The University of Melbourne's mathematics students: Who are they? Why are they here? Will they stay?[1]

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Students at the University of Melbourne participated in a larger study that aimed to explore the critical factors contributing to decisions to pursue mathematics at the tertiary level. Of particular interest and concern to the Department of Mathematics was knowing the composition of the student cohort, the students' reasons for choosing to study mathematics, and whether they would continue into higher levels. The findings and their implications are reported in this paper.

Background to the study[2]

Like other mathematics departments in Australian tertiary institutions, the Department of Mathematics at the University of Melbourne is concerned about the declining numbers and calibre of students pursuing mathematics courses. As part of a larger study exploring the critical factors which contribute to decisions about studying mathematics at the tertiary level, a survey questionnaire was administered to students enrolled in mathematics courses at three universities during 1996. Students at the University of Melbourne were involved and the data were gathered during Semester 1.

The literature suggests that a number of cognitive, affective, learning environment, social and cultural variables are implicated in students' decision making (see Forgasz, 1996). A range of relevant variables was included in the survey instrument administered to the students. Statistics consistently indicate that more males than females are enrolled in the most demanding mathematics courses offered at the grade 12 level in Victoria (Teese, Davies, Charlton, & Polesel, 1995) and across Australia (Dekkers, De Laeter, & Malone, 1991), and in tertiary courses in the "hard" sciences at both the undergraduate and postgraduate levels (Gaffney & Gill, 1996). These persistent patterns of gender difference are of continuing interest, concern and challenge. Gender was also included as a variable of particular interest in the research design. Australia's multi-cultural profile was also recognised in the study; students' national/ethnic backgrounds were examined.

The Study

The University of Melbourne's Department of Mathematics was particularly interested in knowing who comprised their cohort, why the students were taking mathematics courses and whether they would persist with their mathematical studies. The data gathered were explored to provide partial answers to these questions and the findings are reported here.

The survey questionnaire

The survey questionnaire comprised items aimed at exploring a range of factors implicated in decisions to pursue tertiary level mathematics. These included: perceptions of mathematics learning environments (school and university), beliefs about self as a learner of mathematics (affective and cognitive), beliefs about the influence of significant others (parents, teachers, careers advisers etc.), and reasons for studying mathematics (at grade 12 and at university). Biographical and background information were also gathered: for example, information about grade 12 schooling and indicators of socio-economic status and ethnicity. Data were entered into a database and analysed using $SPSS_{WIN}$.

The sample and sampling procedure

Due to funding and logistical considerations, it was decided to distribute the questionnaires to about 25% of the first year mathematics students (≈600), about 50% of the second year students (≈400) and to all third year students (≈100). The sample excluded students taking an Engineering degree (mathematics is compulsory), but did include students taking combined Engineering degrees (e.g., Science/Engineering). The

sampling procedure implemented was designed to cause least disruption to lecturers' and tutors' teaching programs. The questionnaires were mainly distributed through tutorials but also in lecture groups with small numbers. In some cases, students completed the questionnaires immediately; in others, they took them away and returned them the following week. In all, 374 (213M - 58%, 161F) completed questionnaires were returned; a response rate of ≈34%. The sample completing questionnaires at the University of Melbourne was representative of the total number of completed questionnaires gathered from the three universities participating in the study: 1072 students comprising 619 (58%) males, 448 (42%) females, 5 (sex not indicated).

Results

Who are they?

A profile of the University of Melbourne students is presented first. The vast majority (99%) were full-time students, under 21 years of age (96%) and had progressed directly from school to university (91%).

