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ABSTRACT

This study was conducted in response to the perceived problems of growing non-participation rates of students in mathematics courses, particularly at Year 12 and beyond, and the decline in skill levels of students entering tertiary courses in science and mathematics. There are signs that mathematics has been devalued by society and the education system, one effect of which has been the decreased amount of time devoted to mathematics in the secondary curriculum which, combined with other factors, has led to a decreased number of students wishing to continue with mathematics or to pursue careers involving mathematics. A survey was conducted to address what factors are most influential on student choices to study or not to study mathematics in Year 12 and what students' views are about mathematics as a subject of study. The 393 students surveyed came from Year 12 classes in 10 South Australian secondary schools. The major factor influencing students' choice as to whether or not to study mathematics was if they considered that mathematics was needed for further study. For those who did study mathematics at Year 12, their ability to do mathematics was the other major factor while for those who didn't, it was the lack of appeal of the subject rather than their inability to do it. (Contains 56 references.) (ASK)

RESEARCH REPORT

of

A Study of the Influences on Students' Reasons for Studying or not Studying Mathematics

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This survey was conducted with the aid of a Flinders University URB Establishment Grant 1997-98 and with the cooperation of the Adelaide Consortium for Mathematics Education Inc.

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List of Abbreviations used in this report

AAMT	Australian Association of Mathematics Teachers Inc.
ACER	Australian Council for Educational Research
ACME	Adelaide Consortium for Mathematics Education Inc.
AGPS	Australian Government Publishing Service
ASCII	American Standard Code for Information Interchange
D	Disagree
DECS	Department for Education & Children's Services (SA) [now DETE]
DEET	Department for Education, Employment & Training (Federal)
DETE	Department for Employment, Training & Education (SA)
ERIC	Education Resources Information Center (US)
GEN	Gender Equity Network
IT	Information Technology
MERGA	Mathematics Education Research Group of Australasia Inc.
NAEP	National Assessment of Educational Progress (US)
NBEET	National Board for Education, Employment & Training (Federal) [now DEET]
PES	Publicly Examined Subject
SA	Strongly Agree
SACE	South Australian Certificate of Education
SAS	School Assessed Subject
SD	Strongly Disagree
SPSS	Statistics Package for the Social Sciences
SSABSA	Senior Secondary Assessment Board of South Australia
TAFE	Technical and Further Education
TER	Tertiary Entrance Rank
TIMSS	Third International Mathematics and Science Study
URB	University Research Budget

EXECUTIVE SUMMARY

AIMS

This study was conducted in response to the perceived problems of growing non-participation rates of students in mathematics courses, particularly at Year 12 and beyond, and the decline in skill levels of students in science and mathematics who have been entering tertiary courses. There are worrying signs that mathematics has been devalued by society and the education system, one effect of which has been the decreased amount of time devoted to mathematics in the secondary curriculum which, combined with other factors, has led to a decrease in the number of students wishing to continue with mathematics or to pursue careers involving mathematics. The major consequence is the dearth of students and graduates able to "feed the IT revolution" within South Australia.

So a survey was conducted to address the following questions:

- What factors are most influential on student choices to study or not to study mathematics in Year 12?

- What are students' views about mathematics as a subject of study, as a subject for further study, and as a means of enhancing their employment prospects? What has influenced their views and choices?

The 393 students surveyed came from Year 12 classes in 10 South Australian secondary schools, and provided a sample tolerably representative of the whole Year 12 cohort, including schools which were large/small, urban/rural, state/ independent/Catholic, and boys only/girls only/mixed.

KEY FINDINGS

- The major factor influencing students' choice to study or not to study mathematics is whether they consider that mathematics is, or may be, needed for further study. For those who do mathematics at Year 12, their ability to do mathematics is the other major factor, while for those who don't, it is the lack of appeal of the subject rather than their inability to do it.

- Students believe that mathematics is a relatively uncreative subject, which is not essential for succeeding in life, but is a necessary stepping stone for most students to future study or careers; that is, it is useful, but more in an instrumental than a practical way.

- Students believe that to succeed in mathematics does not require memorising textbooks and notes nor good luck, and see little relationship between mathematics and areas of knowledge dealing with human or social issues.

- Students believe that there is very little difference between (professional) mathematicians and users of mathematics.

- Students have a very limited view of teachers as users of mathematics and of the career opportunities for practitioners of mathematics. They also have a distorted view of mathematicians and users of mathematics, whom they see as somewhat cloistered individuals who, except for their teaching and professional responsibilities, are computer-tied and office-bound with little contact with the wider community and not very concerned with social issues.

IMPLICATIONS

This survey points to three main kinds of problem associated with the issue of studying or not studying mathematics in Year 12:

- an *information* problem – many students are not adequately informed about the positive values of mathematics and its role in study and careers;
- an *image* problem – many students have limited and distorted views of mathematics and those who use it; and
- a *curriculum and teaching* problem – many students are not being exposed to appropriate content and methods of mathematics which will better inform their views of the nature and relevance of mathematics.

It is therefore proposed that

- there is a need for clearer pathways to be defined relating school mathematics subjects to specific university and TAFE courses;
- more up-to-date and informed advice about career options involving mathematics should be made available to students;
- mathematics courses in which students enrol should be not only worthwhile exemplars of mathematics in its own right, but should provide students with a view of mathematics as a creative and socially relevant subject; and
- mathematics courses in which students enrol should include contemporary applications, particularly those relevant to social issues and a variety of career clusters.

1. INTRODUCTION: THE PROBLEM(S)

In its discussion of the importance of mathematics, the *National Statement on Mathematics for Australian Schools* argues for "the raising of levels of confidence and competence in mathematics" because it is "essential for widespread scientific literacy and for the development of a more technologically skilled workforce." (Australian Education Council, 1991, p. 6) Both these conditions in turn are essential preconditions, it is argued, for a workable democracy to exist in today's world. Assuming that this argument is valid, it must be of great concern to governments, employers and the community at large to observe that over the last two decades there has been an apparent swing away from doing mathematics among senior secondary students in Australia (Jones, G., 1981; Jones, W., 1988; Benger, G., 1995). Further, there seems to have been a noticeable swing at Year 12 away from 2 units to 1 unit of mathematics, and from academic to general mathematics. The resultant reduction in the pool of mathematical competence means that there may be less high school leavers qualified to enter post-secondary level courses in mathematics, science, engineering and technology, and a general lower level of numeracy and scientific literacy within society. By choosing not to go on with mathematics, students are not only reducing their immediate career options, but may also be contributing to a situation which challenges the country's economic health and its ability to operate as a democratic nation.

The national trend away from mathematics as a subject of study at Year 12 and beyond has been noted locally. In 1995, Dr David Panton, School of Mathematics, University of South Australia, in a discussion paper (Panton, 1995) presented to the Adelaide Consortium for Mathematics Education (ACME) highlighted the paucity of current and prospective graduates skilled and qualified in mathematics to "feed the IT revolution" within South Australia and also the decreasing participation rates in mathematics at both Year 12 and beyond. He went on to claim that

- participation levels in science and mathematics in secondary schools [were] too low; and
- skill levels of students in science and mathematics leaving secondary schools have declined.

His view was that the root causes of declining participation rates and standards were:

- the devaluation of science and mathematics in our society and school system;
- the reduction in time devoted to the subjects;
- the 'concurrent' method of teacher training which has developed entrenched negative attitudes to the teaching of science and mathematics.

