Victorian Government's *Blueprint for Government Schools*:

There are many excellent professional development practices for teachers across the system. However, there are not enough opportunities to share these between teachers. The Government considers teacher professional development to be central to improving student learning, and is committed to providing teachers with significant opportunities for professional renewal and development ... A key requirement of participants will be that they bring their learning back to their school and also to other schools so that the benefits can be shared across the system.⁴⁹⁸

The two key professional development strategies outlined in the Blueprint include a professional leave program enabling 460 teachers each year to undertake teacher professional leave for periods ranging

⁴⁹⁵ Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Agenda for Action*, Commonwealth of Australia, Canberra, p.39.

⁴⁹⁶ *ibid.*

⁴⁹⁷ *ibid.*, p.39.

⁴⁹⁸ Department of Education & Training 2003, *Blueprint for Government Schools: Future directions for education in the Victorian government school system*, DE&T, Melbourne, pp.20–21.

from four to ten weeks; and an induction program for beginning teachers to complement existing mentoring programs for these teachers.⁴⁹⁹ A third major professional development initiative is outlined under Flagship Strategy 1: Student Learning. The Principles of Learning and Teaching from P–12 (PoLT) initiative will provide a structure to help teachers focus their professional learning to strengthen their pedagogical capacity.⁵⁰⁰

Professional development has also been a key component of many other Victorian Government initiatives over recent years. These include the Science In Schools Research Project; School Innovation in Science (SIS) initiative; Schools Innovation in Teaching: Science, Maths and Technology (SIT); Middle Years Pedagogy Research and Development (MYPRAD) project; Improving Middle Years Mathematics and Science; the Early Years Numeracy Program; and Access to Excellence.⁵⁰¹ SIS and SIT are particularly important in the context of the current discussion. The focus of professional development under the SIS/SIT model is to encourage teachers to:

- view science and mathematics education in schools as encouraging scientific literacy, and numeracy as well as providing a sound basis for students to take up related careers;
- provide all students with opportunities to develop an interest in, enthusiasm for, and understanding of, science and mathematics and their importance in daily life and in future well-being;
- continue to develop their understanding of science and mathematics in order to become more effective in supporting student learning and conveying the richness and relevance of mathematical and scientific ideas;
- view the science and mathematics classrooms as innovative and active places where students can make connections with the community and where there is a clear focus on supporting students to become autonomous thinkers and learners within a stimulating science environment; and
- link science learning to the world outside the classroom as an important aspect of increasing its relevance. The links might be with families, with other subject areas and teachers, with local people, with local resources such as

⁴⁹⁹ *ibid.*

⁵⁰⁰ *ibid.*, p.15.

⁵⁰¹ Written Submission, Victorian Government, June 2005, pp.9–11.

parks or shopping centres, or with other countries and communities via the internet or exchange programs.⁵⁰²

The SIS/SIT program has contributed to project development in the area of teacher professional development in programs such as:

- Travelling Scholarships for Teachers of Science;
- Online Science Extended Professional Development;
- Teachers of Technology and Science in Industry;
- The Graduate Certificate in Science (Primary Teaching); and
- The Graduate Certificate in Science Education (Physics).⁵⁰³

Extensive professional development programs such as those outlined above have now been operating for a number of years. The Committee therefore suggests that the continued calls for additional professional development opportunities come not from a lack of investment in such activities but, rather, gaps in the way current professional development is sometimes delivered. The following sections therefore explore some challenges in effective delivery of teacher professional development and some best practice models identified by the Committee.

Challenges in Delivering Effective Professional Development

The Committee acknowledges that the sheer size of the teacher workforce, together with the difficulties associated with having teachers undertake professional development during school hours, represent considerable challenges for schools and employing authorities in meeting all the identified needs for teacher professional development. These challenges are exacerbated for many teachers in rural and regional Victoria. Many of the opportunities for professional development are conducted in Melbourne, making it costly, at best, for rural and regional teachers to attend. Time and distance can, however, place many opportunities off-limits, particularly for teachers in smaller schools where there is only a small amount of flexibility within existing staffing complements to cover school-based responsibilities during the staff member's absence. The Committee heard that the rising costs of professional development are also of concern:

Low cost or free professional development is becoming less common because industry, the universities and CSIRO have been pressured to increase productivity,

⁵⁰² *ibid.*, pp.21–22.

⁵⁰³ *ibid.*, pp.22.

which discourages their staff from providing *pro bono* professional development. Some entrepreneurs are now providing professional development, without any quality assurance mechanism.⁵⁰⁴

It should be noted that the Committee spoke with many teachers and principals who felt that current levels and delivery of professional development are effective. For example, Ms Camille O'Sullivan, Mathematics and Science Teacher at Templestowe College, stated:

... there are lots of opportunities for professional development, which is pleasing. We are doing a special physics one at the moment, in partnership with Melbourne University. That has been really successful ... [Melbourne University] bring a lot of their equipment with them to demonstrate, and try to get our year 9s – who are traditionally disengaged – interested in science. I do not think it is PD that we are missing out on; we have a lot of opportunities ...⁵⁰⁵

The Committee also heard that existing professional development opportunities are not always prioritised effectively at the school level. The Victorian Institute of Teaching, reported, for example, that teachers often complain that professional development is system and school driven rather than aimed at the professional requirements of individual teachers.⁵⁰⁶ The Committee also heard that some common delivery modes for professional development are not always the most effective for specific professional development needs.

Much of the criticism of existing teacher professional development was based on the frequent, often ad hoc nature of workshop and seminar style delivery. Workshops and seminars can deliver fresh perspectives and contemporary research results quickly to teachers and have the advantage of being able to be delivered on-site in schools. Many participants in the inquiry noted, however, the limitations of workshops and seminars in meeting a diverse range of professional development needs.

The Victorian Government noted, for example, that:

Traditional professional development programs, commonly in the form of one-off workshops, may not provide teachers with long-term and sustainable learning.⁵⁰⁷

⁵⁰⁴ Written Submission, Associate Professor K. Lim, January 2005, pp.11–12.

⁵⁰⁵ Transcript of Evidence, Public Hearing, Templestowe College, 5 September 2005, p.7.

⁵⁰⁶ Mr A. Ius, Chief Executive Officer, Victorian Institute of Teaching, Transcript of Evidence, Public Hearing, Melbourne, 8 August 2005, p.29.

⁵⁰⁷ Written Submission, Victorian Government, June 2005, p.21.

The Mathematical Association of Victoria similarly stated:

Teachers should stop receiving one-shot workshops and become active decision makers in the process of designing and choosing professional development opportunities.⁵⁰⁸

Evidence highlighted a range of other weaknesses of existing teacher professional development. Some witnesses suggested professional development is rarely outcomes focused or evaluated,⁵⁰⁹ while others indicated that there is often little consideration given to strategic plans or the specific professional development needs of individual teachers.⁵¹⁰ Many participants also suggested that some teachers have difficulty integrating their learning into the classroom or school following professional development, either due to lack of skills or time.⁵¹¹ Additionally, the Committee observed that professional development is often a voluntary activity that some of those most in need of developing their skills and knowledge tend to avoid.

In light of the above challenges, the Committee examined various models of teacher professional development. The Committee believes that existing professional development allocations could be better utilised at the school level. Additionally, the Committee believes that as occurs in most other professions, teachers must take greater responsibility for their professional learning.

Professional Networks and the Sharing of Best Practice

There are many examples of exemplary education practices among Victorian teachers and school learning communities. Many submissions and witnesses emphasised that the ability to tap into these working models of best practice is often the most effective and, yet, a relatively low-cost strategy for facilitating professional learning. Some of the models facilitating the sharing of best practice include the Leading Schools Fund, the Program for Enhancing Effective Learning (PEEL), expert teaching teams and centres of excellence. Some participants also identified shared web resources and electronic discussion boards

⁵⁰⁸ Written Submission, Mathematical Association of Victoria, December 2004, p.6.

⁵⁰⁹ See for example, Written Submission, Mathematical Association of Victoria, December 2004, pp.5–6, and Ms S. Gunningham, Consultant, Victorian Schools Innovation Commission & Teacher, Peter Lalor Secondary College, Transcript of Evidence, Public Hearing, Melbourne, 20 June 2005, p.33.

⁵¹⁰ Mr A. Ius, Chief Executive Officer, Victorian Institute of Teaching, Transcript of Evidence, Public Hearing, Melbourne, 8 August 2005, p.29, and Mr B. Armstrong, Principal, Balwyn High School, Transcript of Evidence, Public Hearing, Balwyn High School, p.23.

⁵¹¹ See for example, Ms V. Steane, Maths Teacher, Kew High School, Transcript of Evidence, Public Hearing, Balwyn High School, 25 July 2005, p.20; Dr N. Webb, Manager, Think Time Tutoring, Transcript of Evidence, Public Hearing, Melbourne, 8 August 2005, p.4; and Ms S. Shanahan, Mathematics Co-ordinator, Eaglehawk Primary School, Transcript of Evidence, Public Hearing, Bendigo, 1 August 2005, p.30.

as useful for sharing best practice. The use of ICT in professional networks and sharing of best practice was viewed as particularly useful for those in rural and regional Victoria, as a complementary measure to more formal professional development and networking opportunities.

The Leading Schools Fund was implemented in 2004 as Flagship Strategy 7 of the Victorian Government's *Blueprint for Government Schools*. As outlined in the Blueprint, the Leading Schools Fund:

... builds on the knowledge and good practice which already exist in schools and it provides schools with the incentive and opportunity to reach beyond their current practice and performance.⁵¹²

The Leading Schools Fund provides a framework that:

- focuses on whole school development and enhancement; and
- facilitates strategic partnerships and collaboration between schools so that schools can learn from each other, assist each other and strengthen the public school system.⁵¹³

The concept of Leading Schools was supported by a number of submissions and witnesses, who suggested schools where science is being taught well should become 'lighthouses' and be used as an inspiration for other teachers.⁵¹⁴ The existing cluster model across government schools was also highly valued by many participants in the inquiry, particularly when addressing student transitions between primary and secondary school.⁵¹⁵

The Committee met with the co-ordinators of PEEL, which has been recognised in previous reports, as well as in written submissions to this inquiry, as an effective model for facilitating professional learning.⁵¹⁶

⁵¹² Department of Education & Training 2003, *Blueprint for Government Schools: Future directions for education in the Victorian government school system*, DE&T, Melbourne, p.27.

⁵¹³ *ibid.*

⁵¹⁴ See for example, Written Submission, Ms A. Pisarevsky, Teacher, Bell Primary School, August 2005, p.2.

⁵¹⁵ Ms D. Souter, Assistant Principal, Gowrie Street Primary School, Transcript of Evidence, Public Hearing, Shepparton, 2 August 2005, p.11 and also see, Transcripts of Evidence, Public Hearings, Parkdale Secondary College, 12 September 2005 and Templestowe College, 5 September 2005.

⁵¹⁶ See for example, Committee for the Review of Teaching & Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Main Report*, Commonwealth of Australia, Canberra, p.155; D. Goodrum, M. Hackling & L. Rennie 2001, *The Status and Quality of Teaching and Learning of Science in Australian Schools*, report prepared for the Department of Education, Training & Youth Affairs, Commonwealth of Australia, Canberra, p.69, and Written Submission, Mr N. Champion, January 2005, p.2.

PEEL is an autonomous and reportedly cost-effective group, in which teachers investigate how students learn and develop and refine ways of increasing student engagement. Participants are involved in action research into classroom approaches that stimulate and support active student learning that is more informed, purposeful, intellectually active and independent. PEEL members share and analyse their classroom experience, ideas and new practices with intra, or inter-school networks of teachers. The experiences and findings are also shared through the network's journal; through an annual conference; collective meetings; a website; a range of short courses and in-service activities; and a database of over 1,000 articles from teachers.

PEEL members have documented higher levels of student interest and engagement, which reportedly resulted in fewer difficulties in classroom management. The program has also recorded rises in favourable learning behaviours among students. These include offering and justifying opinions; seeking a link with personal life; and offering ideas, new insights and alternative explanations. In some instances, a fifteen-fold increase in such behaviours has been documented.⁵¹⁷

Other models that utilise a core of expert teachers were also recommended to the Committee. Models such as the Victorian Government's SIS/SIT initiative and the Catholic Education Commission of Victoria's Success in Numeracy Education (SINE) program rely on expertise and experience of leading teachers to support and mentor other teachers in their subject area. For example, the SIS Regional Project Officers, who were dedicated to the promotion of science, directed professional development, provided resources and assisted school science co-ordinators with the specific issues they encountered in their schools. SINE similarly relied upon roving experts:

... an experienced classroom practitioner who visits schools within his/her zone, advising numeracy co-ordinators regarding the use of appropriate assessment tools, interpreting relevant data and showing how instruction can be modified to ensure that it is targeted towards the needs of the students.⁵¹⁸

The Committee notes that ongoing professional relationships such as those described above have been identified in the literature as particularly useful for the professional learning of primary teachers.⁵¹⁹ The Committee believes, however, that they are equally valuable for secondary school teachers.

⁵¹⁷ Supplementary material provided to the Committee by the Faculty of Education, Monash University, Project for Enhancing Effective Learning (PEEL), June 2005.

⁵¹⁸ Written Submission, Catholic Education Commission of Victoria, December 2004, p.4.

⁵¹⁹ See for example, Written Submission, School of Education, Victoria University, December 2004, p.2. See also, Committee for the Review of Teaching and Teacher Education 2003, *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics – Main Report*, Commonwealth of Australia, Canberra, pp.160–163.

The Science Teachers Association of Victoria and the Australian Institute of Physics recommended a model equivalent to the Physics Teaching Resource Agents (PTRA) program in the United States.⁵²⁰ Run by the American Association of Physics Teachers, the PTRA program seeks to provide sustained professional development to teachers of physics and physical science by maintaining a nationwide team of over 100 accomplished high school teacher-leaders trained and updated yearly to conduct workshops in their local regions. Potential participants are selected based on their mastery of physics content knowledge, creativity, successful teaching experience, familiarity with physics education research, and the capacity for professional leadership.⁵²¹

Victoria has many Centres of Excellence offering opportunities for professional networking and sharing of best practice in a well-resourced environment with a wealth of expertise at hand. Science facilities such as the Gene Technology Access Centre, ecolink, and the new Victorian Space Science Education Centre are ideal for facilitating professional learning. School-based centres of excellence are also of considerable value. For example, schools such as St Helena Secondary College and Balwyn High School, which the Committee visited, have state-of-the-art science and technology facilities, as well as exemplary staff who can be utilised to demonstrate effective teaching strategies to other existing and pre-service teachers.

Additionally, several stakeholders suggested that highly accomplished teachers of mathematics or science (possibly formally accredited against the subject association standards) could be approached to open their classrooms to their peers and to act as mentors.

⁵²⁰ Written Submission, Australian Institute of Physics, Victorian Branch, Education Committee, December 2004, p.1.

⁵²¹ For further information on the Physics Teaching Resource Agents (PTRA) program, refer to the American Association of Physics Teachers website, <<http://www.aapt.org>>.

Compulsory Professional Development

The Victorian Institute of Teaching is currently undertaking a consultative process to establish a framework for the formal renewal of registration for teachers. The Committee welcomes this process and believes a registration system that requires teachers to demonstrate continual professional learning will further enhance the professionalism of teaching.

Teaching as it stands is in contrast to most other professions, which typically require members to complete a specified minimum number of hours of professional development in order to retain their professional status. A number of submissions and witnesses advocated compulsory professional development as an effective strategy to ensure that teachers maintain and enhance their professional knowledge. In the context of this inquiry, the Committee advocates that any future move toward compulsory professional development should include a quality assurance mechanism, to ensure that all teacher professional development is relevant and of a high standard. The Committee also believes that minimum requirements should be set for the update of mathematics and science content knowledge, as well as effective pedagogy. These requirements could set out:

- the overall time to be spent on professional development in each year of teaching;
- the proportion of time to be allocated to professional development in various areas, such as content knowledge, pedagogy, curriculum and school or system initiatives; and
- the types of professional development that would be deemed acceptable as contributing to mandated professional learning requirements.

