

Section 1 – Executive Summary and Recommendations from the *Maths? Why not?* project



May 2008

EXECUTIVE SUMMARY

Background

Concerns are currently being expressed about Australia's capacity to produce a critical mass of young people with the requisite mathematical background and skills to pursue careers in Science, Technology, Engineering and Mathematics (STEM) to maintain and enhance this nation's competitiveness. These concerns permeate all levels of learning and skill acquisition, with programs to assess mathematical achievement of primary and early secondary students regularly identifying areas that require concerted action.

Internationally, Australia's 15 year old students perform very well on the mathematical literacy scale in terms of the knowledge and skills as investigated by the Organization for Economic Cooperation and Development (OECD) in its Programme for International Student Assessment (PISA) for 2002 and 2003 (OECD 2000, 2004). In addition, the Trends in International Mathematics and Science Study (TIMSS) for 1994/5 and for 2002/03 revealed that Australian Year 8 students' achievement in mathematics was significantly higher than the international average in all content areas considered (Thomson & Fleming, 2004).

Along with these indicators of achievement in the early years of secondary schooling, there is encouraging national evidence indicating that these levels of mathematical literacy are translating into increased enrolments in senior mathematics courses. There is a paradox, however, with enrolments in higher-level courses¹ declining and enrolments in elementary or terminating mathematics courses increasing (Thomas, 2000; Barrington, 2006). This trend is not an encouraging basis from which to improve the percentage of university graduates from mathematics-rich courses that lead into STEM careers.

Against this background of perceived need and encouraging student performance in early secondary schooling, the research question identified for the project was:

Why is it that capable students are not choosing to take higher-level mathematics in the senior years of schooling?

The answers are deceptively simple. Nevertheless, it was anticipated that responses to it would provide important insights into a number of critical issues underpinning the learning and teaching of mathematics in Australia and provide a platform for constructive action to address STEM skill shortages.

¹ This term is used to refer to mathematics courses taken at schools which lead on to mathematics-rich courses at the tertiary level courses.

Sources of data

The main source of data for the Project was in the form of on-line surveys completed by mathematics teachers and career professionals². In addition to background information about the respondents, 27 Likert scale questions were asked about perceived influences on students' decisions to take higher-level mathematics courses. The questions were considered in four groups. These groups were related to:

- *School influences*, such as, timetable restrictions, course availability, and students' experience of junior secondary mathematics;
- *Sources of advice influences*, such as, job guides, other teachers in the school, and friends in the same year level;
- *Individual influences*, such as, perceptions of ability, interest, and previous achievement; and
- *Other influences*, such as, gender, parental aspirations, and understanding of career paths.

In addition, there were questions relating to enrolment trends in respondents' schools over the past five years, aspects of teaching and learning that encourage students to take higher-level mathematics courses, and strategies to increase student participation in higher-level mathematics courses. Both teachers and career professionals had the opportunity to elaborate on their responses to these questions by providing additional comments.

The information obtained from these surveys was supplemented with student surveys and focus group discussions involving students and mathematics teachers. Both qualitative and quantitative analyses were carried out.

Findings

Of the four major groupings of questions about perceived influences contained in surveys, the Individual Influences group was perceived by both mathematics teachers and career professionals as having the greatest impact on students' decision making. The specific areas identified as contributing to this impact were students':

- Self-perception of ability;
- Interest and liking for higher-level mathematics;
- Perception of the difficulty of higher-level mathematics subjects;
- Previous achievement in mathematics; and
- Perception of the usefulness of higher-level mathematics.

Further analysis³ of these data was undertaken to identify any significant item effects and interactions. Three areas of interest were highlighted by this analysis. Firstly, the most significant items from the four groups of perceived influences were:

² This is the generic title used in this Report to describe people in schools with responsibilities to provide career and course advice/counselling.

³ This was undertaken using a two (survey group: mathematics teacher/career professionals) by two (location: rural & regional/metropolitan) by group of items MANOVA design.

- Students' experience of junior secondary mathematics;
- The greater appeal of less demanding subjects;
- The advice of mathematics teachers;
- Students' perception of how good they are at mathematics;
- Parental expectations and aspirations; and
- Students' understanding of career paths associated with higher-level mathematics.

Secondly, the interaction between survey group and the groups of items revealed a number of differences. The first of these related to the appeal of less demanding subjects where teachers perceived this to be more influential than did careers professionals. The others related to the advice of students' mathematics teachers, the advice of parents and other adults, students' understanding of career paths associated with higher-level mathematics, and of the way tertiary entrance scores are calculated, where career professionals perceived these to be more influential than did mathematics teachers.

Thirdly, the interaction between location and the groups of influences highlighted three areas which were perceived to be more influential for regional and rural respondents than for metropolitan respondents. These were the likelihood of taking higher-level courses in a composite class and/or by distance education, the perceived difficulty of higher-level courses, and the advice of other teachers.