One of his proposed actions was for a survey to be undertaken of Year 11 and 12 students to ascertain their attitudes to science and mathematics, based on a 1994 study undertaken by researchers at the University of Warwick (Freeman, Mond & Stewart, 1995) with a view to informing future debates and discussions.

Data from the Senior Secondary Assessment Board of South Australia (Benger, 1995) indicated a substantial decline during the period 1992–1995 in the actual number and percentage of total students undertaking Publicly Examined Subject (PES) mathematics courses and a smaller decline in the actual number and percentage of total students undertaking School Assessed Subject (SAS) mathematics courses during Year 12:

Subjects	1992		1993		1994		1995	
	No of students	% of total	No of students	% of total	No of students	% of total	No of students	% of total
Mathematics 1	2477	11·1	2104	8·9	1690	7·3	1439	6·9
Mathematics 2	2473	11·1	2097	8·9	1696	7·4	1445	6·9
Mathematics 1S	4918	22·1	3892	16·5	3304	14·3	2891	13·8
Quantitative Methods	n/a	-	138	0·6	120	0·5	66	0·3
Applied Mathematics	1764	7·9	1841	7·8	1685	7·3	1346	6·4
Business Mathematics	3961	17·8	4286	18·2	4212	18·3	3800	18·1

While these figures indicated a decline in participation rates in mathematics courses at Year 12, it is a matter of debate whether these rates are too low. There has been as yet no collected evidence of a decline in standards, although it has been observed (e.g. Hannan, Ferguson, Pollock & Reeders, 1995; Ainley, Jones & Navaratnam, 1990) that many of the more able students, particularly those taking a strong mathematics–science combination of Year 12 subjects, choose not to proceed with these subjects in higher education. Evidently, some students choose 'advanced' mathematics as a vehicle for achieving a high Tertiary Entrance Rank in order to gain admission to courses with high cut-off scores (which are seen as more prestigious or attractive: medicine, dentistry, law, ecotourism and so on). It is argued that the growing popularity and/or availability of such courses and the trend away from the 'hard' sciences have reduced the overall quality and quantity of students entering tertiary mathematics. In response, universities have mounted bridging programs and schemes to attract high achievers to mathematics and mathematics-based courses.

Of the 'root causes' proposed above, the third is now less relevant in that all three universities in South Australia have adopted patterns of graduate entry or equivalent end-on programs of teacher education for the preparation of secondary teachers of mathematics. The problem is to attract students to those programs. The other two 'root causes' are propositions about which there is widespread agreement within the mathematics education community, although it might be worthwhile to collect some qualitative evidence to support them:

- To what extent are science and mathematics devalued in our society and the school system?
- How much time is devoted to science and mathematics within the taught curriculum?
- To what extent do these factors contribute to decreased participation rates and standards in Year 12?

2. THE SURVEY

After a great deal of discussion the Executive Committee of ACME decided in 1996 to seek answers to the following questions as a basis for further action in response to the problems identified by Panton:

- What factors are most influential on student choices to study or not to study (academic) mathematics in (a) Year 11, (b) Year 12, 1st Year Tertiary, (d) 3rd Year Tertiary?
- What are students' views about mathematics as a subject of study, as a subject for further study, and as a means of enhancing their employment prospects? What has influenced their views and choices?

At the beginning of 1997, a small URB Establishment Grant was awarded by Flinders University to Peter Brinkworth, a member of ACME, to undertake, in collaboration with members of ACME, a survey to address these questions.

3. A REVIEW OF RELEVANT LITERATURE

3.1 Factors which encourage participation at Year 12

Two major studies (Jones, W. 1988; Ainley et al., 1990) have been undertaken across Australia and have a bearing on the survey questions.

The Jones study looked at factors influencing a student's decision to take mathematics in Year 12, and in particular the decision to take advanced level mathematics (e.g. Mathematics 1 & 2) rather than ordinary (Mathematics 1S or Quantitative Methods) or basic level (Applied or Business Mathematics) courses.* The factors pursued are evident from Jones' Subject/Career Choice Model, which became his theoretical model for investigating the factors:

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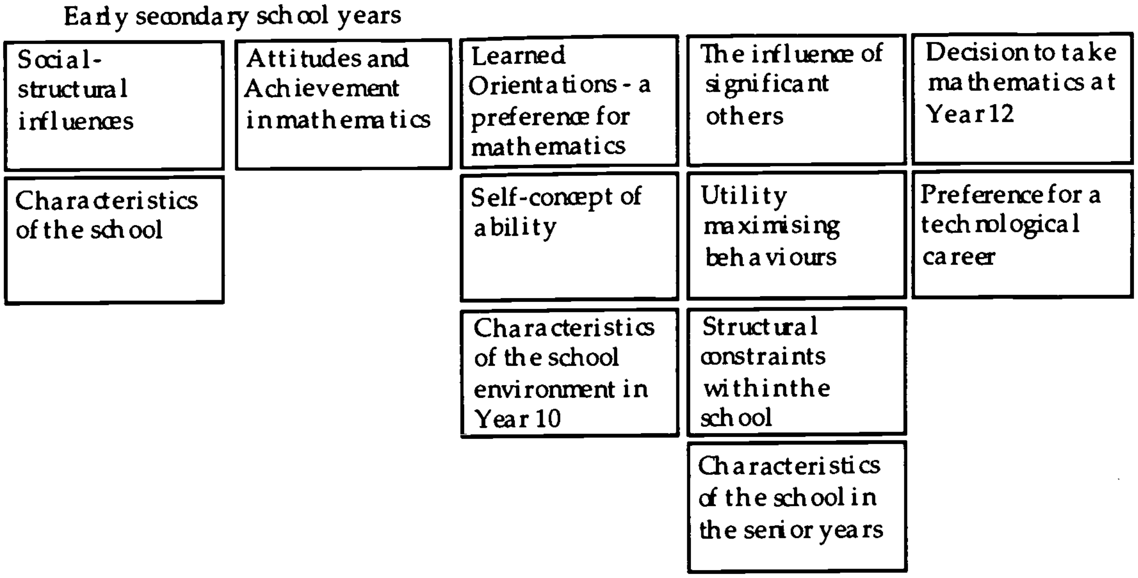
[1]* This was Jones' method of classification in 1988. Mathematics 1S is no longer offered in South Australia although Mathematics 1 has effectively replaced it.



(Jones, 1988, p. 14)

Jones found that significant influences on decisions about mathematics were

- **achievement in and a liking for mathematics in the early and mid-secondary years;**
- **seeing mathematics as useful in the future;**
- **postsecondary course requirements** ; and
- **the encouragement received from parents and teachers.**

The factors identified by Jones go well beyond those proposed by Panton.

While Jones looked at decisions regarding the taking of mathematics *per se*, Ainley et al. (1990) looked at choice involving combinations of subjects, in the belief that combinations of subjects "potentially [say] more about students' orientation than does enrolment in any given subject." (p.119) Of particular interest were choices which included the taking of mathematics: for example, 16 per cent of the Year 12 students surveyed were in a mathematics–science course type, while 17·5 % of all enrolments were in a mathematics subject. (The South Australian students in the study were distributed across 65% PES, 33% SAS and 1% non-SACE mathematics subjects.)