Mr Neil Champion, one of the principals/teachers advocating for compulsory professional development, suggested that a points-based system such as that used for social work could be adopted:

Such an approach should be a minimum requirement for each teacher. There should be a level of professional control of the system. The points could be allocated according to certification level and the complexity of the activity. For example, attendance at a professional conference should be less valued than presentation of a workshop, publication of a paper or achievement of higher degree courses, the highest

points being directly related to successful completion of the subject knowledge component of the activity.⁵²²

The Committee suggests that informal methods of professional learning should also be valued, provided they can be evidenced through appropriate mechanisms, for example, a professional journal.

The Committee is supportive of a points-based system for compulsory professional development. The model should provide the Victorian Institute of Teaching with the opportunity to determine the breadth, depth and focus of teacher professional development. Further, in considering such an approach, the Committee believes that the Institute will also need to address the need for a quality assurance mechanism and to provide teachers with a resource to support their selection of appropriate professional development activity. Approaches to consider include the formal accreditation of professional development providers or courses and/or a central on-line registry of providers that includes detailed descriptions of their programs along with evaluations or ratings from previous participants. While such approaches may constitute an additional responsibility for the Institute, the Committee believes that it would considerably bolster the quality of professional development.

Recommendation 9.1: That the Victorian Institute of Teaching consider and develop an appropriate model of mandated professional development for Victorian teachers, particularly mathematics and science teachers whose disciplines face rapid advancement.

Adopted by the Education and Training Committee

Committee Room, Parliament of Victoria

Melbourne 3000

23 February 2006

⁵²² Written Submission, Mr N. Champion, January 2005, p.5.

Appendix A

List of Written Submissions

Name of Individual/Organisation	Date Received
Mr Trevor White	24 October 2004
Mr A T Kenos, MACE, MAITD	29 October 2004
Mr Robert Money	11 November 2004
Victorian Automotive Industry Training Board Inc	19 November 2004
Ms Mandy Kirsopp	26 November 2004
Applied Physics, RMIT University	7 December 2004
Numeracy Australia Pty Ltd	8 December 2004
Ms Ruth Tideman, AM, BSc, BEd, MWomHlth, MACE	8 December 2004
Ms Susannah Garcia (Undergraduate Student)	13 December 2004
The Discovery Science and Technology Museum Inc	14 December 2004
School of Education, Victoria University	14 December 2004
Faculty of Education, Monash University	15 December 2004
Ms Bree A Gorman (PhD Student)	15 December 2004
Renaissance Learning Australia	15 December 2004
Australian Institute of Physics, Victorian Branch, Education Committee	16 December 2004
Emeritus Professor Richard White, AM, FASSA	16 December 2004
Catholic Education Commission of Victoria	17 December 2004
Department of Mathematics and Statistics, The University of Melbourne	17 December 2004
Faculty of Science, Monash University	17 December 2004
Faculty of Science, Technology and Engineering, La Trobe University	17 December 2004
Science Industry Australia Inc	17 December 2004

Name of Individual/Organisation	Date Received
The Mathematical Association of Victoria	17 December 2004
Victorian Institute for Chemical Sciences	17 December 2004
Victorian Schools Innovation Commission	21 December 2004
Vice Chancellor's Office, University of Ballarat	22 December 2004
Associate Professor Kieran F Lim, Director, Chemical Sciences Degree Program, Faculty of Science and Technology, Deakin University and Deputy Chair, Division of Chemical Education, Royal Australian Chemical Institute	4 January 2005
Australian Mathematical Sciences Institute	4 January 2005
Australian Mathematical Society	4 January 2005
Dr Norman Webb, BSc, PhD, DipEd and Mr David Webb, Think Time Tutoring	4 January 2005
Faculty of Education, Australian Catholic University	4 January 2005
Faculty of Education, Faculty of Engineering & Faculty of Science, The University of Melbourne	4 January 2005
Gordon Institute of TAFE	4 January 2005
Mr Don Collins, Teacher, Princes Hill Secondary College	4 January 2005
Mr Neil Champion, former Head of Secondary College, Oakleigh Greek Orthodox College, former VCAA Science Manager (1999 to 2003) and Author of VCE Physics texts	25 January 2005
Faculty of Education, La Trobe University	31 January 2005
Science Teachers' Association of Victoria	31 January 2005
Mathematics Education Research Group of Australasia, Inc	18 February 2005
Faculty of Education, Deakin University	4 March 2005
Faculty of Science, Engineering & Technology, Victoria University	19 April 2005
Mr Denis Rietdyk	27 April 2005
Victorian Government	2 June 2005
Department of Mathematical & Statistical Sciences, La Trobe University	17 June 2005

Name of Individual/Organisation	Date Received
Mr Arthur John Higgs (Retired Teacher)	20 June 2005
Mr Anthony Brimson	22 June 2005
On The Pulse Education Services	24 June 2005
Dr Peter Glazebrook Principal Science Advisor, Rio Tinto Ltd	27 June 2005
Ms Katherine Lindsay (DipEd Student)	29 June 2005
Ms Babette Francis, National & Overseas Co-ordinator, Endeavour Forum Inc	8 July 2005
Mr Alan Walker, Manager, Ceramic Oxide Fabricators (Aust) Pty Ltd	8 July 2005
Mr Harold McNair, Recruitment Officer, Gippsland Group Training Ltd and Ms Bev Wort, Careers Advisor, Traralgon College	15 July 2005
Dr Raimund Pohl	27 July 2005
Mr Brian Thomas, Teacher, Bellarine Secondary College	27 July 2005
Mr Joe Piper, General Manager, Educational Operations, Central Gippsland Institute of TAFE	28 July 2005
Mr Gary Simpson, MEd, MA, MAIBiol, MACE, Co-ordinator of Independent Learning, Woodleigh School	1 August 2005
Mr Ian MacDonnell, Senior Science Co-ordinator, Methodist Ladies' College	1 August 2005
Mr Peter Cox, La Trobe University	1 August 2005
Gunbower Primary School	4 August 2005
Faculty of Science, The Australian National University	12 August 2005
Mr Peter Hope, Teacher, Karoo Primary School	12 August 2005
Ms Ann Pisarevsky, Teacher, Bell Primary School	17 August 2005
Deer Park West Primary School	30 August 2005
BioMelbourne Network	31 August 2005
Engineers Australia, Victorian Division	31 August 2005

Name of Individual/Organisation	Date Received
Minerals Council of Australia, Victorian Division	31 August 2005
Science Schools Foundation Inc	31 August 2005
Victorian Model Solar Vehicle Challenge Committee, Monash University	31 August 2005
Mr Theo Read, Teacher, Mount Erin College	2 September 2005
National Centre for the Public Awareness of Science, The Australian National University	2 September 2005
Questacon – The National Science & Technology Centre	2 September 2005
Australian Geoscience Council Inc	8 September 2005

Appendix B

List of Witnesses – Public Hearings and Briefings

Briefing – Spring Street, Melbourne 18 April 2005

Name	Position	Organisation
Mr Michael White	Chief Executive Officer	Victorian Curriculum and Assessment Authority
Mr John Firth	General Manager	Victorian Curriculum and Assessment Authority

Public Hearing – Spring Street, Melbourne 18 April 2005

Name	Position	Organisation
Dr Nancy Lane	Manager	International Centre of Excellence for Education in Mathematics, Australian Mathematical Science Institute
Dr Michael Evans	Schools Project Manager	International Centre of Excellence for Education in Mathematics, Australian Mathematical Science Institute
Ms Janine McIntosh	Schools Project Officer	International Centre of Excellence for Education in Mathematics, Australian Mathematical Science Institute
Mr Ray Peck	President	The Mathematical Association of Victoria
Mr Dave Tout	Vice-President	The Mathematical Association of Victoria
Mr Simon Pryor	Executive Officer	The Mathematical Association of Victoria

Briefing – Spring Street, Melbourne
29 April 2005

Name	Position	Organisation
Ms Jane Niall	Deputy Secretary, Business Development	Department of Innovation, Industry and Regional Development
Mr John Werry	Manager, Emerging Skills	Department of Innovation, Industry and Regional Development
Mr Tony Cook	General Manager, Student Learning Division, Office of Learning & Teaching	Department of Education and Training

Public Hearing – Spring Street, Melbourne
29 April 2005

Name	Position	Organisation
Mr Andrew Rimmington	Senior Policy Adviser, Employment, Education & Training Division	Victorian Employers' Chamber of Commerce and Industry

Public Hearing – Gene Technology Access Centre, Melbourne
6 May 2005

Name	Position	Organisation
Mr Brian Stevenson	Programs Manager	Gene Technology Access Centre
Dr Brendan Crabb	Research Scientist	Walter and Eliza Hall Institute of Medical Research
Professor John McKenzie	Dean, Faculty of Science	The University of Melbourne
Professor Kaye Stacey	Nominee of Head, Department of Science & Mathematics Education	The University of Melbourne
Dr Rod Fawns	Senior Lecturer, Department of Science & Mathematics Education	The University of Melbourne

Briefing – CSIRO Science Education Centre, Melbourne
9 May 2005

Name	Position	Organisation
Mr David Trotter	National CSIROSEC Manager	CSIRO Science Education Centre
Mr Chris Krishna-Pillay	Manager	CSIRO Melbourne Science Education Centre

Public Hearing – Monash University, Clayton Campus
10 June 2005

Name	Position	Organisation
Professor Richard Gunstone	Director of the Centre for Science, Mathematics & Technology Education, Faculty of Education	Monash University
Dr Debbie Corrigan	Senior Lecturer, Science & Technology Education	Monash University
Dr Ian Mitchell	Co-Founder	Project for Enhancing Effective Learning
Mr David Lumb		Project for Enhancing Effective Learning

Public Hearing – Spring Street, Melbourne
20 June 2005

Name	Position	Organisation
Mr Garry McLean	Assistant Director of School Services, Catholic Education Office	Catholic Education Commission of Victoria
Mr Paul Sedunary	Manager of Curriculum & Innovation, Catholic Education Office	Catholic Education Commission of Victoria
Professor Philip Clarkson	President	Mathematics Education Research Group of Australasia

Name	Position	Organisation
Professor Peter Sullivan	Past Vice-President of Research	Mathematics Education Research Group of Australasia
	Pro-Vice-Chancellor	La Trobe University
Ms Viv White	Chief Executive Officer	Victorian Schools Innovation Commission
Ms Sue Gunningham	Consultant	Victorian Schools Innovation Commission
	Teacher	Peter Lalor Secondary College
Mr Dan O'Keeffe	Secretary, Education Committee	Australian Institute of Physics (Victorian Branch)

***Public Hearing – Spring Street, Melbourne
18 July 2005***

Name	Position	Organisation
Ms Pamela Danby	Market Development Manager	Science Industry Australia Inc
Mrs Jo Davey	Director	Numeracy Australia Pty Ltd
Mr Peter Corboy	Director	Numeracy Australia Pty Ltd
Professor Michael Adams	Representative	Victorian Institute for Chemical Sciences
	Head of Applied Chemistry	RMIT University
Mr Trevor Rook	Representative	Victorian Institute for Chemical Sciences
	Senior Lecturer, Department of Applied Chemistry	RMIT University
Associate Professor David McFadyen	Representative	Victorian Institute for Chemical Sciences
	School of Chemistry	The University of Melbourne
Mr Anthony Brimson	Designer and Presenter, 'Physics in Schools'	
Mrs Carol Brimson	Presenter, 'Physics in Schools'	

***Public Hearing – Balwyn High School
25 July 2005***

The following lists all participants who made a formal presentation to the Committee's public forum at Balwyn High School and/or contributed discussion that was recorded by Hansard. A broad range of additional stakeholders attended the forum either to observe proceedings and/or to contribute to the inquiry in a less formal manner.

Name	Position	Organisation
Mr Bruce Armstrong	Principal	Balwyn High School
Ms Megan Barr	Year 12 Student	Balwyn High School
Mr Barry Clarke	Teacher	Kew High School
Professor Russell Crawford	Dean, Faculty of Life & Social Sciences	Swinburne University of Technology
Dr Leslie Dale	Retired Teacher	
Ms Jacqui Dickenson	Year 10 Student	Balwyn High School
Ms Dominique Grant	Year 11 Student	Balwyn High School
Mr Wayne Heathcote	President	Balwyn High School Council
Mr Colin Hopkins	Former Outreach Co-ordinator	Balwyn High School
Mr John Jackowski	Head of Science	Scotch College
Ms Ina Kuehlich	Regional Project Officer – Science, Eastern Metropolitan Region	Department of Education and Training
Mr Ezra Kumar	Year 12 Student	Balwyn High School
Ms Shakira Kumar	Year 12 Student	Balwyn High School
Mr Graeme Lane	Principal	Balwyn North Primary School
Mr Alex Leahy	Science Teacher	Balwyn High School
Mr Andrew Mark	Head of Mathematics	Balwyn High School
Ms Jacquie O'Brien	Executive Officer	Gateway Local Learning and Employment Network
Ms Llaaneath Poor	Year 10 Student	Balwyn High School
Mr Bradley Potenzi	Year 12 Student	Balwyn High School
Ms Val Steane	Maths Teacher	Kew High School
Mr Corey Walker	Science Teacher	Balwyn High School

***Public Hearing – Bendigo Town Hall
1 August 2005***

Name	Position	Organisation
Associate Professor Vaughan Prain	Interim Head, School of Education	La Trobe University
Dr Steve Tobias	Lecturer, School of Education	La Trobe University
Dr Barbara Tadich	Lecturer and Course Co-ordinator, School of Education	La Trobe University

***Public Hearing (Industry Forum) – Bendigo Town Hall
1 August 2005***

The following lists all participants who made a formal presentation to the Committee's public forums in Bendigo and/or contributed discussion that was recorded by Hansard. Additional stakeholders attended the forums either to observe proceedings and/or to contribute to the inquiry in a less formal manner.

Name	Position	Organisation
Mr Jeff Bothe	Executive Officer	Bendigo Manufacturing Group
Ms Genevieve Bowyer	Educational Community Affairs	Bendigo Mining Ltd
Mr Tony Brennan	Recruitment Services	Bendigo Bank Limited
Mr Neville Davies	Science Projects Officer	Department of Education and Training
Councillor David Jones	Councillor	City of Greater Bendigo
Ms Sandy Roberts	General Manager	Central Victorian Group Training Company Ltd
Ms Maxine Semple	Training Consultant	Victorian Employers' Chamber of Commerce and Industry
Mr Alan Walker	Manager	Ceramic Oxide Fabricators Australia Pty Ltd

***Public Hearing (School Community Forum) –
Bendigo Town Hall 1 August 2005***

The following lists all participants who made a formal presentation to the Committee's public forums in Bendigo and/or contributed discussion that was recorded by Hansard. Additional stakeholders attended the forums either to observe proceedings and/or to contribute to the inquiry in a less formal manner.

Name	Position	Organisation
Mr Ralph Algren-Ussing	Head of Maths	Girton Grammar School
Ms Lucie Armstrong	Science Teacher	Kangaroo Flat Secondary College
Ms Delene Cammerford	Teacher	Camp Hill Primary School
Mr Bruce Carpenter	Science Co-ordinator	Bendigo Senior Secondary College
Ms Sylvia Cuming	Head of Science	Girton Grammar School
Ms Kylie Freer	Integrated Studies Co-ordinator	Strathfieldsaye Primary School
Ms Angie Kloft	Cluster Educator, Innovations and Excellence	Kangaroo Flat Cluster
Ms Lorraine McKerrow	Middle Years Co-ordinator and Maths KLA Leader	Kangaroo Flat Primary School
Mr Chris Nielsen	Mathematics Teacher and Co-ordinator	Kangaroo Flat Secondary College
Ms Sharon Shanahan	Mathematics Co-ordinator	Eaglehawk Primary School

***Shepparton – Shepparton Science & Technology Centre
2 August 2005***

The following lists all participants who made a formal presentation to the Committee's public forums in Shepparton and/or contributed discussion that was recorded by Hansard. A broad range of additional stakeholders attended the forums either to observe proceedings and/or to contribute to the inquiry in a less formal manner.