In addition, a number of recurring themes emerged from the qualitative analysis of the mathematics teachers and career professionals extended response data. Again, these reinforced the central roles of prior learning experiences, student learning needs, and advice about postsecondary options. These themes were:

- Previous learning experiences in mathematics, which neglect the consolidation of understandings, were perceived to be a necessary foundation for learning throughout schooling and life.
- Syllabus and curriculum frameworks which contain so much content that they do not leave sufficient time for the consolidation of understanding and knowledge.
- Heavy student workloads associated with higher-level mathematics courses.
- Teaching and learning practices which do not adequately support the learning of mathematics from primary school through to secondary school.
- Pedagogical approaches that do not engage students because teachers are often required to teach outside their area of expertise.
- Assessment practices which vary in approach to purpose, structure and feedback provided (e.g., formative, summative, holistic, pen and paper tasks, problem solving tasks, grades and/or comments).
- Subject choices which are based more on their mark potential for tertiary entrance scores than on their preparation for tertiary study.
- University information which lacks clarity or is ambiguous about pre-requisites needed to undertake mathematics-rich courses.
- Career advice which gives students an incomplete picture of potential options because of a lack of a holistic approach from relevant stakeholders (e.g.,

through partnerships between schools, employers, other education institutions, people working in the field).

Overall, mathematics teachers' perceptions are that students need a substantial level of achievement in mathematics prior to choosing a higher-level mathematics subject. This is needed in order to sustain interest in and liking for the study of higher-level mathematics – students need a realistic self-perception of their ability that will then allow them to engage, and persevere, with a challenging senior mathematics course. Career professionals reinforced this message and added that more needs to be done in the area of conveying the usefulness of mathematics.

Coupling this perception about usefulness with the relative importance of mathematics teachers' advice which career professionals acknowledged, there are implications for clarifying the central role that mathematics teachers have in supporting student learning. That role, and associated support, is based on the provision of learning experiences which consolidate concepts and which emphasise personal relevance so that students acquire positive perceptions of their ability and a capacity to understand the role mathematics has beyond secondary schooling.

The additional data that was collected from student surveys and focus group discussions provided supporting commentary for three key areas identified in the study. These comments related to the importance of quality junior secondary school experiences, of engendering a positive self-perception of ability in students, and of highlighting the career and personal relevance of mathematics.

From the student comments, individual and post-secondary considerations accounted for most of the influences on their decisions. The most important of these included the idea that studying mathematics contributes to increased levels of knowledge and understanding that can be applied in other (problem-solving) disciplines, and the notions that positive junior secondary school experiences and acquiring confidence in their ability will support their choices. In addition, the importance of mathematics was acknowledged through its general, career and personal relevance beyond secondary school. Nevertheless, students also identified mathematics as a difficult subject and that the knowledge and skills acquired come at a price in terms of effort and time allocation associated with balancing study and personal schedules.

In their discussion, mathematics teachers focused on the changing culture of students, and the need to respond to a diverse range of competitive academic and social pressures. One important consequence of this competition was identified as an inability, among what was thought to be an increasing number of students, to maintain the effort required to undertake a 'hard' course, such as higher-level mathematics. In responding to this, mathematics teachers indicated that the way mathematics is taught and the nature of support offered by mathematics teachers to their students are two critical components in addressing the change in student culture.

RECOMMENDATIONS

Six broad themes were identified to provide a holistic approach for schools, education authorities and universities to respond to the issue of declining enrolments in higher-level mathematics courses.

Mathematics teaching and learning

1. That educational authorities actively support the teaching of mathematics in the primary and junior secondary years to ensure that it is directed towards maximising the pool of students for whom higher-level mathematics in the senior years at school is a viable and attractive pathway. School systems need to foster a culture of sustainable professional development within schools that enables mathematics teachers to act on the student-related influences identified as the main findings of this report by:

- implementing pedagogical strategies that engage students;
- focusing on conceptual understandings at all levels and at key stages in learning, and
- having access to intervention programs that address students' particular learning needs.

2. That educational authorities have in place mechanisms that identify students, or which enable students to self-identify, as in need of support programs in mathematics. These students should be provided with opportunities to consolidate their understandings of important aspects of mathematics at critical development points in their learning (e.g., through 'second chance' programs).

3. That the Commonwealth and/or other research funding bodies initiate further research into the range of mathematics-specific issues that emerged in the Maths? Why Not? Project as possible influences on students' engagement and decision making, namely:

- The conceptual obstacles experienced by students in the middle years of schooling, with a view to developing strategies to overcome them;
- The role of formative and summative assessment in early secondary mathematics and the effects of each on students' self-efficacy;
- The links between student-teacher relationships and performance in mathematics;
- Problematic components of curriculum and teaching that were identified (e.g., lack of rigour, shallow treatment of important ideas, irrelevance of content, lack of opportunities for creativity, subject workload); and
- The extent to which teachers develop for students a 'world view' of mathematics and mathematicians.

