The Option of Selecting Higher-level Mathematics Courses: Transitional Tensions

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Steady declines in the number of students taking higher-level mathematics courses have been evident across most States and Territories over the last decade. Rather than its potential for positive feedback, mathematics learning is perceived to be 'hard', repetitive and demanding of time. No wonder many students question their engagement. This paper draws on the perceptions of teachers and career professionals to focus on three important transitions that students make throughout schooling, and considers the influences on their decision-making.

There is no shortage of expression of concerns within Australian educational contexts about the capacity to produce a critical mass of young people with the requisite mathematical background and skills to pursue careers that will help to maintain and enhance national competitiveness (Ainley, Kos & Nicholas, 2008; Anlezark, Lim, Semo & Nguyen, 2008). The malaise permeates 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. Australia is not alone in its desire to see more students undertaking courses in the so called 'enabling' subjects (e.g., van Langen & Dekkers, 2005; Lowell & Salzman, 2007).

Throughout schooling, the range of issues that impact on the quality of teaching and learning include the qualifications, supply and retention of teachers who teach mathematics; course structures in schools; and access to, and uptake of, professional development. At the tertiary and policy-making levels, the nature of teacher preparation courses and the lowering or removal of mathematics prerequisites for entry into courses in science, technology, engineering and mathematics further compound the problem. Reports, such as, the *Audit of Science, Engineering And Technology Skills* (DEST, 2006), the Australian Academy of Science's *National Strategic Review of Mathematics Research in Australia* (2006), and the Australian Council of Deans of Science's *Preparation of Mathematics Teachers in Australia* (2006) repeatedly articulate the scope of the consequences of having a reduced skill-base in the enabling subjects. *Australia's Teachers: Australia's Future – Advancing Innovation, Science, Technology and Mathematics* (DEST, 2003) marked the beginning of a significant attempt to address a number of factors identified through the work of the Committee for the Review of Teaching and Teacher Education as contributing to a lack of vitality in the teaching of science, technology and, in particular, mathematics in our schools. These are deeply ingrained issues and trends.

Against this background of diverse priorities and urgent needs, the *Maths? Why Not?* project (McPhan, Morony, Pegg, Cooksey & Lynch, 2008), from which this paper is drawn, sought to bring together commentary about participation in mathematics. The purpose was to consider relevant material from the literature covering research in mathematics education, trends revealed in international studies, and data based on the experiences and perceptions mainly of teachers and careers professionals.

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). Results from the projects carried out in 2000, 2003 and 2006

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place Australia 5th (out of 31 countries), 11th (out of 40 countries) and 10th (out of 57 countries) respectively for mathematical literacy (OECD 2002d, 2004, 2007). 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) and, for 2007, not significantly different from the TIMSS average (Thomson, Wernert, Underwood, & Nicholas, 2007).

Against this background 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 tension however, with enrolments in higher-level courses declining and enrolments in elementary or terminating mathematics courses increasing. This trend is not an encouraging basis from which to improve the percentage of university graduates with a mathematics or statistics major.

Context

A number of themes are evident in the literature concerning influences that impact on students' decisions to undertake higher-level mathematics. Four of these themes that are relevant to this paper are described briefly. The first relates to the strategic nature of mathematics and the importance of a tertiary entrance score in helping students realise post-secondary options. Mathematics has considerable pre-requisite 'currency' in terms of maintaining patterns of study or securing a career pathway and this is a view expressed by students whether they are interested in mathematics or not (Brinkworth & Truran, 1998). In addition the aspirations for further study have been associated with higher levels of numeracy in junior and early secondary school (Marks, McMillan & Hillman, 2001). The second theme concerns the motivational aspects and general educational experiences within the curriculum that can influence a student's decision. It is not surprising that what takes place in the classroom is largely responsible for the promotion of quality learning (Ingvarson, Beavis, Bishop, Peck & Elsworth, 2004) and students look to teachers to be engaged in a curriculum that is exciting and challenging (DEST, 2006).

The third theme highlights the importance of performance and ability as indicators of participation. From the Longitudinal Surveys of Australian Youth, the majority of students enrolled in advanced mathematics courses are drawn from the top two quartiles of achievement in Year 9 literacy and numeracy (e.g., Fullarton & Ainley, 2000). Achievement in the early years that contributes to a sense of competence, interest and further study cannot be realised, however, in the absence of a curriculum and teaching strategies that are engaging (Khoo & Ainley, 2005). The fourth theme relates to the image of mathematics and whether or not mathematics is a subject to be enjoyed or endured. Generally, students' views about mathematics have been summarised in terms of its lack of creativity and its necessity as a stepping-stone due mainly to an emphasis on tests and the pressure of covering a syllabus, aspects which do not afford students the opportunity to express themselves (Brinkworth & Truran, 1998).