Public Hearing (Primary Schools Forum) – Shepparton

Name	Position	Organisation
Ms Jenny Bannister	Mooroopna Innovation & Excellence Cluster Educator	Department of Education and Training
Mr Jolon D'Amore	Grade 4 Student	Mooroopna Primary School
Mr Cliff Downey	Principal	Mooroopna Primary School
Ms Debbie George	School Development Officer, Hume Region	Department of Education and Training
Mr John Howley	Principal	Guthrie Street Primary School
Mr James Keeshan	Grade 3 Student	Mooroopna Primary School
Ms Pam Montgomery	Shepparton Cluster Co-ordinator	Department of Education and Training
Mr Bruce Oakley	Grade 4 Student	Mooroopna Primary School
Mr Shaun O'Shannessy	Principal	Tatura Primary School
Mr Dom Poppa	Vice Principal	St Mel's Primary School
Ms Kerrieanne Souter	Assistant Principal	Gowrie Street Primary School
Ms Heather West	Teacher	Guthrie Street Primary School

Public Hearing (Secondary Schools Forum) – Shepparton

Name	Position	Organisation
Mr Jerry Abraham	Maths Teacher	Shepparton High School
Mr Peter Feain	Assistant Principal	Shepparton High School
Mr Alby Freijah	Assistant Principal	Mooroopna Secondary College
Ms Susanne Gill	Maths/Science Learning Area Leader	Mooroopna Secondary College
Mr Keith Gray	Acting Principal	Wanganui Park Secondary College
Ms Nicole Hayes	Maths and Science Teacher	Kyabram Secondary College
Ms Helen Peake	Science Co-ordinator	McGuire College
Mr Bill Porter	Assistant Principal	McGuire College

Name	Position	Organisation
Ms Karen Utber	Science Learning Area Leader	Wanganui Park Secondary College
Ms Robyn Waight	Maths Learning Area Leader	Wanganui Park Secondary College

Public Hearing (Industry Forum) – Shepparton

Name	Position	Organisation
Mr Mark Breuer	General Manager	Coomes Consulting Group Pty Ltd
Mr Jim Crawshaw	Committee Member and Past Chairman	North-East Victoria Area Consultative Committee
	Business Development Manager	The Factory
Ms Jennifer Hippisley	Executive Officer	Goulburn Murray Local Learning and Employment Network
Mr Andrew Hughes	Head	Goulburn Valley Environmental Consultants
Mr Danny Lythgo	Manager	Shepparton Science and Technology Centre
Mr Matt Nelson	Manager, Economic Development	City of Greater Shepparton
Mr Dean Rochfort	Director, Corporate & Economic Development	City of Greater Shepparton
Mr Peter Ryan	Chief Executive Officer	Goulburn Ovens Institute of TAFE
Mr Rod Schubert	General Manager, Human Resources	SPC Ardmona Operations Ltd
Mr Lindsay Short	Executive Officer	Campaspe Cohuna Local Learning and Employment Network
Ms Shelley Sutton	Business Liaison	City of Greater Shepparton
Ms Dawn Taylor	President	Shepparton Chamber of Commerce and Industry
Mr Trevor Tennant	Director and Mechanical Design Manager	Rubicon Systems Australia Pty Ltd

***Public Hearing – Spring Street, Melbourne
8 August 2005***

Name	Position	Organisation
Dr Norman Webb	Manager	Think Time Tutoring
Mr Neil Champion	Interested Citizen	
Mr John McDonald	Program Director, In2Science Peer Mentoring Program	La Trobe University
Ms Susan Halliday	Chairperson	Victorian Institute of Teaching
Mr Andrew Ius	Chief Executive Officer	Victorian Institute of Teaching
Ms Ruth Newton	Manager, Accreditation	Victorian Institute of Teaching

***Public Hearing – Scienceworks Museum, Melbourne
19 August 2005***

Name	Position	Organisation
Ms Genevieve Fahey	Manager	Scienceworks Museum
Ms Pennie Stoyles	Education Manager	Scienceworks Museum
Mr Ranjith Dediwalage	Vice-President/Convenor Education Committee	Science Teachers' Association of Victoria
Mr Ben Tinney	Vice President	Young Scientists of Australia – Melbourne Chapter
Ms Tegan Dobbie	Secretary	Young Scientists of Australia – Melbourne Chapter
Mr Nick Wallis	Treasurer	Young Scientists of Australia – Melbourne Chapter
Ms Elise White	National Liaison	Young Scientists of Australia – Melbourne Chapter
Mr David Hawkins	Business Director	BASF Australia Ltd

***Public Hearing – Spring Street, Melbourne
31 August 2005***

Name	Position	Organisation
Mr Jim Sonnemann	National Director, Siemens Science Experience	Science Schools Foundation Inc
Ms Katherine Hurford	Associate Director, Public Policy	Engineers Australia
Ms Alison Coe	Executive Director, Victorian Division	Engineers Australia
Ms Glenda Graham	Accreditation and Industry Manager	Engineers Australia
Mr Tim Murphy	Chief Executive Officer	BioMelbourne Network
Mr Chris Fraser	Executive Director, Victorian Division	Minerals Council of Australia
Ms Kathy Doolan	Education Manager	Minerals Education Victoria
Dr Mike Hollitt	Interested Citizen	
Mr John Lasich	Technical Director	Solar Systems Pty Ltd

***Public Hearing – Montmorency Secondary College
1 September 2005***

Name	Position	Organisation
Mr Andrew Argyropoulos	Year 11 Student	Montmorency Secondary College
Ms Victoria Baxter	Principal	Montmorency Secondary College
Mr Tim Bench	Year 8 Student	Montmorency Secondary College
Mr David Craze	Year 11 Student	Montmorency Secondary College
Mr Peter Curtis	Teacher	Briar Hill Primary School
Ms Jacqui Doulis	Year 9 Student	Montmorency Secondary College
Mr Peter Eyre	Science Teacher	Montmorency Secondary College
Ms Angela Golding	Maths/IT Teacher	Montmorency Secondary College
Ms Pat Greenhalgh	Maths/Science Teacher	Montmorency Secondary College
Ms Sandra Greenhill	Maths Co-ordinator	Montmorency Secondary

Name	Position	Organisation
Ms Janelle Hellyer	Year 11 Student	Montmorency Secondary College
Ms Kristyn Heywood	Year 12 Student	Montmorency Secondary College
Mr Elliott Hobbs	Year 7 Student	Montmorency Secondary College
Mr Steve Horn	Science Co-ordinator	Montmorency Secondary College
Mr Geoff Leong	Maths Teacher	Montmorency Secondary College
Ms Kelli MacDonald	Maths/English Teacher	Montmorency Secondary College
Mr Tony Massingham	Maths/Science Teacher	Montmorency Secondary College
Ms Raelene Morley	Teacher	Sherbourne Primary School
Ms Karen Paul	Teacher	Sherbourne Primary School
Mr Ben Rhyder	Year 7 Student	Montmorency Secondary College
Mr Allan Robinson	Assistant Principal	Montmorency Secondary College
Ms Krystyna Walker	Year 8 Student	Montmorency Secondary College

***Public Hearing – Templestowe College
5 September 2005***

Name	Position	Organisation
Ms Kate Bunting	Year 9 Student	Templestowe College
Ms Dominique Gundry	Team Leader	Bulleen Heights School
Ms Julie Harding	Maths Teacher	Templestowe College
Ms Sally Holloway	Senior School Principal	Templestowe College
Mr Weibin Lin	Year 12 Student	Templestowe College
Ms Christine McGuinness	Year 8 Student	Templestowe College
Ms Helen Marotta	Year 7 Co-ordinator and Cluster Educator	Templestowe College
Mr Sean Marsiocovetere	Vice Captain, Year 12 Student	Templestowe College
Mr Leigh Meredith	Year 12 Student	Templestowe College

Name	Position	Organisation
Ms Toni Nicholson	Science Co-ordinator	Templestowe College
Ms Camille O'Sullivan	Maths and Science Teacher	Templestowe College
Mr Liam Porter	Year 7 Student	Templestowe College
Mr Daniel Singh	Physics and Maths Teacher	Templestowe College
Mr Andrew Sloane	College Principal	Templestowe College
Mr Steven Tran	Year 7 Student	Templestowe College
Ms Georgia Van Kalken	Year 8 Student	Templestowe College
Ms Jenny Vasiladis	Teacher	Templestowe Valley Primary School
Mr Chris Vine	Year 8 Student	Templestowe College
Ms Hannah Wearne	College Captain, Year 12 Student	Templestowe College
Mr Jesse Wilson	Year 9 Student	Templestowe College
Ms Sue Wright	Maths and Science Teacher/Maths Co-ordinator	Templestowe College

***Public Hearing – Parkdale Secondary College
12 September 2005***

Name	Position	Organisation
Ms Karen Anderton	Year 9 Student	Parkdale Secondary College
Mr Rhys Campbell	Year 12 Student	Parkdale Secondary College
Ms Mary Flinos	Year 7 Co-ordinator	Parkdale Secondary College
Ms Sarah Guthry	Science Co-ordinator	Parkdale Secondary College
Ms Jenna Haycroft	School Captain	Parkdale Secondary College
Ms Melanie Isaacs	Science and English Teacher	Parkdale Secondary College
Mr Arvind Kale	Year 9 Student	Parkdale Secondary College
Mr Niranjen Kumar	Year 9 Student	Parkdale Secondary College
Mr Chris McGuire	Assistant Principal	Parkdale Secondary

Name	Position	Organisation
Mr Josh Millgate	Year 10 Student	Parkdale Secondary College
Ms Helen Stebbins	Year 10 Student	Parkdale Secondary College
Ms Rachael Waugh	Year 9 Student	Parkdale Secondary College
Mr Steve Woolfe	Leading Teacher	Kingswood Primary School
Mr Wayne Youngs	Maths KLA Leader	Parkdale Secondary College

Additional School Visits and Consultations

School	Date
McGuire College	2 August 2005
Eltham College	1 September 2005
St Helena Secondary College	1 September 2005
Eaglehawk Primary School	13 October 2005
Kangaroo Flat Secondary College	13 October 2005
Mount Eliza Primary School	4 November 2005

Appendix C

List of Perth Meetings

Meetings – 31 May 2005

Name	Position	Organisation
Ms Elaine Horne	Science Curriculum Officer	Curriculum Council
Ms Donna Miller	Curriculum Framework Development – Maths	Curriculum Council
Ms Linda Penny	Senior Policy Officer, Office of Science & Innovation	Department of Premier and Cabinet, Western Australia
Dr Pam Garnett	Chair, Education Working Group Subcommittee	Western Australian Science Council
Ms Pam Moss	Head of Curriculum	Department of Education and Training, Western Australia
Ms Louise Nielson	Primary Science Project Manager	Department of Education and Training, Western Australia
Ms Glenys Reid	Principal Curriculum Officer, Numeracy	Department of Education and Training, Western Australia
Mr Richard Gray	Principal Curriculum Officer, Mathematics	Department of Education and Training, Western Australia
Mr Robert Fitzpatrick	Acting Principal Curriculum Officer, Science	Department of Education and Training, Western Australia
Mr Glen Bennett	Acting Manager, Curriculum Projects	Department of Education and Training, Western Australia

Meetings – 1 June 2005

Name	Position	Organisation
Mr Russell Elsegood	Director, Science and Technology Awareness Raising Program	Murdoch University
Ms Yolanda Pereira	Co-ordinator, Science and Technology Awareness Raising Program	Murdoch University
Mr Barry Kissane	Senior Lecturer, Mathematics Education, School of Education	Murdoch University
Dr Sarath Chandran	Head of Science Department	Lynwood Senior High School
Mr Steve Doyle	Head of Physical Education	Lynwood Senior High School
Mr Hugh Probert	Head of Mathematics Department	Lynwood Senior High School
Ms Marilyn McKee	Science Program Organiser	Lynwood Senior High School
Ms Terri McCauley	Mathematics Teacher	Lynwood Senior High School
Ms Sally Randle	English Teacher	Lynwood Senior High School
Mrs Joyce Michael	Year 8 Co-ordinator	Lynwood Senior High School
Ms Giovanna Vuori	Year 7 Co-ordinator	Lynwood Senior High School
Mr John Mariotti	Environmental Consultant	Lynwood Senior High School
Mr Tom Lyons	Science Teacher, Science, Mathematics & Related Technologies Program	Lynwood Senior High School
Ms Noemi Reynolds	Secondary Professional Development, John Curtin College of the Arts	Mathematical Association of Western Australia

Meetings – 2 June 2005

Name	Position	Organisation
Mr Alan Brien	Chief Executive Officer	Scitech Discovery Centre
Mr Paul Nicholls	Director, Science Education	Scitech Discovery Centre
Associate Professor M O'Neill	Dean and Head of School, Graduate School of Education	University of Western Australia
Dr Jan Dook	Lecturer, Science Communication, Faculty of Life & Physical Sciences	University of Western Australia
Mr Andrew Reay	Education Adviser	Chamber of Minerals and Energy of Western Australia
Ms Julie Sheppard	President	Science Teachers Association of Western Australia
Mr Dave Wood	Secretary	Science Teachers Association of Western Australia
Professor Leonie Rennie	Dean, Graduate Studies	Curtin University of Technology

Site Visit – 3 June 2005

Kent Street Senior High School

Appendix D

Australian Bureau of Statistics: Socio-Economic Indexes for Areas (SEIFA) 2001

Index of Relative Socio-Economic Disadvantage

This index is made up of a composite of all the available variables from the 2001 census that either reflects or measures disadvantage. It only includes variables that are measures of or indicators of disadvantage and in this respect differs from the other three indexes which include variables associated with both advantage and disadvantage.

The index encompasses: low income earners, relatively lower educational attainment, high unemployment, unskilled occupations, public housing rental households, one-parent families, lack of English language fluency, Aboriginal and Torres Strait Islanders and dwellings without motor vehicles.

For all of the indexes, low index values denote disadvantage. Because the Index of Relative Socio-Economic Disadvantage only gauges disadvantage, it is on a continuum of low disadvantage (high index numbers) to high disadvantage (low index numbers), in order to retain consistency with the three other indexes which are all on a continuum of advantage (high numbers) to disadvantage (low numbers). In this instance however, high index numbers equate to either a lack of or low disadvantage, rather than advantage.

Index of Relative Socio-Economic Advantage/Disadvantage

Unlike the previous index which focuses only on disadvantage, this index measures an area's well-being, and is a continuum of advantage to disadvantage. It is derived from attributes relating to income, education, occupation, employment status, internet usage and size of dwelling.

Scoring well on this index indicates that an area has a relatively high proportion of people with high incomes, tertiary qualifications and professional occupations and a low proportion of people with low incomes, lack of qualifications and unskilled occupations. A lower score on this index indicates the reverse.

Index of Education and Occupation

Derived from attributes such as the proportion of people with a higher qualification, or undertaking a higher qualification and those employed in a skilled occupation, this index reflects the educational and occupational structure of communities.

High index numbers denote a high concentration of people with higher educational qualifications or undertaking further study and persons employed in higher skilled occupations. Low index numbers denote a concentration of people with relatively lower qualifications, occupational skills or unemployed persons.

Index of Economic Resources

The Index of Economic Resources is derived from attributes relating to income, expenditure and the assets of families, such as family income, rent paid, mortgage repayments, and dwelling size.

High index scores reflect high incomes, large mortgages and/or rental payments and large dwellings.

Looking at how postcodes score across indices can indicate the degree of heterogeneity or homogeneity within an area.

Explanatory Notes

Please note that there are limitations to the indices as measures of the socio-economic aspects of areas because they are entirely based on variables arising from the census, and therefore some of the indices may lack relevant variables because they were simply not a part of the census.

There are two factors in particular which the indexes do not represent well. First, the indexes contain only limited information about wealth. While income and expenditure are included, aspects such as inherited wealth, savings, indebtedness, and property values are not (such data was not collected by the census). This shortcoming is most serious in the Index of Economic Resources.

Second, an area's infrastructure such as schools, community services, shops and transport is not represented by the indexes. Such information is considered to be important to the concept of advantage or disadvantage. For example, rapidly growing outer suburban areas may suffer from locational disadvantage rather than a socio-economic disadvantage.¹

Please refer to the *SEIFA Information Paper* and/or the *Technical Paper* for a fuller discussion.