Ainley et al. found that student choice is constrained by what subjects and subject combinations a school offers, timetable limitations, previous studies undertaken, and rules governing subject selection for the Certificate of Education. Factors associated with the choice of a Year 12 mathematics–science type course (typically Mathematics 1, Mathematics 2, Physics, Chemistry) were

- **gender** (participation rates for males were two to three times those for females);
- **socio-economic background** (participation rates for students in the top category were one and a half times those for students in the bottom category);
- **parental education** (participation rates for students with one parent with a completed higher education were double those for students whose parents had reached middle secondary level);
- **ethnic background** (participation rates for students whose home language was not English were about double those of other students); and
- **attitudes and achievements** (strong associations with early achievement in numeracy, interest in investigative activities, enjoyment of mathematics, requirements of work or future studies).

School type and location had little influence: the participation rates for all-boys schools compared with those for all-girls schools simply reflected the different rates for male and female students. Overall, it was found that students are more likely to select mathematics if they develop a growing sense of competence, interest in and excitement about mathematics, and if the school is able to provide the appropriate curriculum pathways.

Other studies have shown that choosing to do mathematics at Year 12 is associated with the following factors:

- reasons of **future employment /career choice** (Kaczala, 1980; Johnston, 1994; Foyster, 1990; NBEET, 1995);
- reasons of **tertiary entrance** (Berg, 1993);
- choosing it as a subject for a **high Tertiary Entrance Rank** (Hannan et al., 1995);
- contact with appropriate **role models** , particularly in the case of females (Brown, 1995); and
- having **congruence with personal needs and cognitive style** (Cavanagh, 1993).

Foyster (1990), in a South Australian study, noted that choosing mathematics for reasons of further study was more important for students than liking mathematics or needing it for further employment. This is echoed in the work of Johnston (1994) in her study of Year 11 girls. A frequently expressed view was "You need it even if you don't want to do it". Reasons given for choosing mathematics were **needing mathematics for further study or a career, keeping one's options open, "mathematics should be useful"**, and **"mathematics is less of a language problem"**. The last reason was common among girls of Vietnamese background, suggesting to Johnston the importance of cultural background. She found also that choice was heavily influenced by **past achievement in mathematics**, and this was supported by the school's process of decision-making about subject choices.

3.2 Factors which encourage further study of mathematics

It is widely accepted that taking mathematics opens up pathways to further learning, and promotes the acquisition of basic skills for living or employment. Abbott-Chapman & Wyld (1993) found that **high levels and high scores** in mathematics are a clear pre-requisite to retention success up to university level. **Achievement in mathematics** and **subject choices** made in the high school up to Year 10 are critical in determining pathways to future study and employment. In particular, **higher scores in mathematics** are associated with higher retention rates into higher education (Grimison & Pegg, 1995; Abbott-

Chapman & Wyld, 1993; NBEET, 1995). The recent TIMSS study (Lokan, Ford & Greenwood, 1996) also found that **getting good results** in mathematics was critical for future plans for students in the early years of high school, and found that this was strongly related to feelings of **self-efficacy** and **enjoyment of mathematics**, as was the case in the Jones study referred to earlier and a number of other studies (Hamlett, 1991; Kempa & McGough, 1977).

Further study in mathematics is encouraged by feelings of **confidence and satisfaction in doing mathematics** particularly when there is a level of **support from family members** according to Hannan et al., (1995) in their study of students' views of their future. Preference for mathematics and science studies is strongly associated with students from professional/managerial families, although **parental influence** generally is significant in encouraging further study. In fact, Wilkowski (1993) found that parents are more influential than **sources from universities and TAFE colleges**, which in turn are more influential than **friends and siblings** in making choices about doing further mathematics. Other factors identified by Hannan et al. were the school's **curriculum provision** (what range of subjects, what kinds of subjects, with what flexibility, etc), the **school ethos**, complemented by its **size**, the **level of retention** of students at the school, and school certificate requirements (SACE in South Australia). They observed that it was important for students to have options for further study open from Year 8 onward, together with accurate information about the consequences of modifying their subject choices. Further studies have proposed the importance of **relevant work experience** (Hamlett, 1991) and the **nature of the mathematics taught** (Hannan, 1983), and that these are significant where students need to see a link between school mathematics and the mathematics associated with students' career choices.

Dekkers, De Laeter & Malone (1986) have pointed out that further study of mathematics in general is encouraged by the provision of **a greater range of mathematics subjects to choose from**, while Burton (1986), Galbraith (1986) and Grimison (1995) highlight the importance of **parental attitudes and encouragement**. Burton (1986) and Cooney (1992) stress the need for **positive role models**

of success in mathematics in the media, and more generally a **positive public image of mathematics and mathematicians**. It should be noted also that there is clear evidence that parents universally rank mathematics as a subject of the highest importance for students to study (Galbraith, 1986; Kelly et al., 1986).

3.3 Factors which discourage further study of mathematics

As Newton might have said: to every factor encouraging the further study of mathematics, there is an equal and opposite factor discouraging it. Unfortunately, the situation is rather more complex than this, and, as one might expect, the discouraging factors seem to be more numerous and imposing than those which encourage. A further difficulty in assessing the evidence is that, as for the factors cited above, it is virtually impossible to weight the factors.

G. Jones (1981) proposed a conceptual framework for investigating the reasons why students drop out of mathematics, in response to concerns expressed at the time about the move of students away from advanced mathematics in Year 12. He proposed the following factors as having some influence according to the research evidence available then:

- **parents' attitude** towards mathematics and towards the learner in the context of mathematics;
- **students' achievement in mathematics, confidence in learning mathematics , perceived attitude of self and others on success in mathematics, perceived usefulness of mathematics, mathematics as a male domain;**
- **teachers' attitudes** towards mathematics and the learner in the context of mathematics; and
- both **quality of instruction** and **engaged time** in learning mathematics.

Since then, evidence has tended to confirm the significance of these factors, especially on attitudes and the effect of gender. There has also been a great deal of research on gender issues related to choosing or not choosing mathematics.

On the question of attitudes, Buxton (1981) has documented that **dislike** and **fear of mathematics** as well as **poor performance** are clear discouragers of further study of mathematics. This has been supported too by Leder (1992), Johnston (1994), Thorndike-Christ (1991), Byrne (1993) and others, especially in the case of girls, although Johnston suggests that negative attitudes are not necessarily a barrier to progress because of perceptions that mathematics is needed to get on. It has been known for some time that achievement and attitude are strongly related (Dungan & Thurlow, 1989). More specifically, Byrne (1993) found that underachievement is strongly related to **poor self-esteem** and **reliance on extrinsic motivation to succeed**, while Wither (1988) associated poor achievement with **negative manipulation, test anxiety** and **low perseverance**. The TIMSS study (Lokan et al., 1996) associated poorer performance with students' perception of **being in a disorderly or too orderly class!** Poor achievement in turn discourages further study, as noted earlier.

Jones (1990) showed that in the context of outcomes of girls' schooling in Australia there were the discouraging factors of **poor school ethos, negative community attitudes, low aspirations, poor motivation** and **negative teacher attitudes**. Discouraging teacher attitudes can vary from "maths is maths" (denying any gender bias by assuming that mathematics is dehumanised objective knowledge) to "you don't need maths" (confirming the gender stereotype that girls don't do mathematics) (Grasset, 1990; Jacobs, 1991). In an extensive US study, Fear-Fenn & Kapostasy (1992) amassed the following discouraging factors for female students of mathematics: **stereotypic images/expectations, lack of self-confidence, peer pressure, the learning environment, teacher behaviour, lack of female role models, failure to see relevance, attributional style or personal responsibility**, and **lack of incentives**. It should be noted in passing that research regarding gender differences must be tempered by knowledge of the local situation: for example, the TIMSS study (Lokan et al., 1996) found no significant differences between attainment of girls and boys in early high school, while DEET figures for Year 12 enrolments in mathematics in tertiary accredited subjects in 1991 showed no significant differences in male and female participation rates, although there were gross gender differences at the higher and further education levels according to field of study (Gender Equity Network, 1993).