These themes of strategic value, motivation, engaging educational experiences, and image provide the background for exploring reasons for declining enrolments in higher-level mathematics courses. Identifying reasons has the potential to inform strategies to resolve the tensions experienced at key transitional points in the continuum of learning mathematics from junior school through to university and beyond.

Data and Analysis

The methodology adopted sought to explore several clusters of influences that may have an effect students' choices. The investigation of participation in higher-level mathematics courses undertaken was in line with recent research concerning falling enrolments in the Sciences (e.g., Lyons, 2006; Schreiner & Sjøberg, 2005). The clusters of influences to be explored were:

1. Mathematics curriculum;
2. Classroom experience of mathematics;
3. Teaching and learning practices;
4. School and curriculum organization;
5. Career information and advice; and
6. Preparation for, and access to, further education.

The project focused on the perceptions and issues at the time of students' formal decision making in relation to choices of senior school mathematics subjects made around Year 10. As part of the project, mathematics teachers and career professionals were surveyed for their perceptions about influences impacting on students' subject choices and career decisions. Separate surveys were constructed for each of the groups and each survey comprised a number of sections.

There were a number of common items in the survey forms for teachers and careers advisers. Quantitative data was obtained from four groups of questions that comprised a stem and a scale for indicating endorsement of statements in the stem. These questions related to the school context, sources of advice, individual, and other influences to reflect a balance of student-oriented and non student-oriented items.

The qualitative data consisted of extended responses made by respondents when they had the opportunity to elaborate on their endorsements of a number of question stems. Their comments were coded within a general framework comprising ten general categories, each with a number of specific categories. This grid was developed by two members of the project team using a protocol established at an Advisory Committee meeting as well as by using general themes identified in the literature scan. These general categories were then refined in terms of a number of specific categories (e.g., timetabling; class organisation) and, once refined, comments were analysed jointly and separately by the two members of the project team. An additional perspective on the data was provided by undertaking a two (survey group: maths teachers/career professionals) by two (location: regional & rural/metropolitan) by group of items MANOVA analysis. This analysis was carried out in order to identify any significant item effects or interactions.

Survey Free-response Comments

This section provides an overview of some of the free-responses from teachers and career professionals. These comments are presented in three categories based on the results for the structured questions and they reflect aspects of the transition that students make throughout schooling and on to further study. Of the four groupings of questions, student-related items were perceived to have the greatest influence on decision making about taking higher-level courses. There was little difference in the way teachers and career professionals ranked the influences and, after student-related items, the image of mathematics was perceived to be the next relevant issue. The three categories used to present teacher and career professional perceptions were informed by the six most important influences: (a) self-perception of ability; (b) interest and linking for

mathematics; (c) students' previous achievement in mathematics; (d) the perceived difficulty of higher-level mathematics; (e) the greater appeal of subjects perceived as less-demanding; and (f) the perceived usefulness of mathematics.

The first three, (a) – (c), are an outgrowth of foundation learning experiences for students and these are set within the context of the *early secondary* years of schooling (and earlier). This is also an important time for students for reasons associated with the initial formulation of future career options. The remaining influences, (d) – (f), in the list relate to the image of mathematics and the strategic usefulness it holds for students beyond the compulsory years of schooling. Key decisions at these times relate to the *selection of senior subjects* that will make up a students' secondary schooling exit credential and whether or not to include mathematics courses as part of *post-secondary options*. Mathematics courses take on a 'currency' value at these times, a currency which will enable students to resolve decisions about balancing academic and social identity priorities.

Teachers' Perceptions

Early secondary experiences. The comments concerning the preparation for higher-level mathematics course highlighted two priority areas for teachers and these provided important detail about key aspects of early experiences. Firstly, there were priorities that are external to the students, such as, the teachers they encounter, and the curriculum that is offered. Associated with these are specific issues of teacher qualification, pedagogy, and opportunities within the curriculum for the consolidation of essential skills. Typical comments from teachers included:

> The quality of teachers they experience firstly at primary level and then secondary. It is the teacher, through creative pedagogy that can bring the subject of mathematics alive. [QLD, Rural & Regional (RR)]

> At junior secondary, students need to develop their basic maths skill (arithmetic, algebra, geometry) through a routine type of work. This can help them in dealing with more advanced (investigative) type of maths problems. [SA, Metropolitan (Metro.)]