Index of Relative Socio Economic Disadvantage

% Persons aged 15 years and over with no qualifications (0.31)
 % Families with offspring having parental income less than \$15,600 (0.29)
 % Females (in labour force) unemployed (0.27)
 % Males (in labour force) unemployed (0.27)
 % Employed Males classified as 'Labourer & Related Workers' (0.27)
 % Employed Females classified as 'Labourer & Related Workers' (0.27)
 % One parent families with dependent offspring only (0.25)
 % Persons aged 15 years and over who left school at or under 15 years of age (0.25)
 % Employed Males classified as 'Intermediate Production and Transport Workers' (0.24)
 % Families with income less than \$15,600 (0.23)
 % Households renting (government authority) (0.22)
 % Persons aged 15 years and over separated or divorced (0.19)
 % Dwellings with no motor cars at dwelling (0.19)
 % Employed Females classified as 'Intermediate Production & Transport Workers' (0.19)
 % Persons aged 15 years and over who did not go to school (0.18)
 % Aboriginal or Torres Strait Islanders (0.18)
 % Lacking fluency in English (0.15)
 % Employed Females classified as 'Elementary Clerical, Sales & Service Workers' (0.13)
 % Occupied private dwellings with two or more families (0.13)
 % Employed Males classified as 'Tradespersons' (0.11)

Index of Advantage/Disadvantage

% Persons aged 15 years and over with degree or higher (0.24)
 % Couple families with dependent child(ren) only with annual income greater than \$77,999 (0.24)
 % Couple families with no children with annual income greater than \$77,999 (0.23)
 % Employed Males classified as 'Professionals' (0.23)
 % Persons aged 15 years or over having an advanced diploma or diploma qualification (0.21)
 % Employed Females classified as 'Professionals' (0.21)
 % Single person households with annual income greater than \$36,399 (0.20)
 % Persons using Internet at home (0.19)
 % Couple families with dependents and non-dependents or with non-dependents only with annual income greater than \$103,999 (0.18)
 % Single parent families with dependent child(ren) only with annual income greater than \$36,399 (0.17)
 % Persons aged 15 years and over at university or other tertiary institution (0.15)
 % Employed Males classified as 'Associate Professionals' (0.14)
 % Single parent families with dependents and non-dependents or with non-dependents only with annual income greater than \$62,399 (0.13)
 % Employed Females classified as 'Advanced Clerical & Service Workers' (0.10)
 % Dwellings with four or more bedrooms (0.08)
 % Single parent families with dependents and non-dependents or with non-

dependents only with annual income less than \$26,000 (-0.10)
% Employed Females classified as 'Elementary Clerical, Sales & Service Workers' (-0.10)
% Employed Males classified as 'Tradespersons' (-0.13)
% Employed Females classified as 'Intermediate Production & Transport Workers' (-0.13)
% One parent families with dependent offspring only (-0.13)
% Couple families with dependents and non-dependents or with non-dependents only with annual income less than \$52,000 (0.15)
% Females (in labour force) unemployed (-0.16)
% Males (in labour force) unemployed (-0.16)
% Single person households with annual income less than \$15,600 (-0.18)
% Employed Males classified as 'Intermediate Production and Transport Workers' (-0.19)
% Employed Males classified as 'Labourers & Related Workers' (-0.19)
% Employed Females classified as 'Labourers & Related Workers' (-0.19)
% Couple families with dependent child(ren) only with annual income less than \$36,400 (-0.20)
% Couple only families with annual income less than \$20,800 (-0.20)
% Persons aged 15 years and over with highest level of schooling completed being Year 11 or below (-0.24)
% Persons aged 15 years and over with no qualifications (-0.25)

Index of Economic Resources

% Couple families with dependent child(ren) only with annual income greater than \$77,999 (0.33)
% Couple families with no children with annual income greater than \$77,999 (0.32)
% Single person households with annual income greater than \$36,399 (0.30)
% Households paying rent greater than \$225 per week (0.30)
% Households paying mortgage greater than \$1,360 per month (0.29)
% Couple families with dependents and non-dependents or with non-dependents only with annual income greater than \$103,999 (0.27)
% Single parent families with dependent child(ren) only with annual income greater than \$36,399 (0.24)
% Single parent families with dependents and non-dependents or with non-dependents only with annual income greater than \$62,399 (0.20)
% Dwellings with four or more bedrooms (0.13)
% Single parent families with dependents and non-dependents or with non-dependents only with annual income less than \$26,000 (-0.16)
% Households paying rent less than \$88 per week (-0.19)
% Couple families with dependents and non-dependents or with non-dependents only with annual income less than \$52,000 (-0.23)
% Single person households with annual income less than \$15,600 (-0.27)
% Couple only families with annual income less than \$20,800 (-0.28)
% Couple families with dependent child(ren) only with annual income less than \$36,400 (-0.28)

Index of Education and Occupation

% Persons aged 15 years and over with degree or higher (0.33)
 % Employed Males classified as 'Professionals' (0.31)
 % Employed Females classified as 'Professionals' (0.29)
 % Persons aged 15 years or over having an advanced diploma or diploma qualification (0.28)
 % Persons aged 15 years and over at university or other tertiary institution (0.21)
 % Employed Males classified as 'Associate Professionals' (0.18)
 % Employed Males classified as 'Advanced Clerical & Service Workers' (0.12)
 % Employed Females classified as 'Elementary Clerical, Sales & Service Workers' (-0.14)
 % Males (in labour force) unemployed (-0.17)
 % Females (in labour force) unemployed (-0.18)
 % Employed Females classified as 'Intermediate Production & Transport Workers' (-0.18)
 % Employed Males classified as 'Tradespersons' (-0.19)
 % Employed Males classified as 'Labourers & Related Workers' (-0.24)
 % Employed Females classified as 'Labourers & Related Workers' (-0.25)
 % Employed Males classified as 'Intermediate Production & Transport Workers' (-0.26)
 % Persons aged 15 years and over with highest level of schooling completed being Year 11 or below (-0.32)
 % Persons aged 15 years and over with no qualifications (-0.32)

Comparing non-ABS data on postcode with ABS data on Postal Area as enumerated

The primary consideration when doing a comparison with Census data based on the Postal Area classification is that the Postal Areas are derived using a 'best fit' of whole CDs. The census data are correct for the Postal Area but the Postal Area only approximates the area of the postcode. The Postal Area classification also excludes some postcodes and as such there will be no census data for these postcodes.

Appendix E

Mathematics and Science Education and Awareness Programs Examined by the Committee

The Committee collected data on participation by schools throughout Victoria in the following programs. The years for which data was collected varied according to how the organisations capture and report the data. All data other than that obtained via a website was provided by the organisation listed, in direct response to a request from the Committee. The Committee acknowledges that this represented a significant amount of work for some organisations and thanks them for the valuable contribution they have made to this inquiry.

Program	Year(s)	Organisation Supplying Data
ASISTM	Round 1 (2005)	Obtained on website, < http://www.asistm.edu.au >
BHP Billiton Science Awards	2005	BHP Billiton (Community Programs Advisor)
CSIRO Discovery – In Centre Visit (Canberra)	2000 to 2004	CSIRO Discovery
CSIRO Family Science Evening	2002 to 2004	CSIRO Melbourne Science Education Centre (SEC)
CSIRO Lab on Legs	2003 & 2004	CSIRO Melbourne SEC
CSIRO Melbourne SEC – In Centre Visit	2003 & 2004	CSIRO Melbourne SEC
CSIRO Scienceathon	2003 & 2004	CSIRO Melbourne SEC
CSIRO – Student Research Scheme	2003 & 2004	CSIRO Melbourne SEC
Discovery Science & Technology Centre – In Centre Visit	2003 to 2005 (financial year)	Discovery Science & Technology Centre
EngQuest	2003 to 2005	Engineers Australia (Victorian Division)
Geoscience Australia Education Centre – In Centre Visit	2002 to 2004	Geoscience Australian Education Centre
GTAC Student Programs	2004 & 2005	Gene Technology Access Centre

Program	Year(s)	Organisation Supplying Data
GTAC Teacher Programs	2004 & 2005	Gene Technology Access Centre
In2Science Peer Mentoring Program	2004 & 2005	La Trobe University website: < http://www.latrobe.edu.au/scitecheng/mentoring >
Mathematics Challenge for Young Australians	2003 to 2005	Australian Mathematics Trust
Maths Talent Quest	2003 to 2005	Mathematical Association of Victoria
Minerals Education – Student Presentation	2003 to 2005	Minerals Education Victoria
Minerals Education – Teacher PD	2003 to 2005	Minerals Education Victoria
Monash Science Centre – Exhibition	2003 & 2004	Monash Science Centre
Monash Science Centre – Lending Library	2004 & 2005	Monash Science Centre
Monash Science Centre – Outreach	2005	Monash Science Centre
Monash Science Students in Schools Program	2004 & 2005	Monash Science Centre
National Maths Talent Quest	2003 to 2005	Mathematical Association of Victoria
Peer Tutor Program	2002 to 2005	RMIT University, School of Applied Sciences
Questacon – In Centre Visit	2002 to 2005 (financial year)	Questacon – The National Science and Technology Centre
Questacon Smart Moves	2003 to 2005	Questacon – The National Science and Technology Centre
Questacon Smart Moves Invention Convention	2005	Questacon – The National Science and Technology Centre
Robocup Junior	2003 to 2005	Brian Thomas, Bellarine Secondary College
Science in Schools	2000 to 2002	Deakin University, Faculty of Education
Science Talent Search	2004 & 2005	Science Teachers' Association of Victoria
Scienceworks – In Centre Visit	2003 & 2004	Scienceworks Museum
Scienceworks Teacher PD	2003 to 2005	Scienceworks Museum
Shell Questacon Science Circus	2002 to 2004	Questacon – The National Science and Technology Centre

Program	Year(s)	Organisation Supplying Data
Shell Questacon Science Circus Teacher Workshop	2002 to 2004	Questacon – The National Science and Technology Centre
Siemens Science Experience	2003 to 2005	Science Schools Foundation
Star 6	2003 & 2004	Scienceworks Museum

Appendix F

Study Tour, Hon. Helen Buckingham MLC – List of International Meetings

England (London, York)

Name	Position	Organisation
Dr Paul Browning	ICT & Resource Director	National Science Learning Centre, University of York
Mr David Buckingham	Victorian Agent General	Government of Victoria
Ms Sue Cousin	Senior Policy Head	Standards Unit, Department for Education and Skills
Professor Celia Hoyles, OBE	Chief Adviser for Mathematics	Department for Education and Skills
Professor John Holman	Centre Director	National Science Learning Centre, University of York
Ms Helen Haywood		UK Branch, Commonwealth Parliamentary Association
Ms Ann Hodgkinson		UK Branch, Commonwealth Parliamentary Association
Mr Andrew McCully	Delivery Director	School Standards Group, Department for Education and Skills
Ms Andrea Mapplebeck	Professional Development Leader	National Science Learning, Centre University of York
Ms Natalie Parish	Head	Intervention and Targets Unit, Department for Education and Skills
Professor Adrian Smith	Principal	Queen Mary College, University of London
Ms Miranda Stephenson	Deputy Director	National Science Learning Centre, University of York

Name	Position	Organisation
Mr Barry Sheerman, MP	Chairman	Education and Skills Select Committee, House of Commons
Mr Andrew Tuggey	Secretary	UK Branch, Commonwealth Parliamentary Association
Mr Ian Turner	Director	Strategy and Program Networks, Specialist Schools Trust

Scotland

Name	Position	Organisation
Mr Robert Brown MSP	Convenor	Education Committee, Parliament of Scotland
Mr Frank Creamer	Curriculum Branch	Qualifications, Curriculum & Assessment Division, Education Department, Scottish Executive
Rt Hon Lord James Douglas-Hamilton	Deputy Convenor	Education Committee Parliament of Scotland
Mr Peter Donachie	National Qualifications Branch	Qualifications, Curriculum & Assessment Division, Education Department, Scottish Executive
Dr Gari Donn	Lecturer	Moray House, School of Education Edinburgh University
Mr Tom MacIntyre	Lecturer/Director of Studies	Science, Technology, Mathematics & Computing, Moray House, School of Education, Edinburgh University
Mr Jeff Maguire	Head	Euyrdice Unit (International Relations) Education Department, Scottish Executive
Ms Margaret Neal	Assistant Secretary	Scotland Branch, Commonwealth Parliamentary Association
Mr Peter Peacock MSP	Minister for Education and Young People	Scottish Government

Name	Position	Organisation
Mr John Richardson	Director	Scottish Schools Equipment Research Centre
Mr Alan Starrit	Principal Education Officer	Learning and Teaching Scotland

France (Paris)

Name	Position	Organisation
Mr John Cresswell	Analyst, Directorate for Education	OECD
Mr Hiroyuki Hase	Education & Training Policy Division, Directorate for Education	OECD
Dr Abrar Hassan	Head, Education & Training Policy Division, Directorate for Education	OECD
Mr Bernard Huggonnier	Deputy Director, Directorate for Education	OECD
Mr Paul Santiago	Analyst, Directorate for Education	OECD
Dr Andreas Schleicher	Head, Indicators & Analysis Division, Directorate for Education	OECD

Appendix G

Queensland Government Action Plan for Improving Mathematics and Science Education

Figure 1: A six-step action plan for improving science education 2003–2006

Science education is important in preparing Queenslanders for living and working in a technologically sophisticated era. Our people are our greatest resource. As such, the Government is building a high-quality education program that is exciting and relevant for students and teachers.

Desired outcomes

Science for Life	Inspiring Science	Connecting Science
- All young people in state schools will study science to the end of Year 10 - More young people will study a science subject to the end of Year 12 - Increased opportunities for all young people to engage with science - Increase numbers of school leavers continuing with tertiary studies in science - Increased understanding of the natural world, so young people can make responsible decisions concerning their own and the community's future wellbeing	- A workforce of enthusiastic and competent teachers who provide exciting and relevant science experiences for students - Improved recruitment of high-quality teachers across all levels of science education - All science teachers engaging in continuous professional development and updating their knowledge and skills in science education	- Science will be taught as a continuing process of practical inquiry into real-world issues and problems - More opportunities for teachers and students to engage in experiences beyond the classroom

Supporting actions

ACTION 1	ACTION 2	ACTION 3
Strategies - Require the study of science to the end of Year 10 for students in state schools from 2005 - Develop a 'Science in Society' elective subject for senior school students - Increase support for out-of-class and interactive science activities - Provide access to real-life science experiences in industry and research institutions - Extend formal agreements between the school system and higher education institutions that allow senior students studying science to gain credit toward tertiary-level science studies - Develop a sustainable model of science and technology magnet schools for students who excel in science - Increase access to information and advice about science careers	Strategies <i>a) Professional development</i> - Develop Destination Statements that describe the range of understandings and skills that characterise teachers who are implementing best practice in science teaching - Establish alternative entry pathways for scientists and other experts to become teachers - Provide scholarships for outstanding school students to undertake university double degrees involving science education - Establish science education as a priority area for professional development with at least 70 per cent of teachers of science in state schools undertaking professional development in science education by 2005 - Establish science as a priority area for the ICTs for Learning Innovation Grants in 2004–2005 - Strengthen the connection between science teaching practice and education research <i>b) Science links</i> - Establish physical and electronic networks to promote mentoring and best practice in state schools - Implement science induction programs for teachers new to a school - Identify and support leaders in science in primary schools - Mandate annual District Science Forums for primary and secondary teachers to share expertise with tertiary personnel, science and community experts - Expand the experiential professional learning and sharing of best practice programs provided by the Technology, Maths and Science Centres of Excellence	Strategies - Increase use of interactive science activities that are relevant in a technologically sophisticated world - Expand the online Science Education Gateway on the Curriculum Exchange with engaging, interactive science activities for students across all year levels - Provide examples of learning activities which integrate ICTs into science across all phases of schooling - Implement a Scientists in Schools program - Determine the feasibility of upgrading existing science facilities in established primary schools - Establish productive partnerships between primary and secondary schools to broaden students' experiences

From the Science State — Smart State initiative, we have developed a six-step action plan to:

- Improve the scientific literacy of Queenslanders
- Encourage more young people to aspire to careers in science
- Improve the overall quality of science education in the Smart State

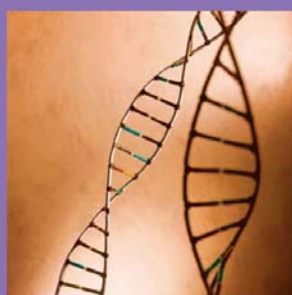
Science All-Stars	Partners in Science	Making it Happen
• Increased acknowledgment of outstanding students and best practice in science teaching • Improved retention of high-quality science teachers • Greater engagement of schools and industry in promoting science education	• More productive science partnerships between industry, business, government, research and educational institutions • Improved learning experiences for students and teachers across all phases of schooling • Increased investment in Queensland science education • Increased public awareness and community engagement in science education	• Increased scientific literacy of Queenslanders • More young people aspiring to careers in science • Improved quality of science education in Queensland
ACTION 4	ACTION 5	ACTION 6
Strategies • Instigate a comprehensive awards program for outstanding science teachers, students, educational institutions and industry supporting the science education initiative • Provide scholarships for teachers to undertake post-graduate studies in science or science education • Acknowledge and reward Science Success Schools that achieve high levels of student participation in science education • Share the strategies of Science Success Schools	Strategies • Assist educators to form partnerships with industry and research institutions to promote mentoring relationships and help develop science courses that have maximum benefits for participants, industry and the community • Encourage ongoing investment in Queensland science education through corporate, public, private and community-driven ventures • Promote industry connections that allow young people to take on vocational education and training experiences together with their science studies • Encourage partners to develop Industry Science Scholarships to support young people undertaking tertiary-level studies in science • Promote partnerships between centres of excellence and local organisations • Support teacher professional associations • Increase public awareness of science and engagement in science education	Strategies • Establish a task force to implement the action plan and advance science education in Queensland • Appoint a Queensland Science Education Ambassador to chair the task force • Develop Destination Statements for science teachers • Monitor and evaluate changes in science education

Source: Education Queensland 2003, *Science State Smart State Spotlight on Science 2003–2006*, Queensland Government, pp. 6–7.