School backgrounds and socio-economic status: The school types attended for grade 12 studies and their locations were as follows:

School type

government	39%	co-educational	56%
Catholic	35%	single-sex	44%
Independent	21%		

School location

Victoria	94%	metropolitan	74%
interstate	2%	non-metropolitan	22%
overseas	4%	other	4%

Statistics on school type attended by Australian students have been relatively stable over the past few years. In 1993, about 72% of all Australian students attended government schools; in 1995 the proportion was 71% (Australian Bureau of Statistics Statsite, 1997). About 10% attended Independent (non-government, non-Catholic) schools in 1993 (derived from Ministerial Council on Education, Employment, Training and Youth Affairs, 1994). Among the sample of University of Melbourne mathematics students, the proportion of students from non-government schools was considerably higher than the Australia-wide data. The vast majority of government schools in Victoria are co-educational and many non-government (Catholic and Independent) schools are single-sex. The statistics on attendance at single-sex schools appear consistent with the school types attended by students. Since fees are associated with non-government schools, it can be inferred that many University of Melbourne mathematics students are from middle to high socio-economic backgrounds. About 29% of the students, however, were in receipt of financial assistance from the federal government through the *Austudy* scheme.

Ethnicity indicators: The results were as follows:

- 72% of the students were Australian born
- 49% had Australian born mothers; 48% had Australian born fathers
- 27% regularly spoke languages other than English [LOTEs] at home
- 10% who completed grade 12 studies in Australia had taken the alternative English program, *English as a second language* [ESL]

The data suggest that several students were themselves new migrants to Australia. Others were the offspring of one or more parents not born in Australia. The various waves of immigration to Australia appeared to be well-represented among the students studying mathematics at the University of Melbourne. Hence cultural/ethnic factors are likely to have played a part in shaping the students' decisions to study at the university and to study mathematics in particular.

Why are they here?

Students were asked to indicate why they had studied mathematics at the grade 12 level at school and at university in 1996 by marking one or more reasons from a list provided. Space was available to list other reasons. The percentages of students responding to each alternative are summarised below. Relevant statistics are also shown in brackets for the variables for which statistically significant gender differences were found.

Why mathematics was studied at school

keep options open	74%	(M: 70%; F: 80%)
wanted to	58%	
parents wanted	14%	
teacher encouraged	30%	(M: 26%, F: 36%)
career advice	25%	
like mathematics	54%	
good at mathematics	58%	(M: 64%, F: 51%)
to be with friends	3%	
pre-requisite for university	79%	
other choices worse	8%	
improve TER[3]	40%	
other	3%	

Why mathematics was studied at university

like mathematics	46%	
good at mathematics	36%	(M: 41%, F: 28%)
wanted to study mathematics	40%	
parents wanted me to	6%	
to keep options open	45%	(M: 40%, F: 52%)
lecturer/tutor encouraged me	4%	
career advice	14%	(M: 11%, F: 19%)
to be with friends	1%	
compulsory for another subject in 1996	31%	
pre-requisite for mathematics next year	27%	
pre-requisite for non-mathematics course next year	39%	
essential for career	28%	
the other choices I had were worse	9%	
other	8%	

The large proportions of students who had taken mathematics at school and at university because they *wanted to keep options open* were of particular interest. At both levels, the findings suggest that many students were uncertain about their future career paths, more so when choosing to study school mathematics than university mathematics. The significant gender differences on these items imply that the females were more tentative than the males. This interpretation is consistent with the finding that more females than males had taken mathematics at school and at university following *career advice*.

The proportions of students who indicated that they had studied mathematics at school because they *liked it,* and because they *wanted to* were disappointing. The explanations for these findings and for the small proportions of students who gave *careers advice* and *teacher encouragement* as reasons invite further investigation. A measure of success for the efforts to promote greater female participation in mathematics appears to be reflected in the finding that more females (36%) than males (26%) said that their *teachers had encouraged* them to study mathematics at school. On the other hand, it may be that females were more aware or were more willing than males to acknowledge the encouragement of their teachers.