> A properly qualified and professionally up-to-date mathematics teacher of every student in every year of junior secondary would be a fine start. [SA, Metro.]

Secondly, teachers identified priorities associated with attributes of students themselves. These included the level of preparation that students reach, and reasons for engaging with mathematics. Specifically, teachers drew comparisons in preparation between mathematics and other subjects – those that lacked 'rigour', and the potential of mathematics to meet students' personal needs for relevance, success and enjoyment. Representative comments included:

> Students entering Year 8 … have good technology skills or they can do a social impact study, but when it comes down to the rigour of higher-order mathematics, their knowledge base lets them down. [QLD, RR]

> Students want relevance and success. They also want to enjoy what they are doing particularly at the junior levels. If these factors are being met it is likely that they will continue with mathematics. [SA, Metro.]

> There is an increasing number of subjects that are rarely if ever using tests. Students do not get enough overall practice and hence … they perceive maths as being very hard. Also, students who fail maths at one year are promoted to the next year level, even though they are condemned to failure. [SA, RR]

Senior subject selection. The message coming from teachers was resoundingly clear when it came to influences about choosing high-level mathematics courses. That message was mathematics is a hard subject with a heavy workload, with the ultimate choice based on issues, such as, work ethic, competition from the wide array of alternative (easier) subject offerings and the (relatively few) intrinsic rewards of studying higher-level courses. Typical comments from teachers included:

> The perceived heavy workload of higher courses is very off-putting for most students especially if easier options are available. [WA Metro.]
>
> The students perceive maths (and rightly) as requiring more work and having a higher degree of difficulty than other subjects with the equivalent potential score. [TAS, RR]
>
> Many students in recent years are looking for an easier pathway without a willingness to extend or challenge themselves intellectually. [NSW, RR]
>
> Mathematics … is too hard and students need to work from Year 8 onwards and can't just pick it up like some Year 12 subjects; it's more difficult than other subjects and so students choose subjects that will give them better marks. [SA, Metro.]
>
> Senior mathematics courses need a radical overhaul if they are to compete with other subjects. The reality is that nearly all other subjects hold a substantial real-world interest for students whereas mathematics keeps removing our students from it. [NSW, RR]

Post-secondary options. The commentary from teachers concerning the place of mathematics in student's post-secondary life highlighted two areas of concern. The first of these relates to the disparity between student hard work in senior secondary mathematics courses and the pre-requisite value of this hard work at the tertiary level. Specifically, the changing approaches to pre-requisites have detracted from the preparation value of higher-level mathematics course. Typical comments from teachers included:

> The students see it as a 'hard' option and can achieve a higher TER taking other subjects. Given that few university subjects have mathematics as a pre-requisite, they have little incentive to take the subject. [SA, Metro.]
>
> Universities have changed their pre-requisites and the higher-order mathematics subjects are no longer required. [WA, Metro.]
>
> Students think they are disadvantaged by doing a harder subject and believe they can instead do a bridging course if they get into their course of interest. [SA, Metro.]

The second area highlighted gave some insight into the relevance of mathematics in supporting students' career plans preparation for life. Despite the imperatives concerning the benefits of studying mathematics, teachers drew attention to the reality of its capacity for remuneration and real-world relevance. Representative comments included:

> Students need to be reassured that levels of achievement in mathematics are strong relative to other subjects. An appreciation for the broader skills developed through the study of maths, not just for engineering or other quantitative fields, needs to be developed in schools and the community. [SA, Metro.]
>
> Mathematics is not associated with a high paid job. [NSW, Metro.]
>
> Maths is still a high status subject. However, we present work that requires a lot more practice and repetition to master than other subject areas and these qualities are not required in other areas of life today as frequently as they once were. [QLD, Metro.]

Career Professionals' Perceptions

Early secondary experiences. These comments concerning the preparation for higher-level mathematics course also highlighted two similar priority areas. Firstly, there were priorities that are external to the students, such as, organisational and quality issues related to the teachers they encounter. In addition, there were the student-related priorities, such as, the role of confidence, enjoyment and their results. Typical comments from career professionals included:

> This subject more than most struggles to survive poor junior experiences, i.e., teachers they don't like, lots of staff changes, poor teaching etc. To some extent, the bright, capable student will get through – often selected for advanced activities etc; it's the middle range students who waver – they just lose confidence. It can be an easy option not to rise to the challenge of the more difficult maths. [VIC, Metro.]