Appendix H

South Australian Government Strategies for Mathematics and Science Education

The Science and Mathematics Strategy



Science

There are nine specific aspects of a science education strategy from which science education in our schools can benefit. They are:

- 1 The promotion to the broader community of the importance of science education in our schools, and particularly its fundamental role in developing scientific literacy. This requires the development of programs that can promote interaction between the scientific, business and industry communities and teachers and students in schools as a way of making science more contextual and relevant, particularly to secondary students. The community has a shared responsibility with all stakeholders to support science teaching and learning in our schools.
- 2 The attraction of larger numbers of students into science teaching and the retention of experienced science teachers in the classroom. In collaboration with training institutions and universities, the strategy can help to entice young school leavers to consider a worthwhile career in science teaching and to involve older, more experienced science teachers in supportive mentoring programs to share their expertise.
- 3 The collaboration with universities and tertiary teacher training institutions to investigate models of good science teaching practice and incorporate elements of these into university pre-service science education courses.
- 4 The provision to teachers of ongoing professional learning programs to help them teach science in ways that promote improved learning outcomes and scientific literacy.
- 5 The targeting of authentic professional development models to address teacher needs in science education.
- 6 The promotion of the use of present and emergent learning technologies in science teaching and learning.



- 7 The adoption of constructivist teaching approaches in science teaching and the use of assessment practices that enhance student learning in science.
- 8 The support of the development of professional standards for science teaching through investigation into added ways in which such standards can be utilised for teacher change and pedagogical renewal, and the national implementation of these standards through professional learning programs.
- 9 The promotion of collaborative approaches to research and data collection through strong partnerships with universities. This will include the monitoring of scientific literacy levels through systemic data collection processes and the development of partnerships with universities to instigate research projects into science education.



The strategy for **Mathematics**

The strategy for mathematics will build on the four significant initiatives that are occurring in mathematics education currently. They are:

- 1 Increased emphasis on numeracy and the ability to successfully apply mathematics to everyday tasks.
- 2 The implementation of the South Australian Curriculum, Standards and Accountability (SACSA) Framework with the associated incorporation of constructivist learning theories into mathematics teaching.
- 3 Major re-development of the South Australian Certificate of Education (SACE) Stage 1 and Stage 2 mathematics courses to be more contextual in nature and to fully integrate the use of technology.
- 4 The opening of the Australian Science and Mathematics School (ASMS) located at Flinders University.

The strategy for mathematics education will, therefore, promote the following activities.

- Teachers are at various stages of adopting constructivist approaches to the teaching of mathematics and there is a need for local research to highlight the strengths and benefits of these approaches. The projects planned to support the mathematics education strategy provide significant support through a range of professional development opportunities to teachers to adapt their current methods of teaching mathematics and to introduce new approaches successfully into mathematics classrooms. The strategy aims to use the opportunity these four initiatives present to improve significantly the mathematics learning outcomes for the full range of students. The clear intention of the strategy is to ensure a greater number of students progress to advanced levels of mathematics and meets the demands of business, industry and education.
- Rapid advances in technology are making the learning of mathematical procedures less important. Many of the procedures can be rapidly reproduced on a graphic calculator or through the use of appropriate software. A key component of the strategy is to support teachers as they develop the skills to use information and communication technologies (ICTs) appropriately and then as they implement the use of the technologies for improved learning of students in mathematics.
- The mathematics education strategy will make explicit links with the DECS Literacy and Numeracy Strategy and explore the connections between mathematics and numeracy to further improve student and teacher understanding of the applications of mathematics in the community.
- Professional development for teachers is a significant component of the strategy. A monitoring and evaluation program to ensure the aims of the strategy are being met will support the professional development program. The monitoring and evaluation program will be designed to fully integrate with the work of the ASMS and give teachers in-class strategies for developing new mathematics teaching methods with the ability to monitor their successes and the need for further development simultaneously.

Shared strategies *for science and mathematics*

In summary, the strategies for science and mathematics will address the following issues which are common to both Learning Areas.

The issue of ensuring that students engage in their science and mathematics learning through curriculum that is relevant and facilitated by experienced and committed teachers of science and mathematics, in order to apply their learning in a changing world.

The issue of the community understanding the role of science and mathematics in shaping an equitable, sustainable and prosperous society and that the community has a shared responsibility in supporting science and science education, and mathematics and mathematics education.

Strategies to support this issue will include:

- Generating teacher professional development activities in engaging methodology.
- Facilitating access to high quality information about career pathways.
- Designing interesting, engaging and inclusive curriculum.
- Providing access to appropriate resources and learning materials.
- Facilitating the greater use by students and teachers of existing and emerging technologies to enhance learning.
- Identifying and addressing the literacy and numeracy demands of science and mathematics learning.



Strategies to support this issue will include:

- Developing productive partnerships with business, industry clusters, tertiary bodies and community organisations.
- Promoting science and mathematics through the media, publications, the Internet, competitions, student/community projects and award programs.
- Consulting with community groups on science and mathematics education initiatives.





The issue of attracting and retaining more teachers of science and mathematics and providing these teachers with appropriate professional learning opportunities.

The issue of teachers and educators building partnerships through research and promoting and advocating science and mathematics to students, the community and business and industry.

Strategies to support this issue will include:

- Supporting ASMS's statewide professional development programs including mentoring, scholarships and industry placements.
- Providing opportunities for best practice practicums for undergraduates.
- Fostering induction and mentoring programs for beginning teachers.
- Initiating a range of targeted professional learning activities in science and mathematics, integrating ICTs and best practice principles particularly for experienced teachers seeking renewal and teachers looking to enhance their knowledge and confidence.
- Developing professional recognition and qualifications programs for skilled and experienced teachers based upon professional standards and graduate qualifications.
- Initiating and further developing partnerships with business, industry, tertiary bodies and community organisations to attract potential teachers of science and mathematics.
- Supporting innovative science and mathematics teaching online.
- Involving DECS and universities in addressing issues of science and mathematics teacher recruitment, supply and training.

Strategies to support this issue will include:

- Advocating science and mathematics learning as inspiring, creative and exciting.
- Conducting school-based research in best practice science and mathematics teaching and learning.
- Researching and promoting teaching and learning beliefs, approaches and structures that successfully engage disadvantaged students.
- Supporting and promoting science and mathematics programs, awards and events.
- Supporting the central role of the ASMS in its coordination and rationalisation in the areas of curriculum enhancement, professional learning and community awareness.
- Providing a forum where professional associations, professional development providers, outreach educational services, business, industry clusters and community groups contribute to the direction of the Science and Mathematics Strategy in schools.



Source: Department of Education and Children's Services, *Strategic Directions for Science and Mathematics in South Australian Schools 2003 – 2006*, Government of South Australia, pp. 10-13.

Appendix I

Primary Connections 5Es Instructional Model

Phase	Focus
ENGAGE Assessment type Diagnostic	Engage the students and elicit prior knowledge. Questioning is essential during this phase – it is used to guide the children and get them engaged. The ways teachers ask questions and the ways students respond will structure the success of student inquiry.
EXPLORE Assessment type Diagnostic	Provide hands-on experiences and investigation. The child gets directly involved with phenomena and materials.
EXPLAIN Assessment type Formative	Development of explanations for the experiences during the explore phase. Language provides motivation for sequencing events into a logical format.
ELABORATE Assessment type Formative	Extend understanding to a new context / additional concepts. Children expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them.
EVALUATE Assessment type Summative	Reflect on learning journey and collect evidence about achievements. Assessment becomes part of the learning process so that students play a larger role in judging their own progress.

Source: Australian Academy of Science 2004, *Primary Connections: Linking science with literacy*, cited in Written Submission, Gunbower Primary School, 4 August 2005.

Appendix J

University Enrolments by Area of Study (2003)

Award Course Completions for All Domestic Students by State and Broad Field of Education – 2003 (Number)

State/ Institution	Natural and Physical Sciences	Information Technology	Engineering and Related Technologies	Building	Agriculture, Environmental and Related Studies	Health	Education	Management and Commerce	Society and Culture	Creative Arts	TOTAL (a, b)
New South Wales	3,525	2,433	2,284	1,090	1,128	6,177	7,155	12,549	12,600	3,949	51,368
Victoria	3,616	3,126	2,333	724	672	5,753	4,984	9,206	9,650	2,757	41,276
Queensland	2,185	1,673	1,293	487	720	3,630	4,609	6,202	5,272	2,030	26,825
Western Australia	1,287	735	798	267	544	2,071	2,191	3,129	2,912	1,120	14,518
South Australia	1,073	430	578	193	355	2,077	1,323	2,311	2,673	571	11,243
Tasmania	334	226	315	55	219	390	455	444	733	222	3,309
Northern Territory	75	47	2	6	12	229	237	147	140	43	923
Australian Capital Territory	651	369	240	110	61	129	355	1,351	1,883	284	5,028
Multi-State (Australian Catholic University)	0	54	0	0	7	536	1,345	186	568	13	2,482
TOTAL	12,746	9,093	7,843	2,932	3,718	20,992	22,654	35,525	36,431	10,989	157,003

Note: (a) The category of Food, Hospitality and Personal Services has not been included as there were only 31 completions in this study area Australia-wide in 2003

(b) The data takes into account the coding of Combined Courses to two fields of education. As a consequence, counting both fields of education for Combined Courses means that the totals may be less than the sum of all broad fields of education

Source: Constructed by the Education and Training Committee, based on data in the *Selected Higher Education Statistics Series*, 2005

Award Course Completions for All Domestic Students by State and Broad Field of Education – 2003 (%)

State/ Institution	Natural and Physical Sciences	Information Technology	Engineering and Related Technologies	Architecture and Building	Agriculture, Environmental and Related Studies	Health	Education	Management and Commerce	Society and Culture	Creative Arts	TOTAL (a) (b)
New South Wales	27.7	26.8	29.1	37.2	30.3	29.4	31.6	35.3	34.6	35.9	32.7
Victoria	28.4	34.4	29.8	24.7	18.1	27.4	22.0	25.9	26.5	25.1	26.3
Queensland	17.1	18.4	16.5	16.6	19.4	17.3	20.4	17.5	14.5	18.5	17.1
Western Australia	10.1	8.1	10.2	9.1	14.6	9.9	9.7	8.8	8.0	10.2	9.3
South Australia	8.4	4.7	7.4	6.6	9.6	9.9	5.8	6.5	7.3	5.2	7.2
Tasmania	2.6	2.5	4.0	1.9	5.9	1.9	2.0	1.3	2.0	2.0	2.1
Northern Territory	0.6	0.5	0.0	0.2	0.3	1.1	1.1	0.4	0.4	0.4	0.6
Australian Capital Territory	5.1	4.1	3.1	3.8	1.6	0.6	1.6	3.8	5.2	2.6	3.2
Multi-State (Australian Catholic University)	0.0	0.6	0.0	0.0	0.2	2.6	5.9	0.5	1.6	0.1	1.6
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

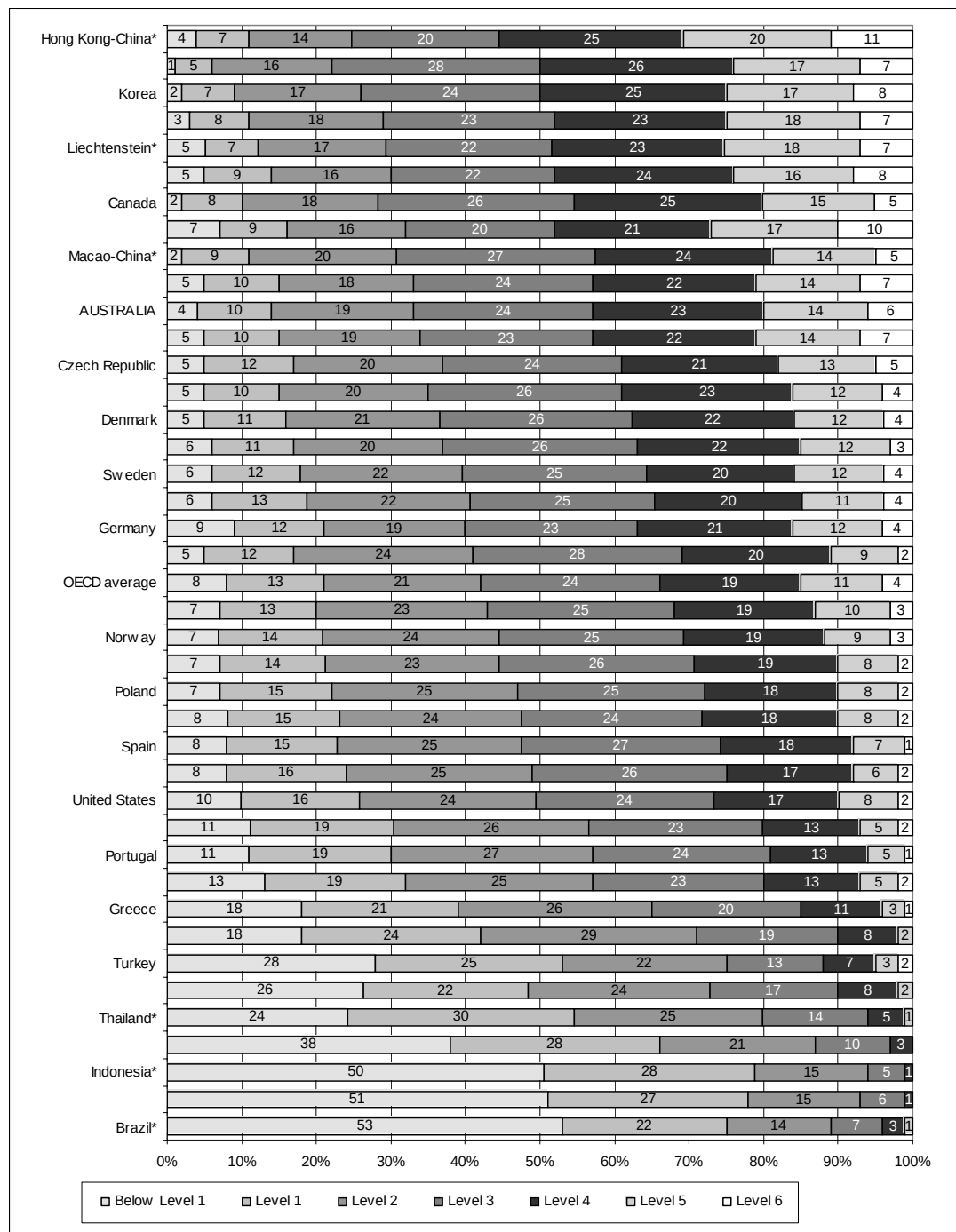
Note: (a) The category of Food, Hospitality and Personal Services has not been included as there were only 31 completions in this study area Australia-wide in 2003

(b) The data takes into account the coding of Combined Courses to two fields of education. As a consequence, counting both fields of education for Combined Courses means that the totals may be less than the sum of all broad fields of education

Source: Constructed by the Education and Training Committee, based on data in the *Selected Higher Education Statistics Series*, 2005

Appendix K

PISA – Proficiency Levels in Mathematical Literacy for all Participating Countries (2003)



Note: * Partner Country
Source: S. Thomson, J. Cresswell and L. De Bortoli 2004, *Facing the Future: A focus on mathematical literacy among Australian 15-year-old students in PISA 2003*, ACER, Melbourne, p. 45.

