



Education and Training Committee

Final Report

Inquiry into the Promotion of Mathematics and Science Education

Executive Summary & Recommendations

March 2006

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.