Other factors which can negatively influence further study of mathematics include:

- being in a school where there is **restricted choice** or **access** to appropriate mathematics subjects (Hamlett, 1991);
- **inavailability of subject choice to support entry into a desired tertiary course** (Byrne, 1993);
- the provision of **poor career/course information** (Hannan et al., 1995);
- **negative images of mathematics in the media** (Cooney, 1994);
- the persistence of the **typical maths lesson** (Grimison, 1995); and
- **difficulties with English language** (Dawe, 1995).

3.4 Students' beliefs about Mathematics

Whether students' beliefs about mathematics have any influence on their decision to study or not to study mathematics or whether they are just reflections of their experiences of learning mathematics does not appear to have received much attention in the literature. In his reconceptualisation of the affective domain as it applies to mathematics education, McLeod (1992) proposed that student beliefs about mathematics and themselves, in conjunction with both positive and negative experiences in learning mathematics, generate emotions which, over time, give rise to their attitudes towards mathematics. Relative to emotions and attitudes, beliefs are largely cognitive, not affective, and involve low level intensity of response but high levels of response stability. According to Lester, Garofalo and Kroll (1989), beliefs consist of students' subjective knowledge and are therefore learned. They develop as a result of students' experience of the school curriculum and from the wider culture. As students get older, their beliefs change, presumably because of their increased experience of both curriculum and culture (Kouba and McDonald, 1987).

From an early age, children begin to form a picture of mathematics as "important, difficult and based on rules" (Brown et al., 1988). Over time, their beliefs change to accommodate the notion that mathematics must be hard and unfamiliar. By the time they have reached the upper secondary school, beliefs have firmed and been confirmed by their experiences in mathematics classrooms which typically "reflect and perpetuate the Newtonian world view" (Fleener, 1996). These beliefs tend to exhibit a cyclic relationship with students' learning experiences: beliefs colour what students learn, which in turn impinges on their beliefs (Spangler, 1992). Furthermore, an examination of students' beliefs provides a graphic insight into both the nature of classroom mathematics as they have experienced it, and the creative ways in which they have learned to deal with it (Cobb, 1986)

Studies in the U.S. have identified the following sorts of beliefs about mathematics among secondary school students:

- males in general report higher perceived usefulness of mathematics, which is generally seen as a male domain (Fennema, 1989).
- mathematics is useful but involves mainly memorising (McKnight et al., 1987);
- mathematics is "doing something", usually something algorithmic (Kouba & McDonald, 1987);
- mathematics is a "skill-oriented subject" (Greenwood, 1984); this belief may interfere with higher order thinking in mathematics (Garofalo, 1989b);
- in the teaching-learning process, the student is passive and the teacher is active (Frank, 1988); and

- memorization is a major component of mathematics learning; mathematics problems should be done quickly (Spangler, 1992).

A formal summary of typical beliefs from secondary students is given by Garofalo (1989b):

- **Belief 1**: Almost all mathematics problems can be solved by the direct application of the facts, rules, formulas and procedures shown by the teacher and given in the textbook.

  Corollary: Mathematical thinking consists of being able to learn, remember, and apply facts, rules, formulas and procedures.

  Belief 2: Mathematics textbook exercises can be solved only by the methods presented in the textbook; moreover, such exercises must be solved by the methods presented in the section of the textbook in which they appear.

  Belief 3: only the mathematics to be tested is important and worth knowing.

  Corollary: Formulas are important, but their derivations are not.

  Belief 4: Mathematics is created only by very prodigious [sic] and creative people; other people just try to learn what is handed down. (Garofalo, 1989b, pp. 502–505)

Beliefs about mathematicians from other studies tend to stereotype the mathematician as an older male with grey Einstein-like hair, wearing glasses and sitting at a desk, using pencil & paper, books, calculator or computer, and sometimes a ruler, and working in a non-descript room with no other people around (Spangler, 1992). This conforms to the public image as represented in cartoons in popular newspapers and magazines and other media.

Of particular relevance to this study are the findings of Hart and Walker (1993):

> Students who do not like mathematics, who do not see themselves as able in mathematics, and who view mathematics as having little use for them in the future will be less likely to decide to take a difficult optional mathematics course than students who perceive mathematics as useful to them. Students who see mathematics as necessary for their future career plans will probably enrol in optional mathematics courses even if they do not enjoy mathematics. (p. 28)

> Perceived usefulness ...[is]...the most important affective predictor ... of students' plans to enrol in additional senior mathematics courses. (p. 29)

3.5 Discussion

While many factors influencing students' views about mathematics and their choice to study or not to study mathematics have been identified, it is not possible to say with any certainty what are the dominant factors, although those factors discussed in the major studies by W. Jones (1988), Ainley et al. (1990) and Hannan et al. (1995) appear to have some support in the research. The range of other factors identified across all the studies suggests that the determinants of choice and success are many and complex, and that any policy responses would need to be wide-ranging; no handful of responses would be sufficient to address the problems posed by Panton (1995).

When thinking specifically of Australia, although the detail is not provided here, what is clear from reading a number of the national studies is that there are wide variations among the states in terms of curriculum provisions, attitudes and achievements, as well as wide intrastate variations. Since few studies have been undertaken specifically in South Australia, results of surveyed research must be interpreted with caution. It must also be borne in mind that samples and populations have probably changed significantly over the years, as have school curricula, the conditions governing career and subject choice and so on. In particular, there have been modifications to the mathematics curriculum in secondary schools as a result of the implementation of the *National Statement on Mathematics for Australian Schools* and changes to Year 11 and 12 patterns of study through modification of requirements to satisfy the South Australian Certificate of Education (SACE).

If any action is to be taken regarding participation rates in studying mathematics, it is imperative that first-hand local data be collected. Research literature can provide a guide for data collection, but is unreliable by itself without either the corroboration or contradiction of the results of a current survey.

This brief review of research suggests that the 'root causes' of declining participation rates proposed by Panton are probably just few among many possible causes. There are other factors which research has identified as possibly contributing to student disaffection with the study of mathematics and the nature of the choices they make about its further study. In order to understand which ones are dominant in South Australia therefore requires the collection of contemporary data, both qualitative and quantitative, from a range of sources which can give a comprehensive snapshot of what students are thinking, believing and doing about mathematics.

4. PURPOSES FOR THE SURVEY

Because of the limits placed on the study by the funds and time available, the questions posed by the Executive Committee of ACME (Section 2, p. 4) were refined to target a more specific group of students (Year 12/13) with an emphasis on the collection of quantitative data by means of a survey.

The purposes of the survey were:

(i) to collect data which would help to answer the following questions:

- What factors are most influential on student choices to study or to study mathematics at Year 12 level?
- What do Year 12 students believe about mathematics as a subject of study, as a subject for further study, and as a means of enhancing their employment prospects? What has influenced their views?

(ii) to provide implications and recommendations for action by ACME Inc. and other relevant bodies in order to address the low participation rates in mathematics, and possibly also the poor skill levels in mathematics of students entering higher education.