Appendix L

Centres of Excellence

Australian Mathematical Sciences Institute (AMSI)

Comprising a consortium of 25 universities and the CSIRO, the Australian Mathematical Sciences Institute (AMSI) was established in 2002. It was partially funded under the Victorian Government's Science, Technology and Innovation Infrastructure grants program.

AMSI's mission is to become a nationally and internationally recognised centre for the mathematical sciences, providing services to its member institutions, improving the international competitiveness of Australian industry and commerce and enhancing the national level of school mathematics, by the provision and support of mathematical and statistical expertise. One of its key objectives is to improve the teaching of mathematics at primary and secondary level by joining with mathematics teacher associations and government agencies to develop a strategy to address issues such as teacher shortfalls and under-qualified teachers.

Much of the Institute's work in mathematics education is now undertaken through the International Centre of Excellence for Education in Mathematics (ICE-EM), which is managed by the Australian Mathematical Sciences Institute (refer below).

Contact Details:

Phone: 03 8344 1777

Website: <<http://www.amsi.org.au/index.html>>

Bacchus Marsh Science and Technology Innovations Centre (Ecolinc)

The Bacchus Marsh Science and Technology Innovations Centre (trading as Ecolinc), is an educational centre that opened in 2005 to promote sustainable environmental practices. The Centre received funding through a *Growing Victoria Together* grant.

The Ecolinc building has been designed using ecological sustainable design principles. This unique building is set within an indigenous wetland, created to demonstrate stormwater purification and to provide habitat to increase natural biodiversity.

Within Ecolinc's three main themes of water, energy and horticulture, students can explore the self-guided sustainability trail including a

model wetland. The centre features thermal chimneys, a natural ventilation 'hot box', and composting toilets. Internal construction and external works include stormwater diversion for the wetland, water recycling and management process.

Ecolinc has many specialised features and provides sustainable environment programs for students of all ages, as well as professional development programs for secondary teachers. It also promotes future career and study options for students interested in environmental studies.

Ecolinc runs programs for VCE Biology, Chemistry, Environmental Science and Physics, in addition to a range of science programs for Prep to Year 10 students.

Contact Details:

Phone: 03 5367 0171

Website: <<http://www.ecolinc.vic.edu.au/>>

CSIRO Science Education Centres

The CSIRO Science Education Centres (SECs) provide interactive science education programs and science shows to schools throughout Australia. There are nine CSIRO SECs; one in the capital city of each state and territory, and another in Townsville, North Queensland. CSIRO SECs cater for primary and secondary students (including VCE students) across the various scientific disciplines. CSIRO SECs also run a range of teacher professional development courses and family science evenings.

The CSIRO SECs aim to:

- alert school students, their families and teachers of science to the contribution of CSIRO and scientific research to our community;
- encourage students to pursue careers in science, engineering and technology; and
- engage, enthuse and educate students, teachers and the wider community about science and its applications.

The Melbourne SEC is the hub for CSIRO's science education programs in Victoria and the Lab on Legs program that takes exciting science shows and workshops to schools around Victoria.

School groups can also visit the three laboratories/classrooms at the SEC in Highett, where science demonstrations and workshops are held. The Melbourne CSIRO Science Education Centre is the base for primary and secondary school programs; teacher professional development; working with a scientist through the Student and Teacher

Research Schemes; Double Helix Science Club (Victoria); and school holiday programs.

Contact Details:

Phone: 03 9252 6387

Website: <<http://www.csiro.au/melbcsirosec/>>

CSIRO Discovery Centre

Based in Canberra, Discovery Centre is an exciting interactive centre showcasing CSIRO's achievements in science and technology. It offers challenging, topical and fun education programs for primary and secondary students.

The educational aim of the Discovery Centre is to teach the importance and relevance of science and technology research to everyday life and the future, by offering education programs to challenge and entertain students in a safe, stimulating environment. The programs are participatory, and aim to be fun-packed and relevant to primary and secondary science.

Contact:

Phone: 02 6246 4602

Website: <<http://www.discovery.csiro.au/>>

Gene Technology Access Centre (GTAC)

The Gene Technology Access Centre is located at University High School and was opened in April 2004. The programs conducted at the Centre, for Victorian students and teachers, were established through a partnership between the Department of Education and Training, University High School, the Walter and Eliza Hall Institute for Medical Research and the University of Melbourne.

The goals of the GTAC are to:

- excite young people about science and to give students the opportunity to work with young scientists;
- enrich science learning in the classroom by providing teachers with effective professional development, resources and access to eminent research scientists;
- increase genetic literacy in the wider community; and
- facilitate informed debate about the societal issues raised by applications in biotechnology.

There are three types of student programs offered at GTAC. Current student laboratory workshops include topics aimed at Year 6 students, middle school students and VCE biology classes.

The student lecture series offers a full-day program of lectures for VCE biology students presented by research scientists and GTAC teachers. In addition, short courses (2–3 days duration) are held for individual students who self-select or who may be nominated by their school. These courses are held at weekends or during school holidays.

Additionally, GTAC offers a suite of teacher education programs including lectures, seminars and workshops targeted at primary, secondary and pre-service teachers. Lectures for secondary teachers include a full-day program covering contemporary biological research and a full-day program for teachers undertaking VCE Units 3 and 4 Biology for the first time. Throughout 2005, a series of two-hour seminars on selected topics was conducted to assist teachers with the implementation of the 2006 Biology Study Design. Laboratory workshops for secondary teachers included two-day workshops on DNA manipulation tasks, using bioinformatics in the classroom and a two-hour workshop for pre-service teachers on teaching DNA Science in the middle years.

Contact Details:

Phone: 03 9340 3600

Website: <<http://www.gtac.edu.au/site/home.html>>

Geoscience Australia Education Centre

Located in Canberra, the Geoscience Australia Education Centre is part of Geoscience Australia, the nation's leading geoscience research and information agency.

The Centre provides structured, curriculum-linked, hands-on activities that aim to enthrall, excite and educate. It also aims to prove that geoscience is not only interesting and relevant, but also great fun. The Centre is an ideal school excursion destination.

Students can expect to explore the many aspects of geoscience through hands-on experiments and activities using scientific equipment, computers and first-class teaching materials.

Contact Details:

Phone: 02 6249 9673

Website: <<http://www.ga.gov.au/education/gec/>>

International Centre of Excellence for Education in Mathematics (ICE-EM)

The International Centre of Excellence for Education in Mathematics (ICE-EM) has been established to strengthen education in mathematics and its contemporary applications. ICE-EM is funded by the Federal Department of Education, Science and Training. It is managed by the Board of the Australian Mathematical Sciences Institute and guided by its Education, Industry and Scientific Advisory Committees.

One of ICE-EM's fundamental tasks is to improve the mathematical sciences base through improved mathematics education in schools, undergraduate studies and research training. The aim is to make studying the mathematical sciences in Australia attractive to both Australian and international students.

ICE-EM is funding a range of initiatives, including

- developing new mathematics course material;
- providing professional development programs;
- providing summer residential placements;
- producing teacher resources for schools and the VET/TAFE sector; and
- carrying out a national awareness campaign targeted at students and their parents.

ICE-EM is also working collaboratively with the Australian Mathematics Trust to develop resources for teachers, students and the community.

Contact Details:

Phone: 03 8344 1777

Website: <<http://www.ice-em.org.au/>>

Monash Science Centre

The Monash Science Centre is designed to bring the community and scientists together to enrich the community's understanding of science.

The Centre's programs take students, teachers and interested members of the public into laboratories, the field, on the internet, and into the classroom to explore how science works and what it is able to offer. The Centre strives to show the interrelationship of science and technology with the arts, politics, economics, law and many other disciplines. The vision of the Centre is to provide a window on science that gives everyone an in-depth understanding of science, and a way of

using scientific thought and knowledge in their everyday life and to provide tools for facing the future realistically and sustainably.

The Centre operates a number of initiatives including displaying scientific exhibits; running holiday science programs and a guest lecture program; providing tailored professional development for primary and secondary teachers; and providing extensive outreach science education programs for schools.

Contact Details:

Phone: 03 9905 1370

Website: <<http://www.sci.monash.edu.au/msc/index.html>>

NTEC@Northland Secondary College

Ntec is a manufacturing and technology centre situated at Northland Secondary College, East Preston. The Centre was developed in response to high levels of youth unemployment throughout the City of Darebin and surrounding areas of Melbourne's North. The Centre was also established to respond to skill shortages within the local and regional economy.

Ntec runs vocational education and training programs that can be accessed by students from all school in Melbourne's North, as well as programs for unemployed and marginalised groups. The central activities of Ntec are focused on:

- increasing the employment and further education and training opportunities and outcomes for local students, and in particular Koori youth, female students and students at risk;
- broadening the community's skills base; and
- responding to regional economic and community concerns to deepen and diversify manufacturing and technology skills and increase long-term, full-time employment opportunities for youth and other job-seekers.

The project is guided by the Ntec Reference Group which comprises a range of different organisations including local government, TAFE institutes, industry, unions, group training companies, community services organisations, Koori organisations and peak bodies such as the Victorian Employers' Chamber of Commerce and Industry and the Australian Manufacturing Technology Institute Limited.

Contact Details:

Phone: 03 9478 1333

Website: http://www.northland.vic.edu.au/flash_content.html

Questacon – The National Science and Technology Centre

Opened in November 1988, Questacon has a vision of ‘a better future for all Australians through engagement with science and innovation’. Questacon contributes to achieving the Commonwealth Government’s commitments under *Backing Australia’s Ability – Building our Future through Science and Innovation*, as an agency within the Commonwealth Department of Education, Science and Training. Questacon’s mission is:

To increase awareness and understanding of science and innovation through inspirational learning experiences.

Questacon’s activities aim to deliver outcomes in Australian government policy areas, which include early childhood learning, Indigenous education, mathematics, numeracy, literacy, promoting the uptake of science at all levels, teacher professional development and showcasing Australian science and technology internationally.

In-centre programs include over 200 science exhibits, three theatre shows, ‘Questacon By Night’ and sleepovers.

Contact Details:

Phone: 02 6270 2800

Website: <<http://www.questacon.edu.au>>

Scienceworks Museum

Scienceworks Museum is a science and technology education centre aimed at providing a wide range of learning experiences beyond the classroom. One of Museum Victoria’s three museums, Scienceworks is largely funded by the Victorian Government.

Scienceworks includes hands-on exhibits, live demonstrations, tours, activities and shows targeting different age groups and capabilities, with a prime focus on visitor engagement. A number of permanent facilities are located at Scienceworks, including:

- the Melbourne Planetarium, which is the only digital planetarium in the Southern Hemisphere;
- the Lightning Room theatre, which offers live lightning demonstrations that are informative and entertaining; and
- the Spotswood Pumping Station, which was built in the late nineteenth century as a key component of Melbourne’s first centralised sewerage system.

Scienceworks education service offers a range of choices for student excursions, with themes based around science and technology as well as broader curriculum areas. Excursions can be planned for students from Prep to Year 12. Teachers can choose to utilise an extensive range of teacher and student resources that link to and support exhibits and displays. These resources are available on the Museum's website.

The Victorian Government's Star 6 initiative offers a travel subsidy of \$3 per student for Year 6 metropolitan students visiting Scienceworks and a full refund of travel costs for non-metropolitan students. All Year 6 students also receive a \$2 subsidy for entry to the Planetarium.

Contact Details:

Phone: 03 9392 4800

Website: <<http://scienceworks.museum.vic.gov.au/>>

Victorian Institute for Chemical Sciences (VICS)

Funded under the Science, Technology and Innovation infrastructure grants program, the Victorian Institute for Chemical Sciences (VICS) was established in 2002. VICS is a partnership between the Chemistry Schools of Monash University, the University of Melbourne and the Department of Applied Chemistry at RMIT University. The Institute has a vision to become the leading multi-campus institute in Australia for teaching and research in the chemical sciences.

The Institute operates a Chemistry Education and Outreach program that has three strategic aims:

- to encourage students to pursue a professional career in the chemical sciences;
- to provide trained educators in chemical sciences; and
- to provide a workforce trained in the chemical sciences and familiar with modern scientific instrumentation and other leading edge scientific technologies.

The Institute's outreach activities expose students to a mixture of new research, fundamental chemical principles and the chemistry of everyday life. The programs can be held on the campuses of Melbourne, Monash or RMIT universities and at schools throughout Victoria.

Secondary student activities aim to develop an interest in and enthusiasm for chemistry through presentations and hands-on experience, an increased awareness of the importance of chemistry in our society and information for students and their parents about career opportunities in the chemical sciences.

The Institute also provides chemistry teachers with the opportunity to participate in professional workshops to update their subject knowledge.

Contact Details:

Phone: 03 8344 3949

Website: <<http://www.vics.net.au/>>

Victorian Space Science Education Centre (VSSEC)

The Victorian Space Science Centre (VSSEC) was established to promote science and mathematics education to Victorian students by exposing them to the exciting world of space science.

Supported by the Victorian Government and Strathmore Secondary College, as well as some of Australia's premier universities, Phillip Spencer and Michael Pakakis (both current teachers at Strathmore) have assembled a complex array of hands-on experiences for students and adults alike. These will be housed in a purpose-built centre, designed to fully immerse the participants in a world of high-tech space exploration.

Scenario-based experiences teach not only team work, communication skills and problem-solving, but also give a firm grounding in scientific method. Whether they are landing on the virtual Martian surface, or simply day-tripping to a Space Station, it remains crucial that everyone works together to ensure their safe return and success of their mission.

Aside from the scenario-based learning experiences, the Victorian Space Science Education Centre uses its links and strong working partnerships with universities, ESA and NASA education to provide students with access to the space science environment by supplying VCE focused coursework and continuing professional development to aid teachers in presenting complex material.

The VSSEC and its staff endeavour to provide access to, and guidance in, science and mathematics and its applications and lessons. With customised laboratories dealing in everything from human physiology to geo-physics, a simulated Martian terrain and operational mission control room, VSSEC is the place to launch your future.

Contact Details:

Phone: 03 9379 7999

Website: <<http://www.vssec.org/>>

Appendix M

University-to-School Mentoring Programs

In2Science Peer Mentoring in Schools Program

In2Science started in 2004 as a joint venture between the Faculties of Science at La Trobe University and the University of Melbourne in conjunction with the William Buckland Foundation. In2science currently has partner schools in both the metropolitan and regional areas of Victoria. Within these schools, university science and mathematics students volunteer their time to work in the classroom for a few hours each week. The primary aim is for mentors to interact with the students, discussing the work students are doing and helping students with their understanding. Peer mentoring also offers university students the opportunity to be actively engaged in a school environment with students to experience first-hand what teaching is like.

In2Science peer mentors are volunteers who receive only travel expenses. All placed peer mentors must attend a training session for half-a-day prior to undertaking their first placement. Peer mentors offer 2 to 3 hours of their time each week during a placement block of 10 to 12 weeks and receive a certificate of involvement.

In 2005, twenty-five secondary schools were involved in In2Science.

Contact:

Mr John McDonald, Program Co-ordinator, La Trobe University

Phone: 03 9479 2523

Website: <<http://www.latrobe.edu.au/scitecheng/mentoring/>>

Peer Tutor Program

RMIT University's Peer Tutor program has been operating since 1998. The program places undergraduate students in science and mathematics classes in primary and secondary schools to assist younger students with learning. RMIT University students can either volunteer for the program or apply to do it as an elective unit that gains academic credit. Peer tutors can participate in metropolitan schools or as part of a team visiting rural and regional based schools to present an intensive program or workshop. Each year, science peer tutors from RMIT University also volunteer for activities such as the Siemens Science Experience, National Science Week and other science related events. The peer tutors must attend a compulsory training session and they may claim some expenses.

Metropolitan Peer Tutor Program

This program offers peer tutors a rewarding opportunity to share knowledge and experience with younger students in schools. Peer tutors work with one or more science and mathematics classes, usually between Years 2 to 10. Peer mentors help school students with their work, usually on a one-to-one basis in class. They can be involved in a variety of science, mathematics or other topics. Placements can vary from 10 to 20 weeks, and involve a three hour visit each week. Some preparatory training is provided in classroom dynamics and communication.