School teachers appear to have been more encouraging of students to pursue mathematics (30%) than their tertiary counterparts. When first year tertiary students were omitted from the analysis, only 4% of the 148 students indicated that they had continued studying mathematics because their *tutors/lecturers had encouraged* them. While encouragement was not identified by many tertiary students as a factor influencing their

decisions, this does not mean it was not given. Clearly there is a difference between school and tertiary learning environments. The comparative sizes of the institutions and cohorts, and the differences in the learning settings (small classes compared to lectures) suggest that school teachers will know their students as individuals better than will lecturers. Regular tutorials are organised in the department with fewer than 20 students and offer better opportunities for one-to-one interaction. However, contact is restricted to 50 minutes per week. Previous research at the school level has identified personalisation as a critical learning environment factor implicated in fostering desirable student beliefs and attitudes towards mathematics (Forgasz, 1995). The extent of perceived personalisation within the department is an issue worthy of attention and further investigation.

A large proportion of students indicated that they had taken mathematics at school because they believed it would improve their TERs (40%). Of these students, only 45% also took mathematics because they believed they were good at it. It is of concern that such a large proportion of students who did not believe they were good at mathematics chose to study it at school in the belief that it would improve their TERs. In reality, simply attempting a grade 12 mathematics subject does not automatically improve the TER. A reasonable performance in *Specialist Mathematics,* the most demanding of the mathematics subjects offered, may result in an improved TER (Prof. Tim Brown, personal communication, 10 March 1997).

As reasons for studying mathematics at school and at university, the influence of significant others including parents and the peer group seemed smaller than might have been anticipated from the literature (e.g., Leder, 1992). It was interesting to note that a greater proportion of males than females had studied mathematics at school and at university because they believed they were *good at it*. This result was consistent with previous findings in Australia (Leder & Forgasz, 1992) and elsewhere (Leder, Forgasz & Solar, 1996).

Factors influencing decisions to study tertiary mathematics: The students were asked to indicate which one or more of a list of factors had influenced their decisions to study tertiary mathematics; the option *other* was also provided. Fewer than 5% of the students indicated that the following factors had influenced them: brother (1%), sister (1%), relatives other than parents or siblings (1%), friends (1%), and open days (2%). The results for the other factors listed, and significant gender differences, are summarised below.

teachers	11%	
careers advisor	7%	
father	12%	
mother	6%	(M: 3%, F: 9%)
own decision	68%	
open days	2%	
information booklets	6%	(M: 3%, F: 9%)
other factors	8%	

The students' *own decisions* were considered the most significant factor in deciding to study mathematics (68%). Yet, a rather large 32% of the students did not indicate that the decision had been their own. For many students, mathematics was a compulsory subject; perhaps, given the choice, some would not have chosen to study mathematics.

The data also suggest that teachers and parents had more influence on students' decisions than did careers teachers or advisors. While some males and females appear to have followed their fathers' advice, males seem less likely than females to be influenced by their mothers. Clearly, university open days and information booklets did not have much impact.

Will they stay?

Students responded on five-point scales (strongly agree to strongly disagree) to a number of items tapping their perceptions of tertiary mathematics and of the learning environment in 1996. The proportions of students agreeing or strongly agreeing with each item is summarised below.

easy	19%	lecturers approachable	63%
enjoyable	40%	tutors helpful	78%
challenging	84%	enough individual help	42%
interesting	49%	tutorials useful	74%
useless	10%	assessment fair	63%
well taught	50%	too much work	25%
understood work	54%	confident of passing	55%
lectures boring	43%		

Mathematics at the University of Melbourne was perceived to be challenging and useful by many students. About half the students found the content interesting and considered that the teaching was good but that lectures were boring. Most students were satisfied that their lecturers were approachable, that tutorials were useful and tutors helpful. The work load was not considered too high and assessment was thought to be reasonably fair. However, only about half the students felt that they understood the work, believed they received enough individual help, and were confident of passing.

A degree of challenge in a tertiary mathematics course is considered desirable. While some students (19%) considered the course easy, about 50% said they understood the work and were confident of passing, 63% that the assessment was fair, and a majority (75%) did not consider the work load too onerous. Hence, of the proportion who indicated that the course was challenging (84%), it is difficult to determine how many found their courses too difficult.