In particular, the survey aimed to sample from students from Year 12/13

- reasons for studying or not studying mathematics;
- opinions about mathematics and mathematicians;
- opinions about what happens in mathematics classes; and
- awareness of mathematical techniques

according to

- age;
- gender;
- type of school;
- level of achievement;
- current study of mathematics; and
- planned future study and/or work

Further, the survey aimed to identify dominant prevailing reasons and opinions, relate these to the outcomes of other studies such as the Warwick and TIMSS studies, and, where possible, establish relationships among the various significant factors identified from the data. In essence, the study attempted to identify the effects of various factors on student choice, but also to understand the nature of those effects.

5. DESIGN AND METHODOLOGY

5.1 Overall design

Because of the modest amount of funding available, the initial decision to collect data by surveying students undertaking Years 11 and 12 at high school and at first and third year tertiary level was modified so that only students undertaking Year 12 (& 13) were to be surveyed using a purpose-written questionnaire. It was decided that the questionnaire would be undertaken by a sample of Year 12 students during Terms 2 and 3 of the 1997 school year from a variety of schools in South Australia, and the results collated and analysed as soon as possible afterwards.

A first draft of the questionnaire was constructed by Peter Brinkworth, Will Morony (DECS) and John Truran, based on a model proposed by John Truran and which included some items from both the Warwick (Freeman, Mond, & Stewart, 1995) and TIMSS (Lokan, Ford, & Greenwood, 1996) studies for comparative purposes. The draft was discussed at ACME Committee meetings and further modified. Professor Richard Jarrett (University of Adelaide) provided estimates on the amount of labour required to carry out the survey and gave advice on the most efficient way to construct the questionnaire. After the receipt of support in principle from the ACME Committee and some Establishment Grant funds from the Flinders University Research Budget to carry out the survey, the draft questionnaire was put into more refined form, and modifications made as a result of informed feedback from various members of ACME. A trial version was finalised in March 1997.

The detailed proposal for the survey was given approval by the Social and Behavioural Research Ethics Committee of The Flinders University of South Australia on March 7 as Project 1316 *A study of influences on students' reasons for studying or not studying mathematics,* and was subsequently formally approved for access to DECS sites by the Research Council of the Department for Education and Children's Services (now DETE) and informally approved by the

Catholic Education Office for access to schools in the Catholic Education system.

The questionnaire was trialled in Year 12 classes at two metropolitan secondary schools, with data being entered on an SPSS database to check the appropriateness of the data format. Following the trial, minor changes were made to the questionnaire and to procedures used in administering the questionnaire. Problems which arose during the trial included:

- the relatively slow response time because of the difficulty schools had in finding time to complete questionnaires within their busy schedules, and the delay resulting from the requirement to obtain parental written consent to participate;
- the low participation rate from the available students in Year 12 classes; and
- some inconsistency of response from some students.

The instrument itself was found to be satisfactory but the main concern arising was that if response rates were to be variable and low, then there would be little control over the precise constitution of the sample. As there was little that could be done about this, it was decided therefore to trust in the process and hope that a tolerably representative sample of Year 12 students would be surveyed by sampling from a cross-section of school types. In practice the sample obtained was fairly satisfactory.

5.2 The sample

Permission was sought from selected schools through their Principals to conduct the survey in their Year 12 classes, with a request to nominate a School Contact Person, who in most cases was the Senior Teacher in charge of Mathematics. A few schools declined to participate or did not reply. The Contact Person nominated was approached to identify the size of the Year 12 cohort so that an appropriate number of consent forms and questionnaires could be dispatched and an approximate timeline for administration and return of the questionnaires could be decided. The process began in April 1997, and the final return of questionnaires was achieved after considerable effort by November 1997.

Data were collected from 393 students in Year 12 classes from 10 secondary schools which had indicated willingness to participate. The schools were sampled from all schools with Year 12 classes and listed in the DECS *Directory of Schools 1997*, selected to include the categories of large-small, metropolitan-rural, state-independent, single sex (male and female)-mixed. The breakdown of the sample of students who responded is as follows:

• **Gender (students studying Mathematics):**	Male:	169
	Female:	222
	n/s	2
• **Gender (students not studying Mathematics):**	Male:	10
	Female:	60
• **Location of students:**	City (Metro area):	265
	Rural (non-Metro):	128
• **School type:**	State:	157
	Independent:	236
• **School mix:**	Mixed:	124
	Single sex (M):	57
	Single Sex (F):	112
• **Year level of students:**	Mature age	1
	Year 13	16
	Year 12	374
	n/s	1
• **Highest year level of mathematics studied:**	Year 10/11	69
	Year 12	323

- **Current enrolment in Mathematics:**

Subject(s)	*f*
Mathematics 1S	150
Mathematics 1D + 2	78
Business Mathematics	76
Applied Mathematics	19
Quantitative Methods	-[2]
none	69

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[2] Quantitative Methods is a School Assessed Subject taken by few students at Year 12 in South Australia. As a result of the sampling process, no students taking this subject were included in the sample.

While not completely representative of the Year 12 cohort in South Australian schools, it was felt that the sample was sufficiently representative so as to be able to make some valid inferences and to suggest further questions for investigation. The sample has a bias towards female students, single sex (female) and independent schools, and those undertaking PES mathematics.

The reasons for the bias in the final sample are complex. Provided that all students in Year 12 and 13 within the schools originally approached had participated, the student sample would have closely represented the characteristics of the state cohort of final year secondary students. However, a small number of schools declined to participate, and the participation rates of students within schools varied greatly: they tended to be highest in independent schools and in single sex female schools. Why this is so is not clear, but it appears that a major contributing factor may have been the requirement by the DECS [now DETE] Research Council that parental consent for all participating students under the age of consent be obtained in writing for each individual student. Apparently independent and single sex female schools either have more compliant parents or have mechanisms for obtaining parental consent which are more effective than in other categories of schools.

Whatever the case, the consent procedures were a source of unreasonable difficulties in that they caused delays in data gathering, placed administrative burdens on school staffs and contributed towards bias in the final sample. While overt consent is clearly essential where the research investigates sensitive, controversial or highly personal matters, it could hardly be said that this survey ventured into that territory. For surveys of a general nature such as this one, less demanding procedure which still obtained the necessary consent but in a more efficient fashion would be welcomed by researchers.

5.3 Instrumentation

Copies of the questionnaire and the instructions to teachers are included in the Appendix. It was designed to be completed in 15–20 minutes, requesting respondents for the most part to select from a set of alternative responses to statements, although opportunity was provided for open-ended responses on a number of items, as well as ample space for "Any Other Comments" (which was rarely used). To support teachers' instructions for administering the questionnaire, two examples of item types were provided on the third page.

The first part (pages 4–7 inclusive) sought information about some relevant personal attributes of respondents so that profiles of various attribute groups could be explored through the data analysis. The second part (pages 8–9) asked for "Opinions about Mathematics" using a four point Likert scale from Strongly Agree to Strongly Disagree for 33 statements of belief (M1–M33). The next two parts (pages 10–11) asked for "Opinions about Users of Mathematics"(U1–U13) and "Opinions about Mathematicians"(A1–A14) using a similar scale to the previous one, with the addition of a fifth possible response: "Don't Know", and the chance to provide an open response (U14 & A14). In the next two parts, students responded according to whether they were currently studying mathematics ("Reasons for Studying Mathematics", S1–S16) or not studying mathematics ("Reasons for Not Studying Mathematics", D1–D16). These two parts contained pairs of parallel statements in different order. In each case students indicated the strength of influence of factors on their decision on a three point scale: Strong Influence, Some Influence, Little or No Influence, and were able to provide an open response if they wished (S17 & D17). In the next part, "Mathematics Classes", students indicated the frequency with which certain things happened in mathematics classes (C1–C10) and the frequency with which homework was assigned in mathematics (C11) in each case on a five point scale. Finally, students were asked whether they had met or not met certain "Mathematical Techniques"(T1–T6) in mathematics classes or elsewhere in the recent past, or were not recognised by them.