Country School Visits – Science Road Crew

Working in small teams, the RMIT Science Road Crew travels to regional areas once or twice per semester. RMIT University peer tutors present science workshops and demonstrations in regional Victorian primary and secondary schools. Teams travel for up to five days working with students in Years 3 to 10. All meals, accommodation and transport are arranged and paid for. Tutors work together to present up to three 90-minute sessions per day in each school. Typical activities feature physics, chemistry, environmental science and food science. Since July 2000, when the first Road Crew went out, the program has visited 114 schools in all regions of Victoria.

Contact:

Ms Louise Delpratt, Peer Tutor Program Manager

School of Applied Sciences, RMIT University

Phone: 03 9925 4987

Website: <<http://www.rmit.edu.au/browse;ID=rek458j99n5b>>

Science Students in Schools Program

The Science Students in Schools Program offers final year Monash University science students the opportunity to work in primary or secondary schools for 1 to 2 hours per week over a school term (8 to 10 weeks).

As part of the program, university students are matched with a school and a class, and work collaboratively with the teacher in ways that aim to enhance the experience of science for the school students and teachers. Participants receive a letter of recognition from Monash University and are able to claim expenses up to \$100 during their placement.

Contact:

Ms Priscilla Gaff, Co-ordinator of Secondary School Placements

The Monash Science Centre

Phone: 03 9905 1371

Mr Michael Roberts, Co-ordinator of Primary School Placements

The Monash Science Centre

Phone: 03 9905 8062

Website: <<http://www.sci.monash.edu.au/msc/>>

STAR Peer Tutoring Programme (Western Australia)

The STAR program was Australia's first university-to-school peer tutoring program. Established in 1994 by Murdoch University in Western Australia, the program is modelled on the successful Pimlico Connection operating in the United Kingdom and, to some extent, on Israel's national Perach project. It is now the biggest program of its type in Australia.

STAR peer tutors are Murdoch University students who volunteer between 2– to 4 hours each week to work with high school students in their classrooms. Peer tutors also participate in school excursions and may help organise field trips to the Murdoch University campus. All peer tutors complete a half-day training program to prepare them for their role. At the end of their time as a STAR peer tutor, volunteers receive a university-authorised document detailing the assignment and the specific skills they have been able to develop and use.

While STAR was initially launched with the objective of improving science awareness among high school students and encouraging more students to consider science as a future career, the principles of tutoring and mentoring have been applied to a range of other disciplines, including Accounting, Computing, Geography, Mathematics, Languages, English, History and Media Studies. Despite this, science remains the clear focus of the STAR Program. STAR now operates a number of complementary programs including STARlink, the STARtrek Science Show and ecoSTAR.

Contact:

Mr Russell Elsegood, Director

Ms Yolanda Pereira, Co-ordinator

Murdoch University

Phone: 08 9360 6650

Website: <<http://about.murdoch.edu.au/star/navpage.html>>

Appendix N

Description of Mathematics and Science Education and Awareness Programs

Mathematics Programs

Australian Mathematical Olympiad Program

The Australian Mathematical Olympiad Program (AMOP) is run by the Australian Mathematics Trust. The top 100 or so students from the Mathematics Challenge for Young Australians and the Australian Mathematics Competition take extra preparation that can lead to selection to participate in the International Mathematical Olympiad.

Contact:

Phone: 02 6201 5135

Website: <<http://www.amt.canberra.edu.au/eventsamoc.html>>

Australian Mathematics Competition for the Westpac Awards

Introduced in 1978, the Australian Mathematics Competition for the Westpac Awards is the original large competition for students of all standards. Almost all secondary schools in the country participate. The Competition was introduced at primary level in 2004.

The three aims of the Competition are to: highlight the importance of mathematics as a subject in the curriculum; to provide students with an opportunity to discover a talent for solving problems which might not come through the normal process; and to provide resources to the teacher.

All students receive a certificate from the Australian Mathematics Trust, recognising their participation in the Competition.

Contact:

Phone: 02 6201 5135

Website: <<http://www.amt.canberra.edu.au/eventsamoc.html>>

Mathematics Challenge for Young Australians

The Mathematics Challenge for Young Australians is a special event run by the Australian Mathematics Trust. The Challenge targets the top 20 per cent of primary students in Years 5 and 6, and secondary students in Years 7 to 10. Whereas it is directed at all students in this category, it may be particularly useful in schools where teachers may be working in isolation and have a handful of talented students spread over a number of classes.

The Challenge provides materials so that teachers may help talented students reach their potential. Teachers in larger schools also find the materials valuable, allowing them to better assist the students in their classes.

The aims of the Mathematics Challenge to Young Australians include:

- Encouraging and fostering: a greater interest in and awareness of the power of mathematics; a desire to succeed in solving interesting mathematical problems; and the discovery of the joy of solving problems in mathematics.
- Identifying talented young Australians, recognising their achievements nationally and providing support that will enable them to reach their own levels of excellence.
- Providing teachers with: interesting and accessible problems and solutions as well as detailed and motivating teaching discussion and extension materials; and comprehensive Australia-wide statistics of students' achievements in the Challenge.

There are three independent stages in the Mathematics Challenge for Young Australians - the Mathematics Challenge Stage, the Mathematics Enrichment Stage and the Australian Mathematics Olympiad Committee Intermediate Contest.

The Challenge is supported by the Department of Education, Science and Training.

Contact:

Phone: 02 6201 5135

Website: <<http://www.amt.canberra.edu.au/mcya.html>>

Maths Talent Quest

The Maths Talent Quest (MTQ) was first held in 1982 and is open to all primary and secondary students. It is organised by the Student Activities Committee of the Mathematical Association of Victoria.

The MTQ aims to promote interest in mathematics and foster positive attitudes amongst students, teachers and parents. The focus is on the process of mathematical investigations. A participation certificate is awarded to every student participating and prizes are awarded in various categories. The top entries from each level are then forwarded to the National Maths Talent Quest.

Contact:

Phone: 03 9389 0310

Website: <<http://www.mav.vic.edu.au/studact/mtq.htm>>

National Maths Talent Quest

The National Maths Talent Quest (NMTQ) involves judging the winners of state/territory talent quests, to find the best entries in the country. All entries receive participation certificates and judges can award merit certificates to outstanding entries that do not receive a major award. The Annual Award Ceremony of the NMTQ moves around the country and is generally held in late November.

Contact:

Phone: 08 8363 0288

Website: <<http://www.aamt.edu.au>>

Science Programs

Australian Science Olympiads

The Australian Science Olympiads provide students throughout Australia with opportunities to enhance their scientific knowledge, understanding and skill in Biology, Chemistry and Physics.

Australian Science Innovations, with financial support from the Department of Education, Science and Training, conducts the Australian Science Olympiad Programs and has the responsibility to ensure Australia's representation at the International Biology, Chemistry and Physics Olympiads.

Contact:

Phone: 02 6125 9645

Website: <<http://www.aso.edu.au/www/index.cfm>>

Bendigo Discovery Science and Technology Centre

With the support of the Victorian Government and the City of Greater Bendigo, Discovery opened in 1995 as Australia's first Science and Technology Centre outside a major metropolitan area.

Discovery exhibits are designed for a broad range of visitors and the philosophy that underpins the exhibit design and program development is to educate, entertain and encourage an interest in the sciences for children, as well as to interest and enlighten older members of the community.

Special activities for schools have included the running of water activities; the very popular Sleepover program; and special show and exhibit area experiences tailored to the requirements of the particular year level.

Contact Details:

Phone: 03 5444 4400

Website: <<http://www.discovery.asn.au/index2.html>>

BHP Billiton Science Awards

The BHP Billiton Science Awards are open to all Australian permanent residents enrolled full-time in primary or secondary schools in Australia (including home-schooled) or undertaking full-time secondary study in TAFE colleges.

The Awards reward young people who have undertaken practical research projects that demonstrate innovative approaches and in-depth scientific procedures.

The BHP Billiton Science Teacher Awards recognise outstanding contributions made by classroom teachers to science education.

Run in conjunction with the CSIRO, the Awards are open for entry from February to early July each year, with the winners announced in early October.

Contact:

Phone: 03 9609 3341

Website: <<http://scienceawards.bhpbilliton.com/>>

Connell Wagner Bridge Building Competition

Every year, since 2000, Connell Wagner has run the Bridge Building Competition for secondary schools in Victoria. The competition aims to increase awareness of the engineering profession as well as encourage problem-solving through teamwork. The project involves planning, teamwork, decision making, creative thinking and innovation.

In 2005, there was a prize of \$1,000 to the winning school and \$100 for each team member.

The Bridge Building Competition has been supported by Engineers Australia (Victorian Division) and Scienceworks Museum.

CREST

CREativity in Science and Technology (CREST) is an award program for primary and secondary school students. CREST provides students with a nationally accredited award for completing experimental science or technology projects. CREST is not a competition and all students who meet the criteria for an Award receive an appropriate Certificate and, in some cases, Medallion.

The CREST Awards are offered by CSIRO Education with support from Alcoa World Alumina Australia and various state and territory education departments.

Contact:

Phone: 02 6276 6567 or 1800 626 646 (freecall)

Website: <<http://www.csiro.au/crest/>>

CSIRO Double Helix Science Club

Double Helix Science Club is a national science club for 7+ year olds that operates as part of CSIRO Education. The Club offers a selection of programs and resources for schools, teachers and other interested members of the community.

Contact:

Phone: 03 9252 6209

Website: <<http://www.csiro.au/melbcsirosec/helix/index.html>>

CSIRO Family Science Evening

The Family Science Evening is a program run by the CSIRO Melbourne Science Education Centre. It is designed for parents of primary school students, the students themselves and their teachers. The aim is to enthuse students and parents in the shared learning of science. An expert from CSIRO will visit a school to run demonstrations and hands-on activities for family groups. The program runs for 1½ hours.

Contact:

Phone: 03 9252 6387 or 03 9252 6410

Website: <<http://www.csiro.au/melbcsirosec/programs/family.html>>

CSIRO Lab on Legs

The Lab on Legs is a CSIRO Melbourne Science Education Centre outreach program that takes exciting science shows and workshops to schools around Victoria. Lab on Legs is both entertaining and informative, and provides links between Australia's scientific research and classroom science. It consists of interactive scientific classroom activities and theatre.

Contact:

Phone: 03 9252 6387

Website: <<http://www.csiro.au/melbcsirosec/programs/index.html>>

CSIRO Science Challenge

The CSIRO Science Challenge encourages students in upper primary school to use their research, analysis and interpretation skills to answer questions based on practical experiments. The experiments can be done at home or at school, using ordinary household materials to show principles of science and technology.

Contact:

Phone: 02 6276 6291

Website: <<http://www.csiro.au/csiro/content/standard/ps6t,.html>>

CSIRO Student Research Scheme and Teacher Research Scheme

The Student Research Scheme (SRS) is an Australia-wide program run by CSIRO in conjunction with scientists from many institutions. The SRS is open to selected students in Years 11 and 12. Students are supervised by a practising scientist or engineer and complete a research project of approximately 20 hours during the school holidays. Following the research, students make a class presentation about their project.

The Teacher Research Scheme provides science teachers with the opportunity to undertake a short research project with a scientist with some funded release time per teacher.

Contact:

Phone: 03 9252 6085

Website: <<http://www.csiro.au/csiro/content/standard/pscs,.html>>

EngQuest

EngQuest is a hands-on way for students to achieve key learning outcomes in science, mathematics and technology. EngQuest provides interactive student projects combined with comprehensive resources and teacher support for primary school teachers across Australia. Registration is free and prizes are offered for the winning projects at state level. All students (and teachers) receive a certificate of participation.

EngQuest is a program of Engineers Australia.

Contact:

Phone: 03 9321 1716

Website: <<http://www.engquest.org.au>>

Family Science Nights (Monash Science Centre)

The Monash Science Centre is keen to support schools with Family Science Nights. It is rewarding for family members to experience together the fun of learning while sharing valuable experiences in the fascinating world of science. The Centre offers school-based or centre-based hands-on family science nights on various topics.

Contact:

Phone: 03 9905 1370

Website: <<http://www.sci.monash.edu.au/msc/lessons/family.html>>

Minerals Education Victoria

The goal of Minerals Education Victoria is to assist the education community to deliver useful information about the minerals industry to students, by providing helpful and relevant experiences and resources in the following subject areas: Science; Technology; Studies of Society and Environment (SOSE); Geography; Chemistry; Business Management and Environmental Science.

Minerals Education Victoria offers an extensive program of interactive presentations, as well as tours, lesson plans, access to resources and information on careers in the industry.

Minerals Education Victoria runs professional development workshops for teachers of science and SOSE.

Contact:

Phone: 03 9629 1851

Website: <<http://www.vicmins.com.au>>

National Science Week

National Science Week began in 1997 with the aim to raise the profile and increase the public's understanding and appreciation of the role of science, technology and innovation in maintaining and improving our society, economy and the environment. National Science Week is a partnership program between the Commonwealth Government and the ABC, Australian Science Festival Limited, the Australian Science Teachers Association and the CSIRO.

National Science Week:

- focuses public attention on the role of science, engineering and technology in the community through public events and extensive debate of scientific issues;
- recognises the importance of science, engineering and technology to Australia's future; and
- celebrates the achievements of Australians working in these fields.

Australian Government funding is available on a competitive basis to provide support for National Science Week projects.

The Australian Science Teachers Association (ASTA) supports and promotes school participation in National Science Week by providing: the annual school theme as a focus for student activities; the annual ASTA National Science Week Resource Book; and the annual ASTA National Science Week Schools Kit. ASTA provides grants for National Science Week for schools through state and territory science teacher associations

Contact:

Phone: 02 6240 5078

Website: <<http://www.scienceweek.info.au/>>

Primary Connections

Primary Connections is a new initiative linking the teaching of science with the teaching of literacy in Australian primary schools. It aims to improve students' learning outcomes in science and literacy through innovative curriculum and professional learning resources that enhance teachers' confidence and competence for science teaching. It is a partnership between the Australian Academy of Science and the Department of Education, Science and Training.

Eight units from the curriculum resource were trialled in 2005 and refined for a rollout in 2006. Approximately 50 primary schools across Australia participated in the trial in 2005. In most schools two teachers

trialled the program in their classrooms. Four schools (two in Victoria and two in Western Australia) trialled the program across the whole school.

Contact:

Phone: 02 6247 5777

Website: <<http://www.science.org.au/primaryconnections/index.htm>>

Questacon Smart Moves

Questacon Smart Moves is a major National Innovation Awareness Strategy (NIAS) program funded through the *Backing Australia's Ability* program.

Smart Moves is a travelling outreach program of in-school presentations and linked website resources aimed at promoting cutting edge research, new ideas and entrepreneurship in science, engineering and technology. Program content draws on the most relevant and inspiring examples of Australian science and innovation to generate sustained interest in science-based careers. The program travels to regional areas in all states.

In 2003, Questacon introduced the Smart Moves Invention Convention, which aims to bring together innovative and entrepreneurial young Australians and give them an opportunity to form networks with similar young people. It also facilitates their contact with established entrepreneurs, who work with them on a one-on-one basis and provide them with entrepreneurial skills to further their ideas. The Convention schedule is run over five days and covers content in areas of innovation and entrepreneurship, including seminars on networking, resources, marketing, exporting, money management, business skills, entrepreneurship and intellectual property. The first Convention brought together 15 secondary students and 10 mentors from around Australia, and the success of that Convention led to an expansion to 30 delegates for 2004.

Contact:

Phone: 02 6270 2949

Website: <http://smartmoves.questacon.edu.au/index_flash.asp>

RoboCup Junior

RoboCup Junior was established in Victoria through the support of the Science in Schools initiative and Interact Events, another Victorian Government IT initiative. One of the key goals of RoboCup is to encourage young people to take an interest in scientific and technological fields, to cultivate their interest through robotic competitions and hands-on creation.

Termed the educational game of the new millennium, RoboCup Junior also aims to address social development by encouraging sportsmanship, sharing, teamwork, understanding of differences between individuals and nations, co-operation and organisational skills.

RoboCup Junior has been developed with three levels of increasing complexity where students can choose to take up the challenge at their own skill and interest level. The three levels consist of RoboCup Junior Dance, Rescue and Soccer.