> So much depends on the teachers they have encountered over the junior secondary schooling. Students require consistent, quality teachers. [WA, Metro.]

> The most influential aspect of a student's decision on mathematics is their results in previous years. [VIC, Metro.]

> Students will choose not to do maths if they don't enjoy it … and they don't realise the ramifications. But, Year 8 maths results determine maths in Year 11 and Year 12. [NSW, Metro.]

Senior subject selection. Career professionals identified a number of competing influences for students when it came to choosing high-level mathematics courses. This mix included information about test results, strategic use of effort, implicit advice received during the formative years. Representative comments included:

> Our advice in the light of test and exam results is to always take the highest level they are capable of; this advice is not always taken. [SA, Metro.]

> Students have become very clever at choosing pathways – why do an extremely difficult and boring course when it is not necessary. [WA, Metro.]

> A really big influence is the maths teachers – they have a system of training up the good students and weeding out those they believe will harm their statistical performance. Many students who, based on objective testing, should be good at maths are turned off early or discarded as lazy. [VIC, Metro.]

> The other restricting factor is that higher-level maths often requires studying two maths … this can restrict their other subject choices. [VIC, Metro.]

Post-secondary options. The commentary from career professionals concerning the place of mathematics in student's post-secondary life could be summed up in one word – 'relevance.' This relevance was qualified in terms of the lack of constructive feedback students receive from tests and for everyday needs. Implicit in drawing attention to the relevance was the notion that more could be done to remedy the situation through appropriated testing or by making explicit the links between mathematics and the real world. Typical comments from included:

> Students seem to be finding maths more difficult and perceive they are not achieving the results they need to go on to higher maths study. Thus their results in maths rule out maths/science courses at tertiary. [VIC, Metro.]

> They (the students) disengage because they do not see that the maths is relevant to their lives. They don't have the maturity or experience to understand that they may need it when they leave school. [NSW, Metro.]

> Maths is useful if it is needed for a career; most of it is irrelevant to everyday needs. I would rather see the majority of students do simple arithmetic and processes that are necessary to live in this world. Calculators have ruined this. [VIC, Metro.]

> It is important for students to see the direct link between what they are studying and the how it can and will impact on their life. If the link is not evident there is very little motivation or reason to study the subject at a higher level. [WA, Metro.]

The free-response commentary from both teachers and career professionals provided an opportunity to support their survey selections. Statements related to the six influences of greatest impact have been presented as a way of describing the transitions that students make throughout schooling. The priorities during these transitions are a mix of influences that are student-related and external to the student. During the early years of secondary education, student confidence, their level of preparation, how well the curriculum meets their needs, and the quality of teaching have impact on the ultimate decision to choose a higher-level mathematics course. When the time comes for higher-level mathematics courses to be an option, strategic decision-making is applied. The ultimate decision then becomes a question of results for effort, the image of mathematics with its workload, and the feedback received to date. Resolving the issue of post-secondary options and mathematics becomes an issue of relevance. This relevance relates to the effort expended in the face of changing tertiary entrance requirements, career relevance and the role of higher-level mathematics courses in everyday life.

Summary

The purpose of this paper was to identify some of the subject-related tensions that students experience during important transitions in their schooling and further study. Resolving such tensions may provide part of the solution to minimising attrition from the enabling science 'pipeline' – a term used within the science education community to refer to the pathway from early education to employment in science, technology, engineering and mathematics (STEM) employment fields (e.g., Tytler, Osborne, Williams, Tytler, & Clark, 2008). The comments presented in this paper introduce the notion that negotiating smooth transitions throughout schooling may be an outgrowth of engaging learning experiences, accumulated knowledge and skill, balanced options, constructive feedback, appropriate work ethic, timely career advice, and personal relevance. In the absence of one, or more of these, mathematics appears relegated to the "too hard basket" and the initiatives that build the constructive image of mathematics are beyond the resources of individual stakeholders, be they teachers or governments.

Whilst the study was based on the perceptions of teachers and career professionals, it highlights the notion that it is the sum total of such perceptions, particularly in the case of teachers, that contribute to an important advisory influence. Since youth identity development is a neglected aspect of mathematics education (Schreiner & Sjøberg, 2007), teachers have an important role to play in the development of cultural and social capital. A lack of information about how teachers develop an appropriate world view for students of mathematics provides the opportunity to investigate further specific aspects of their advice that promote the benefits of studying higher-level mathematics courses.

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