Trialing demonstrated that most students managed to complete the questionnaire successfully within the allowed time, and there were very few instances of students providing incorrect or unusable responses. This proved subsequently to be true of the survey as a whole. The only minor problem occurred where students filled out items S1–S16 *as well as* D1–D16, but this was easily overcome by noting whether the student was or was not currently enrolled in mathematics.

5.4 Form of Analysis

A database was created using an SPSS package on a Powermac, with assistance from Lynne Giles, Statistical Consultant, Computing Services, at Flinders University. After hand coding, data was keyed into an ASCII file by Management Information Services: Operations, Flinders University, and loaded into the SPSS database. Data were available for processing in early January 1998 and exploratory data analysis undertaken in the following months.

Initial results, largely compilations of raw data, were first made publicly available at the DECS Research Expo held on Saturday March 21 at the University of South Australia, Magill campus. Further analysis involving cross-tabulations and statistical testing was then undertaken with a view to identifying significance of data relating to comparisons of various attribute groups. In the case of cross-tabulations, χ^2 tests were used to test for significance.

6. RESULTS & DISCUSSION

6.1 Student achievement

As a general self-assessment of their level of mathematical achievement, students were asked to nominate a word from a graduated list which described their achievement so far. To estimate their actual achievement, students were then asked to state the grade or mark achieved at their last end of term assessment, which was then interpreted and recoded to correspond with the self-assessed scale.

P6 – P7 Students' level of achievement in Mathematics:

Level	self-assessed	"actual"
excellent	39	114
above average	130	135
average	167	94
just a pass	41	31
poor	13	12
unknown	2	6

Although only approximate, these items provide a rough means of categorising the students according to achievement level. The mismatch between the two measures could indicate a number of different interpretations: either students tend to underestimate their ability, or they could be more pessimistic (or perhaps realistic) about their achievement than school results would indicate, particularly if they view Year 12 work as being more challenging than Year 11 work. Alternatively, school assessment procedures may just be more generous in awarding higher grades or marks. Whatever the explanation, there is clearly a bias towards the upper end of the scale.

6.2 Student destination

P10 What the student expects to do next year:

destination	*f*
Work	23
Study	141
Work+study	203
Timeout or travel	17
Unknown or other	8

P11 If study, what type of institution:

type	*f*
School	20
TAFE College	51
University	272
Don't know	23
Other (business college & c)	19

P12 Do you expect to study any statistics course next year?

	f
Yes	88
No	274
Don't know	15

P13 Do you expect to study any mathematics course apart from statistics?

	f
Yes	109
No	254
Don't know	14

P14 Do you expect to study any science/technology type courses apart from mathematics and/or statistics?

	f
Yes	195
No	168
Don't know	13

P15 Do you believe that careers are available for people who graduate from a university with a major study in mathematics?

	f
Yes	263
No	94
Don't know	20

Both the pattern of enrolments in PES and SAS together with the fact that 69% of the sample have their sights set on a pathway to a university course reflect a major concern among students to qualify for university entrance. Of those who expect to study at university, 53% expect to study a science/technology course, 23% expect to take a statistics course and 29% a mathematics course. This is a slightly disturbing result in that virtually all science/technology courses require at least a cognate study of mathematics at first year tertiary level. It appears that there may be many students who are not aware of this fact and some may therefore be undertaking inappropriate courses in preparation for their intended further study. This suggests that students need to be better informed about pre-requisites and assumed knowledge of mathematics for various course options at tertiary level.

While 70% of the respondents believed that *careers are available for those who graduate from a university with a major in mathematics* (P15), it is clear that very few have considered this a possibility for themselves. Only 20% are enrolled in PES Mathematics 1 & 2 which would normally be taken by students expecting to major in mathematics, although the majority of this 20% is most likely to be aiming for one of the "hard" sciences, engineering or related disciplines. Students who are enrolled in PES Mathematics 1 (single) or one of the SAS Mathematics subjects probably have other pathways in mind which involve mathematics, since the majority of statistics and mathematics courses provided at further or tertiary level are service or supporting courses for either science, technology or engineering related programs or for finance, business, economics, commerce or psychology related programs. This is borne out by the current enrolments at universities and TAFE institutes.

Since between 29 and 52% of the sample expect to take either mathematics or statistics in their next year of study, yet 69% expect to be going to university and 82% are enrolled in PES or SAS Mathematics subjects, there is a significant proportion of students who are doing mathematics beyond specific expectation. This suggests that there are a variety of reasons for enrolling in Year 12 Mathematics, a number of which are confirmed by later findings (see Section 6.10):

- **students need to enrol** because it is required for further study (for example, the 20% enrolled in PES Mathematics 1 & 2 would probably have in mind to do Engineering, Physical Sciences or Mathematics which either require this background or assume knowledge of it);
- **they want to do mathematics** because they enjoy it or feel some educational need for it;
- **they must do it** because either the school requires it or it is the only option from what the school has on offer for students to complete the requirements to qualify for the SACE; or
- **they are doing it to keep their options open** in terms of further study or career pathways.

It is also possible that some students are enrolled in mathematics (especially in PES Mathematics) as a device to gain a high Tertiary Entrance Rank (TER) with no intention to continue with the study of mathematics, as found by Hannan et al. (1995). This is alleged to be a strategy used by students who are capable in mathematics (as in other subjects) in order to take advantage of the scaling process used to calculate the TER. Their aim is to obtain a score sufficiently high in mathematics to inflate their TER to a level which will gain them entry to highly competitive tertiary courses which do not require mathematics. However, there is no evidence apparent from this study to support or deny this.

[It is nevertheless a matter of concern that many students who are talented in mathematics do not appear to go on to major in mathematics, although it could be argued that inevitably their mathematical ability would be of great benefit to them irrespective of their field of study or work. Thus doing mathematics per se at Year 12 by these students could be considered valuable.]

6.3 Beliefs about Mathematics

Students responded to statements about mathematics as follows. ['Agree' indicates that at least two-thirds of all students either agreed or strongly agreed with the statement, while 'disagree' indicates at least two-thirds either disagreed or strongly disagreed. In each cell, the items are listed in descending order of strength of agreement as indicated by the mean value on the scale, where SA = 1, A = 2, D = 3 and SD = 4.]

To succeed in mathematics requires

AGREE	DIVIDED	DISAGREE
working through exercises 1·72 *hard work studying at home* *learning its basic rules* 1·95	*lots of natural ability* 2·45	*using computers* 2·87 *memorising textbooks & notes* 2·95 *good luck* 3·25

Mathematics is useful for

AGREE	DIVIDED	DISAGREE
understanding chance 2·01 *understanding science* 2·08 *understanding economics* 2·22	*solving everyday problems* 2·27 *understanding computers* 2·38 *understanding IT* 2·34 *solving simple problems* 2·73	*understanding legal studies* 3·07 *understanding the Internet* 3·07 *understanding environmental studies* 3·09 *understanding literature* 3·35

People who study mathematics are

AGREE	DIVIDED	DISAGREE
	conventional 2·81	*dull* 3·15 *uncultured* 3·28

Jobs for those with mathematics qualifications

AGREE	DIVIDED	DISAGREE
	are more numerous 2·63 *produce higher incomes* 2·71	*produce higher status in society* 2·91 *are more interesting* 3·10

The study of the following are important parts of mathematics

AGREE	DIVIDED	DISAGREE
counting 1·99 *geometry* 2·11 *logic* 2·12	*general relationships* 2·56	

Other results:

AGREE	DIVIDED	DISAGREE
	There's not enough creativity in Year 12 mathematics 2·33 *You can either do mathematics or you can't,* 2·62	*Mathematics is essential for succeeding in life* 3·01

For the few statistically significant differences in response among various attribute subgroups in the sample, analysis of the data showed that

- those students who were not expecting to undertake the study of mathematics beyond Year 12, compared with those who were, believed that there were less jobs for the mathematically qualified, and that those jobs were not only less interesting but also did not necessarily produce higher incomes, although they were seen as producing higher status in society. This same group of students believed more strongly that mathematics is essential for succeeding in life, but less strongly that to succeed in mathematics requires hard work.