Contact:

Phone: Phone: 03 5623 5833

Website: <<http://www.robocupjunior.org.au/>>

Science in Schools

The purpose of the Victorian Government's Science in Schools Research Project, funded under the Science Technology and Innovation initiative, was to develop and trial a model for improving science teaching and learning in Victorian schools. It sought to identify approaches to enhancing the teaching and learning of science from Prep to Year 10, and to raise the profile of science within schools.

The project was initiated against a background of concern about the level of student interest and participation in science. It commenced in January 2000 and was completed in December 2002.

Contact:

Website: <<http://www.sofweb.vic.edu.au/science/inschools/>>

Science Summer School (The University of Melbourne)

The University of Melbourne Science Summer School is a two-week course designed to give students an intellectual and social edge in their final year of schooling and introduce them to science related careers. Participants are resident at Trinity College during the Summer School. Teachers are also encouraged to attend the Science Summer School.

The Science Summer School includes lectures, hands-on laboratory sessions, industry exposure, field trips, mentoring and other extra-curricular activities. The University of Melbourne's senior science academics and leading professionals in science industries provide the academic program. The mentor and pastoral program is supervised by undergraduate mentors as well as teachers.

Contact:

Phone: 03 9348 7000

Website: <<http://www.trinity.unimelb.edu.au/summerschool/science/>>

Science Talent Search

The Science Talent Search (STS) is a science competition open to all primary and secondary students. The STS was started by the Science Teachers' Association of Victoria in 1952 and is one of the longest running competitions of its type in the world. Each year, more than 3,000 Victorian students enter their work into various STS competition sections.

The STS has three broad aims:

1. To stimulate an ongoing interest in the study of science by: encourage independent self-motivated project work amongst students of science; giving students the opportunity to communicate their achievements to a wider audience; and according recognition of effort and achievement in a scientific enterprise.
2. To promote the direct involvement of the students in the processes of science and its communication.
3. To give the public at large an opportunity to see the quality of work being achieved in science, by both primary and post-primary students.

Sections in the STS include: experimental research; creative writing; working models and inventions; games; computer programs; science photography (traditional and digital); video productions; and posters – scientific wall charts.

There are five divisions in the STS: lower primary (Prep to Year 3); Primary (Years 4 to 6); Junior (Years 7 and 8); Intermediate (Years 9 and 10); and Open (Years 11 and 12).

Each year, winning individuals and groups are awarded bursaries totalling tens of thousand of dollars at the Exhibition and Presentation Day. Hundreds of students are rewarded in this way for their efforts and talents.

The STS is aimed at all students, including those planning a career in science or technology, those interested in scientific hobbies, or those wanting to present a point of view through posters, essays, videos, photography, games or computer programs.

The theme for 2006 is 'Australia: Our Dry Continent'.

Contact:

Phone: (03) 9385 3999

Website: < <http://stav.vic.edu.au/home/news/sts>>

Shell Questacon Science Circus

The Shell Questacon Science Circus is an outreach program targeting regional, rural and remote Australian communities every year. From its base at Questacon – The National Science and Technology Centre in Canberra, the Science Circus completes four to five tours per year. The tours enable staff to present exciting science shows in schools, set up a portable science centre and interactive exhibition in community venues and deliver professional development workshops for teachers. Specially adapted programs have also been developed for delivery in remote Indigenous communities.

The Science Circus is staffed by graduate students studying science communication at the Australian National University. It is a joint initiative of Questacon, the Australian National University and Shell.

The Science Circus visits over 600 schools each year, with the participation of over 100,000 visitors in school programs and public exhibitions. Over 90 per cent of Science Circus visitors are primary and junior secondary students and their families.

Contact:

Phone: 02 6270 2800

Website: <<http://www.questacon.edu.au/html/sqsc.html>>

Shepparton Science and Technology Centre

The Shepparton Science and Technology Centre is an educational facility based at McGuire College, Shepparton. The Centre functions as a joint venture between schools, industry and further education providers in the region and is supported by regional community groups, government departments and research enterprises.

The objectives of the Centre are to: promote excellent programs in science and technology for all students; develop innovative and effective curriculum and pedagogy in science and technology; disseminate materials through professional development and other means; develop a strong partnership between schools and local industry; ensure that all students participate in science and technology education; give all students the knowledge of how their lives will be shaped by science and technology; foster in students an interest in and feeling for science and technology; and provide school students and the wider community with access to the use of advanced science and technology equipment.

The centre is linked electronically to other science and technology centres, schools, further education providers, industry and research enterprises, and the Internet, to enable the interchange of information and for professional development and program communications purposes.

The operation of the centre is co-ordinated by the Shepparton Secondary Education Advisory Board Inc, a cluster formed by McGuire College, Mooroopna Secondary College, Shepparton High School and Wanganui Park Secondary College.

Contact:

Phone: 03 5831 8000

Website: <<http://www.sheppstc.org.au>>

Siemens Science Experience

The Siemens Science Experience is a three day hands-on program about science, technology and engineering for students entering Year 10. The programs take place in university laboratories and lecture theatres in 33 universities. Participants perform experiments in the university laboratories, meet and hear university lecturers, and experience what it is like to be on a university campus.

The program also provides information about further studies in science, technology and engineering. It highlights the wide range of careers that allow students to pursue their interest and abilities in the sciences. It also provides the opportunity to meet and share ideas with students from different schools.

A registration fee of \$90 is payable, which enables attendance and participation in all of the activities during the three-day program.

The overall nationwide organisation of the Siemens Science Experience is undertaken by the Science Schools Foundation Inc, which has its office at Siemens Ltd, Bayswater, Victoria. The Science Schools Foundation is a voluntary non-profit organisation that includes representatives of Rotary, Young Scientists of Australia, Siemens Ltd, industrialists and educationalists.

Contact:

Phone: 03 9721 2268

Website: <<http://www.scienceexperience.com.au/>>

SPECTRA

The Science Program Exciting Children Through Research Activities (SPECTRA) provides awards to students who undertake projects within a chosen topic. It is designed to encourage and excite children to do science activities; to recognise and reward student initiative, both individual and team-based; and to provide a tangible reward.

Students do practical and observational activities, visits, research and experiments. Activities are designed to ensure teachers and students can use everyday items, and the activities can be done in the students' own time, or in class time.

SPECTRA is provided for both younger students (Years 1 to 4) and older students (Years 4 to 9).

An information kit is available from the Australian Science Teachers Association to help get started. The kit details how the program works, provides the forms required and samples of all topics.

Contact:

Phone: 02 6282 9377

Website: <<http://www.asta.edu.au>>

Victorian Model Solar Vehicle Challenge

Since 1990, the Victorian Model Solar Vehicle Challenge has provided an active learning program for thousands of Victorian school students. Participants apply the principles of physics and technology in developing and testing model cars and boats, powered by direct absorption of solar energy. Students learn about both mechanical and electrical principles relevant to physics, mathematics and technology subjects at levels from Years 4 to 12. Students also learn through simulations and real track testing that involves experimental design, observation and recording of experimental outcomes and the application of physics principles to enhance performance.

Monash University Faculty of Engineering staff have led the Challenge since its inception.

Contact:

Phone: 03 9903 2156

Website: <<http://www.eng.monash.edu.au/solar/>>

Mathematics/Science Programs

Australian School Innovation in Science, Technology and Mathematics Project (ASISTM)

In July 2005, the Commonwealth Government announced the Australian School Innovation in Science, Technology and Mathematics Project (ASISTM), which is aimed at improving the ways in which science, technology and mathematics are taught in Australian schools.

Initiatives funded bring schools together with industry, science organisations, universities and others to explore ways to encourage a culture of innovation, attract more quality students into teaching, co-ordinate primary and secondary curricula and provide positive role models.

Round one ASISTM funding included 33 Victorian based projects, in which nearly 190 Victorian schools worked with over 100 local partners. Many of the projects had a special focus such as the curriculum, a particular stage of schooling or particular group of students. Others focused on enhancing opportunities for students to undertake science experiments, fieldwork, excursions or assisting access to secondary school laboratories for primary school students.

Contact:

Phone: 03 9657 9748

Website: <<http://www.asistm.edu.au/contact.asp>>

Appendix O

Department of Education and Training 'Like School Group' Categories

Group Seven <i>Nil-Low LOTE, High EMA/Youth Allowance</i> 0 to $\leq$ 0.04 LOTE > 0.43 EMA/Youth Allowance	Group Eight <i>Low LOTE, High EMA/Youth Allowance</i> 0.04 to $\leq$ 0.26 LOTE > 0.43 EMA/Youth Allowance	Group Nine <i>Medium-High LOTE, High EMA/Youth Allowance</i> > 0.26 LOTE > 0.43 EMA/Youth Allowance
Group Four <i>Nil-Low LOTE, Medium EMA/Youth Allowance</i> 0 to $\leq$ 0.04 LOTE > 0.28 to $\leq$ 0.43 EMA/Youth Allowance	Group Five <i>Low LOTE, Medium EMA/Youth Allowance</i> 0.04 to $\leq$ 0.26 LOTE > 0.28 to $\leq$ 0.43 EMA/Youth Allowance	Group Six <i>Medium-High LOTE, Medium EMA/Youth Allowance</i> > 0.26 LOTE > 0.28 to $\leq$ 0.43 EMA/Youth Allowance
Group One <i>Nil-Low LOTE, Low EMA/Youth Allowance</i> 0 to $\leq$ 0.04 LOTE 0 to $\leq$ 0.28 EMA/Youth Allowance	Group Two <i>Low LOTE, Low EMA/Youth Allowance</i> >0.04 to $\leq$ 0.26 LOTE 0 to $\leq$ 0.28 EMA/Youth Allowance	Group Three/ Selected Entry (Three S) <i>Medium-High LOTE, Low EMA/Youth Allowance</i> > 0.26 LOTE 0 to $\leq$ 0.28 EMA/Youth Allowance

Source: Department of Education and Training 2000, *Quality Assurance in Victorian Schools Benchmarks 1999*, p. 80.

Appendix P

Case Studies of Science Education and Awareness Programs Targeting Rural and Regional Communities

Case Study 1 QUT Smart Train (Queensland)

The QUT (Queensland University of Technology) Smart Train is a Queensland based initiative targeting children who do not usually have the opportunity to experience museums or science centres. The Smart Train has, to date, operated four times, in the years 1997, 1999, 2002 and 2005. In its first year, the Smart Train was solely focused on science, with separate carriages dedicated to biology, chemistry, natural science and physics. In its second year, the theme was extended to cover science and technology.

The 2005 Smart Train was an initiative run jointly by all faculties at the Queensland University of Technology – Business, Built Environment and Engineering, Creative Industries, Education, Health, Humanities and Human Services, Information Technology, Law and Sciences. The Smart Train had four carriages of interactive displays, selling its message of innovation and discovery. Displays gave participants an opportunity to experience a real internet radio station, a virtual crime scene, a new Queensland house design for subtropical and tropical climates and the miracle of skin cell growth. There were also optical illusions, interactive crime investigations, artificial hearts and joints, an internet copyright display, a practical demonstration of the value of money and do-it-yourself music mixing. In addition to the train displays, the Einstein International Year of Physics was celebrated on the platform, with physics demonstrations for school groups and physics exhibits for the public to view, provided by the Queensland Museum's Sciencentre.

Hours of opening varied depending on location; most stops were of one or two days duration and many stops included evening openings. Entry was free. Importantly, the Queensland Government subsidised travel costs so that students from more remote areas could visit the QUT Smart Train at a regional centre.

Importantly, the QUT Smart Train also provided a free networking and professional development opportunity for teachers with an interest in science and technology. The topics presented have strong links with the middle years of schooling but were presented in a way to be of interest and relevance across year levels. After school sessions of 1¼ hours duration were offered at the Smart Train. Each teacher attending

the session received a CD-ROM containing information on each exhibit on the train, information on the researchers involved in the projects showcased on the train and links to classroom web resources related to the train exhibits. Topics presented on the CD-ROM were sustainability, tissue engineering, forensic science and DNA, ethical questions, optical illusions and hands-on physics activities.

Website: <www.train.qut.edu.au/>

Case Study 2 BioBus (Queensland)

BioBus is a travelling Biotechnology exhibition touring schools in regional and rural Queensland in 2005 and 2006. The BioBus is a Smart State initiative of the Queensland Department of State Development and Innovation in collaboration with Education Queensland. It is being delivered by Queensland Museum.

BioBus travels directly to schools in 30 to 35 centres each year (as well as Brisbane). It provides an interactive exhibition program, accompanying student laboratory program and teacher professional development. BioBus reflects the Queensland Government's desire to promote the study of science and demonstrate its ongoing commitment to strengthening the State's biotechnology industry.

The exhibition introduces students and community visitors to a wide variety of biotechnology examples in the areas of environment, human health, agriculture and investigating with DNA. There are 24 different stories for Queensland students and teachers to discover. The BioBus provides: a broad introduction to concepts of biotechnology through interactive and hands-on learning; stimulus for post-visit activities/learning experiences for both students and teachers; a showcase for the richness and diversity of Queensland's contributions to biotechnology; and information on career options in biotechnology.

The primary audience for the bus is students in Years 9–12. BioBus is a full learning experience for students with pre-visit materials, interactive exhibition, laboratory experiment and follow-on supplementary materials. With a focus on raising students' awareness on potential careers in biotechnology, students can see and hear current Queensland scientists talking about their work and obtain further career information.

The teacher professional development is an after-school program lasting from 1–1½ hours. The sessions include a presentation covering the importance of the biotechnology industry and the moral, ethical, social, political and religious issues; details of future biotechnology professional development opportunities; and a 30 minute opportunity to engage with the BioBus exhibition.

The BioBus is also open for a community session from approximately 4.00–6.00pm at each venue, with weekend sessions also available at some locations.

Website: <www.qmuseum.qld.gov.au/education/biobus>

Case Study 3 *Lab in a Lorry* (UK and Ireland)

Lab in a Lorry is a joint initiative between the Institute of Physics and the Schlumberger Foundation that aims to make physics and scientific careers more attractive to young people. The program was developed due to concerns about the long-term supply of scientists and engineers in the United Kingdom and Ireland and the public's support for and engagement in science.

Lab in a Lorry is an interactive mobile physics laboratory staffed by volunteer practising scientists and engineers. The aim of Lab in a Lorry is to 'give young people aged 11–14 the opportunity to do experimental science in the way it actually happens: exploratory, accidental, informed by curiosity and intuition, but also bounded and guided by the experience and insight of practicing scientists'.

The Lorry's greatest asset is its volunteers: working physicists who are willing to share their time, enthusiasm and knowledge of science with young people.

The three 44ft long Lab in a Lorry vehicles are a self-contained experience, touring around the United Kingdom and Ireland in 2005 and 2006 visiting schools, festivals and other venues. The internal layout of the Lab has been created by professional educators and industrial designers. It contains three experiment areas accommodating small groups who can conduct hands-on experiments together in a team. Each vehicle is designed to accommodate a maximum of 18 visitors and their leaders at any one time and on any given day, about four groups visit the vehicle, for about one hour each.

Each lorry has three workstations, with a different experiment performed at each. An individual workstation accommodates a maximum of six visitors and one volunteer staff member. Visitors stay at their designated workstation and do not rotate because each experiment takes about one hour. Thus, each visitor conducts one of three experiments. The Lab in a Lorry experience is free.

Website: <www.labinalorry.org.uk>

Case Study 4 *Science on Saturday (Queensland)*

Science on Saturday is a program offering children aged between 7 and 14 the opportunity to participate in hands-on science experiments. The program is an initiative of the Queensland Government, delivered by the CSIRO as part of the Government's Smart State vision to encourage today's children to become tomorrow's scientists. The aim of the program is to show children and parents that science can be fun and exciting and can lead to a wide range of career opportunities. The program is also designed to show participants and their families how science impacts on the lives of all Queenslanders.

Each program runs for six weeks in regional and metropolitan centres across Queensland, with a new topic covered each week. Topics covered are forensic science, electronics, rocks and minerals, flight, genetics, and sun protection. The cost is \$6.00 (pre-paid) or \$7.00 per session and most sessions include something for the participant to take home. Separate sessions are run for juniors (7–10 years) and seniors (10–14 years). The trial program conducted in 2004 operated across six regional centres, with an average of 22.3 students attending each session (total of 1,853 students over the six week trial).

Website: <<http://www.csiro.au/briscsirosec/SOS/index.htm>>

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