Of some concern is the low perception of the availability of sufficient individual help (42%) and that about half the students did not understand the work and were not confident of passing. These three factors may be inter-related. Opportunities for individual assistance are available through the tutorial system. In addition, lecturers and tutors are rostered for several hours per week throughout the year to help students in all subjects offered; more time is made available for subjects with large enrolments. The times and locations are well-publicised: at lectures, tutorials and on noticeboards. Experience has shown that this service is generally under-utilised except in the last few weeks prior to an examination period. The survey responses also imply that sufficient help appears to be obtained from tutorials. Why students do not avail themselves of the other avenues of available assistance remains unknown.

The survey indicated that mathematics had been enjoyed by 66% of the students at school but fewer (40%) indicated that they had enjoyed university mathematics. The differences between the two learning environment and a number of other factors, alone or in combination, may account for the decline in perceived enjoyment of the subject. As indicated by the survey results these may include: perceptions that the subjects (and/or content) are difficult and/or uninteresting; that lectures are considered boring and/or badly taught; that there is insufficient help available; and that students lack confidence.

Implications and Future Directions

Many of the findings discussed above may be implicated in students' decisions about initially selecting and later choosing to continue with tertiary level mathematics studies. The results have several implications for the University of Melbourne's Department of Mathematics, for schools and for the general educational community.

Implications for the University of Melbourne's Department of Mathematics

Before the present study was undertaken, a number of the issues that emerged from the findings of the present study had already been raised within the University of Melbourne's Department of Mathematics. Issues related to the quality of teaching, modes of delivery and assessment, and curriculum evolution, for example, had been discussed and remain high priority concerns. The study's findings highlight the need to re-visit these issues regularly, and confirmed anecdotal evidence and in-house survey results gathered over several years. While every effort has been made to provide ways for

students to seek personal help from lecturers and tutors, the findings imply that these may not always have achieved their purpose. To promote the available opportunities for assistance, frequent reiteration of their availability may be necessary. Continued monitoring of students' reactions to the organised program of assistance is also required and alternatives may have to be considered. Why so few students perceive that their lecturers and tutors have encouraged them to continue with mathematics at higher levels invites further investigation.

Over the years, the Department of Mathematics has encouraged and developed close ties with the school sector. For example, the *Melbourne University Program for Highly Able Students* [MUPHAS], in which students in grade 12 undertake first year university mathematics studies, has a growing number of students and participating schools. The results of the present study suggest other areas in which strengthening and broadening the relationships between schools and the university might benefit a greater cross-section of students. Included are improved careers advice, information booklets, and open days, and finding ways to prepare students better for the transition from school to university learning settings. These concerns are pertinent to all tertiary mathematics departments and schools. The *Australian Mathematical Society* is currently involved in a project to address a range of related issues.

Future directions: The next stage of the study

Students who completed the questionnaires were asked if they would be prepared to be interviewed at a later stage. An unexpectedly large number of students (≈90) volunteered. The interviews will be conducted during 1997. These in-depth interviews should provide some of the answers to the many unanswerable issues raised by the survey data and discussed earlier.

Final Words

At present, the higher education sector in Australia, and science-related faculties and departments in particular, are experiencing tough times. There are many forces competing for the attention, time and efforts of tertiary staff. Yet, the findings of this study serve as a sober reminder that there are several fundamental educational issues that should remain high on the agenda if the number and quality of students within mathematics departments are to increase. While economic considerations cannot be overlooked, cost-effectiveness should not overshadow other considerations. The quality of courses, of teachers, of the modes of delivery, of available personal assistance, of the learning climate, and of school-tertiary relationships may well be related to male and female students' subject choice decisions. It would appear essential for the shorter-term benefit of students and mathematics departments and for the longer-term scientific welfare of the nation that they continue to receive the attention they deserve.

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Notes

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3. TER: Tertiary Entrance Rank, used to select for tertiary courses