- girls disagreed more strongly than boys that people who study mathematics are uncultured, conventional or dull. Girls also disagreed more than the boys that there's not enough creativity in Year 12 mathematics. Boys, however, agreed more strongly than girls that there were more jobs for those with mathematics qualifications, that these jobs were more interesting and that mathematics is essential for succeeding in life.

- higher achievers agreed more strongly than lower achievers that jobs for those with mathematics qualifications are more numerous, more highly paid and more interesting, and that mathematics is essential for succeeding in life. They disagreed more strongly that success in mathematics requires good luck and memorising textbooks and notes, that computers are essential for learning mathematics and that there's not enough creativity in Year 12 mathematics.

- those who expect to study at university agreed less strongly than those who are not university bound that success in mathematics requires either good luck or memorising textbooks and notes. This also applies to higher achievers vis-à-vis lower achievers.

- students intending to study in TAFE courses agreed more strongly that computers are essential for learning mathematics.

6.4 **Some related findings** (see Sections 6.10 and 6.11 for complete results)

For those students who were enrolled in a Year 12 mathematics subject, the most influential factors in choosing to study mathematics were keeping options open, being good at mathematics or finding mathematics easy during the previous year, and requiring mathematics for a course to be pursued later. Taking notice of advice from parents and teachers was only moderately influential, as was awareness of job opportunities for those with mathematics qualifications.

Students who were not enrolled in mathematics were most influenced in their decision to drop mathematics by not having to do mathematics as a prerequisite for later study, finding mathematics boring and believing that mathematics doesn't provide enough room for creativity and self-expression. Finding mathematics difficult or being not good at mathematics in the previous year and finding teaching in language-rich subjects to be much better were also influential factors in their decision.

6.5 What happens in Mathematics Classes in Years 11 and 12 (methods)

What students perceive to happen in mathematics classes during the current year, or in the previous year if they were not studying mathematics, is summarised in the following table. Items are in decreasing order of frequency, with means given for each item, calculated by assigning "Never" = 1 through to "Every Lesson" = 5 on a five point scale.

MOST LESSONS	*We solve equations*	C3	4·21
SOME LESSONS	*We write equations to represent relationships*	C4	3·46
	The reasoning behind the mathematics is explained to us	C8	3·38
	We copy notes from the board	C7	3·35
	We study problems which don't have an obvious method of solution	C5	3·15
	We memorise rules and procedures	C6	3·08
	Relationships between variables are presented to us using tables, charts or graphs	C1	2·93
	We are asked to explain the reasoning behind the mathematics	C2	2·78
ALMOST NEVER	*We practise computational skills*	C9	2·45
	We apply models to data	C10	2·34

6.6 Discussion: beliefs about mathematics

6.6.1 *Overall view of Mathematics*

The beliefs about mathematics expressed by the Year 12 students as a group in this survey present a view of mathematics as a relatively uncreative subject, more usefully related to scientific or numerical/financial pursuits than to language-rich or humanistic/creative ones, somewhat connected to computing, and while based on the study of number, space and logic, only moderately concerned with the study of general relationships. It is not essential for succeeding in life, but is a necessary stepping stone for most students to future study or careers; that is, it is useful, but more in an instrumental than a practical way.

6.6.2 *The Nature of Mathematics Learning*

The image of mathematics held by these Year 12 students appears to be largely consistent with the traditional one found in earlier studies. For example, mathematics is seen as important, difficult, and based on the application of facts, rules, formulae and procedures (Brown et al., 1988). To succeed in mathematics therefore demands hard work learning the rules and practising them constantly. One positive note is the relatively low rating of the need to memorise textbooks and notes as a requirement for success even though the majority of students reported that it was a feature of some, most or all of their lessons. This is at odds with the observation by Spangler (1992) that memorisation is considered by students to be a major component of mathematics learning. While it is still a necessary feature, memorisation does not seem to be as overtly required nowadays because of the practice of supplying all necessary rules and formulae during assessment procedures. One might expect a lesser burden on memory as a result of the use of (graphing) calculators and computer packages, but there is no evidence of their wide-spread use in South Australia to support teaching, and their use has not been sanctioned for assessment purposes in Year 12 publicly examined or moderated mathematics subjects.

Nevertheless the emphasis on hard work and practice means that many students find the subject boring, technical and lacking in creativity, and helps to explain why it is a major "turn off" for those students who discontinue its study.

Could it be that for these students mathematics learning is still dominated by chalk-and-talk approaches? Student reports of what happens in mathematics classes seem to indicate that copying notes from the blackboard and memorising rules and procedures are still not uncommon practices at Year 12. And while teachers are reported to be explaining the reasoning behind the mathematics, the complementary strategy of asking students to provide the explanations, proposed in the *National Statement*, is less common. It appears that students are not continuing to take mathematics because of its intrinsic appeal or inspirational teaching.

6.6.3 The Nature of Mathematical Ability

While good luck is not considered to play a large part in succeeding in mathematics, more than half the students believed that natural ability is required, although a majority felt that it was possible to overcome the lack of talent through hard work. It is worth noting in passing that no gender differences were apparent on any of these items: this appears to be different from the situation described in *A National Statement on Girls and Mathematics* (AAMT, 1990) in which attributions for success were described as different for boys and girls.

6.6.4 Gender Differences

Gender differences in this survey were confined to two specific areas: beliefs about people who study mathematics and beliefs about jobs for people with mathematics qualifications. Girls seem to view those who do mathematics in a more tolerant light than the boys. Given that girls are tending not to go on with mathematics, this suggests that their choice is not being influenced by a concern about being seen as a bit offbeat. Perhaps there is less of a social stigma among girls in doing mathematics than there used to be. Despite this, girls perceive jobs involving mathematics as being even less interesting (and less numerous) than boys do. This suggests that it's OK to be seen studying mathematics at Year 12 as a means to an end, namely further study and a career, but that doing it for a living could be Death from Boredom.

6.6.5 Mathematics for a Career

While mathematics is highly visible in the secondary school curriculum, it does not have a high profile among students when related to jobs, because, except in the case of science- or economics-related careers where the mathematical demands are fairly clear, the mathematics is usually incidental to the job, or seen to be so. It is of some concern that students did not see mathematics to be particularly relevant to understanding legal and environmental studies, which are fields in which an understanding of mathematics (and more specifically of logic and chance & data) is becoming increasingly essential. Even information technology and computing were not rated as highly as one might expect as areas of application for mathematics. This suggests that some overt counselling or promotion needs to be undertaken to inform students about the relevance and benefits to future careers of mathematical study.