4. That Federal, State and Territory governments, in consultation with education authorities, schools systems and other stakeholder groups, collaborate to develop and implement a range of incentives that:

- encourage mathematics graduates into primary and secondary mathematics teaching; and
- address the retention of degree-qualified mathematics teachers in primary and secondary teaching.

Career awareness programs

5. That professional associations involving teachers of mathematics and career professionals work together to develop, trial and implement career awareness programs in the junior secondary and upper primary years of schooling. These learning units should provide information about the potential and value of mathematics-rich careers, and also highlight links between careers and students' evolving understanding of mathematical concepts.

6. That educational authorities, tertiary institutions, and other stakeholder groups form partnerships to work together to support the development of school cultures that promote mathematics-rich careers through the provision of programs that include:

- The regular production of career-related resources, including, a book of mathematics related career advertisements, 'bullseye' type career posters, and career organization newsletters;
- Clear advice to mathematics teachers, careers advisers and parents about the importance of mathematics in choosing and successfully pursuing a career;
- Support for mathematics teachers and careers advisers about what mathematics students can do in terms of career options and pathways; and
- Encouragement for schools to inform parents about career options and desirable pre-requisites related to mathematics for their children.

The secondary-tertiary transition

7. That tertiary admission authorities, in consultation with State and Territory educational authorities, review its procedures to ensure that the calculation of tertiary entrance scores incorporates positive incentives to recognise those students who take advanced (and to a lesser extent intermediate) mathematics subjects in Years 11 and 12.

8. That Federal, State and Territory governments, in consultation with industry, develop a program of post-secondary scholarships and/or cadetships for studying and completing mathematics-rich courses at university (i.e., those that depend on successful completion of higher-level mathematics courses at school).

9. That tertiary institutions develop realistic minimum and desirable levels of mathematical background required for the study of tertiary mathematics subjects at university. These levels should be clearly and unambiguously identified in all promotional material as "pre- requisite knowledge," "assumed knowledge" or similar.

10. That the Commonwealth and/or other research funding bodies initiate further research into the reasons and motivations which contribute to senior secondary students' decision to enrol in tertiary mathematics-rich courses.

Further research to obtain a more comprehensive picture of influences on students' decisions to take higher-level mathematics courses

11. That the Commonwealth and/or other research funding bodies support an evaluation of the Maths? Why Not? methodology for application to a fully representative sample of Australian students and parents/caregivers to identify students' beliefs and perspectives concerning the influences on their subject, course and career choices. The study should contribute to a holistic understanding of 'Generation Y' in relation to these matters, as well as clarify issues for particular subjects (e.g., the uptake into science and mathematics) and particular pedagogical approaches. There should be a broad scope of students studied (e.g., Years 5 – 12 and into the tertiary years) to gain a comprehensive picture of:

- The meaning students attach to terms, such as, 'usefulness,' 'relevance,' 'less demanding subjects' and 'difficulty' when used in the context of choosing mathematics subjects in the senior years;
- The characteristics of earlier learning experiences which contribute to positive achievement and high levels of interest in mathematics, and which have the potential to influence decision-making (e.g., curriculum, pedagogy, teaching, encouragement, feedback, performance); and
- The factors which contribute to developing positive beliefs about mathematics and its application to students' lives and aspirations.

12. That the Commonwealth and/or other research funding bodies initiate further research into the extent of career professionals' knowledge and practice concerning the nature and usefulness of higher-level mathematics, and counselling about possible career paths.

13. That the Commonwealth and/or other research funding bodies initiate further research that:

- Identifies the current benefits and rewards to students of undertaking higher-level mathematics;
- Identifies potential benefits and rewards (associated with other subjects) that may be transferable to mathematics;
- Investigates the relatively low rating that career professionals attribute to their advice;
- Investigates the relative importance of the influences identified in the project that apply to the pre-secondary context, and the efficacy of introducing career programs into the primary years of schooling;
- Analyses the PISA and TIMSS data concerning enrolments in countries that are more successful than Australia in terms of students studying advanced mathematics, and concerning attitudinal characteristics of students;
- Determines whether or not there are critical times during schooling when students make formative decisions about subject choices and careers.

Further research to investigate identified influences more deeply

14. That the Commonwealth and/or other research funding bodies initiate further research to investigate aspects of effective advice which are:

- Characteristic of career professionals (e.g., is the advice subject-specific or motivational; advisory or mandatory; informative or influential); and
- Common to the range of other advisory influences highlighted in the Maths? Why Not? Project (e.g., are there important social constructs inherent in the advice?).

Enrolments in mathematics courses

15. That State and Territory curriculum authorities adopt a nationally consistent approach to the reporting of student enrolments across subjects.

16. That State and Territory professional associations consult concerning the setting of desirable levels of student uptake into senior mathematics courses.