Apart from the problem of visibility of mathematics, students tend to believe that having a job requiring mathematics qualifications does not confer higher social status. Such jobs may confer higher incomes, but most students do not see them on the average as lucrative nor as more interesting than other jobs. Mathematics teaching as a career falls into these categories: it is usually perceived to be a relatively well-paid job of middling social status, ... and you have to be slightly "unconventional" to take it on! Presumably also the prospect of spending one's life getting students to learn rules, work through exercises and work hard studying at home is not considered particularly attractive either.

6.6.6 *The Utility of Mathematics*

More than half the students surveyed were enrolled in one or more "pure" academic mathematics [publicly examined] subjects (labelled Mathematics 1 and 2 in South Australia) at Year 12. The other mathematics students were taking "applied" mathematics [school assessed] subjects: either Applied Mathematics or Business Mathematics. Closer analysis reveals that this largely accounts for the division of beliefs about the usefulness of mathematics for solving simple or everyday problems. For the "academic" students, a socially relevant curriculum which is based on the National Statement and Profiles persists for the most part until Year 10, although for others there are vestiges of social relevance in topics taught mainly in Year 11 pre-SAS courses and courses not leading to Year 12. By Year 12, the pathways in mathematics divide fairly distinctly into pure and applied directions, the former mainly to the university courses, the latter to TAFE. It is only in the "applied" Year 12 subjects that anything like "everyday" problems are dealt with. Would the inclusion of more everyday real life problems in the Year 12 curriculum expand students' views of the usefulness and appeal of mathematics?

6.6.7 *Mathematics and Ability*

Students who achieve at a higher level in mathematics (and may do further mathematics if required) are more optimistic than lower achievers that there are more numerous, better paid and more interesting jobs requiring mathematics. Thus, being good at mathematics is associated with a perception that mathematics may enhance prospects of a good job. This is supported by the fact that more than half of all the students who were doing mathematics at Year 12 reported that being good at mathematics and having greater job opportunities were influential in their choice to continue with mathematics. Those who have already decided not to go on with the subject take a more pessimistic view about the availability and attractiveness of mathematics-related jobs even though they are more likely to believe that mathematics is essential for success in life, but still tend to think of such jobs as conferring higher status. Thus they concede that mathematics is important, but it's not for them.

6.6.8 Mathematics and Computers

The relationship between computers and mathematics had a mixed response. While students perceived that computers were not essential for succeeding in mathematics, they were divided as to whether mathematics was useful in understanding about computers. The higher achieving students tended to take a more negative position on the role of computers. Perhaps they are telling us that it is more important to be able to do mathematics, that is, the "pure" or conceptual mathematics which most of them are enrolled in, without the aid of technology, in much the same way as people tend to believe that one should be able to calculate without the use of an electronic calculator. Alternatively, this view could simply reflect the situation that teaching with the aid of computers is not widespread in Year 12 classrooms, at least not where publicly examined subjects are offered.

TAFE-bound students were more inclined to accept that computers were essential for success in mathematics. This may reflect classroom practice in their Year 12 enrolment such as the use of financial packages in Business Mathematics or their perception of embarking on further courses which require "technical" mathematics. The fact that most university courses requiring mathematics such as engineering, architecture, economics and psychology use it in the technical sense with a major reliance on computers and that even straight mathematics and statistics courses are these days heavily supported by computer packages seems not to have been a factor in students' responses. This suggests that there needs to be clearer communication with students about the nature of tertiary and further programs involving mathematics and their relationship with various career choices. At another level there is the question of the emerging role of computers in the curriculum and particularly in mathematics, and at another level still, the question of the nature and purpose of mathematics, which is rarely addressed at Year 12.

6.7 Beliefs about mathematicians

In this part, there was no attempt to define or describe the work of a "professional mathematician". In addition to the 4 point scale of agreement (SA A D SD), students were able to respond with a "Don't know". As in the previous scale (in 6.3), responses were coded SA = 1, A = 2, D = 3 and SD = 4. "Agree" in the table indicates that at least two-thirds of students either agreed or strongly agreed with the statements, while "Disagree" indicates that at least two-thirds of students either disagreed or strongly disagreed with the statements. Mean values are included in the table.

Professional mathematicians spend a significant amount of their working time

			Don't know
AGREE	*sitting and thinking*	*1·94*	16·5%
	working in groups solving problems	*2·01*	14·7%
	teaching	*2·02*	16·2%
	assessing the work of other professionals	*2·04*	23·3%
	working with computer models	*2·08*	19·1%
	writing computer programs	*2·10*	22·1%
	making useful new discoveries	*2·11*	17·3%
DIVIDED	*earning a large salary*	*2·36*	30·3%
	communicating results the community	*2·46*	25·8%
	doing administration	*2·54*	30·9%
	influencing community decisions	*2·58*	26·8%
DISAGREE	*travelling*	*2·78*	37·1%
	dealing with important social issues	*2·85*	25·7%

6.8 Beliefs about users of mathematics

In this part of the survey questionnaire, users of mathematics were described as being "like middle managers or teachers", who "have normally studied some mathematics at tertiary level and need to be able to use it, but in ways which have been developed by others".

Users of mathematics spend a significant amount of their working time

			Don't know
AGREE	*teaching*	*2·01*	14·3%
	working in groups solving problems	*2·07*	14·3%
	writing computer programs	*2·15*	20·7%
	working with computer models	*2·16*	23·2%
	sitting and thinking	*2·20*	16·0%
DIVIDED	*assessing the work of other professionals*	2·32	28·4%
	making useful new discoveries	*2·40*	17·1%
	communicating results the community	2·50	34·1%
	doing administration	2·52	27·2%
	earning a large salary	2·74	29·7%
	influencing community decisions	*2·84*	26·1%
DISAGREE	*dealing with important social issues*	2·91	24·0%
	travelling	*3·00*	32·7%

6.9 Discussion: Beliefs about mathematicians and users of mathematics

At first glance there are a couple of things which stand out from students' responses. The first is that students have a far from lucid view of the activities and concerns of both mathematicians and users of mathematics. This is suggested by the number of "Don't know" reactions to items, the frequency of which varied from 14·3% to 37·1%. Since teachers of mathematics were identified as "users of mathematics" and are probably the major source of students' beliefs about "users", this seems to suggest that many students do not have a clear picture of teachers as professional users of mathematics. Their unfamiliarity with mathematicians and other users of mathematics is understandable, because there is little public exposure or awareness of professionals in these fields.

The second is that apart from minor distinctions, mathematicians and users of mathematics are virtually indistinguishable in the eyes of students in terms of their behaviour. Except for the majority agreeing that mathematicians spend significant amounts of their working time assessing the work of other professionals and making useful discoveries, students generally rated the activities of the two groups in identical categories. There were other minor differences in rank within each category. For example, mathematicians were seen to spend more of their time sitting and thinking than teaching, while users of mathematics (teachers?) did more teaching than sitting and thinking. Professional mathematicians, most of whom are in universities, would probably disagree with this assessment of their work, and both teachers and university mathematicians would most likely agree that the students had underestimated the amount of time spent doing administration.

This is not surprising, in that the students' only direct role models for users of mathematics as defined are likely to have been the teachers of mathematics whom they have encountered at school. The students' image of a mathematician as a creator or discoverer of mathematics who sits and thinks is not an unreasonable inference and allows students to perceive minor differences from the role models with which they are familiar. Where else might they gain direct information about mathematicians? Certainly mathematicians do not have a high public profile, and for users of mathematics apart from teachers the mathematics they do tends to be subsumed in other aspects of their work, as noted earlier.

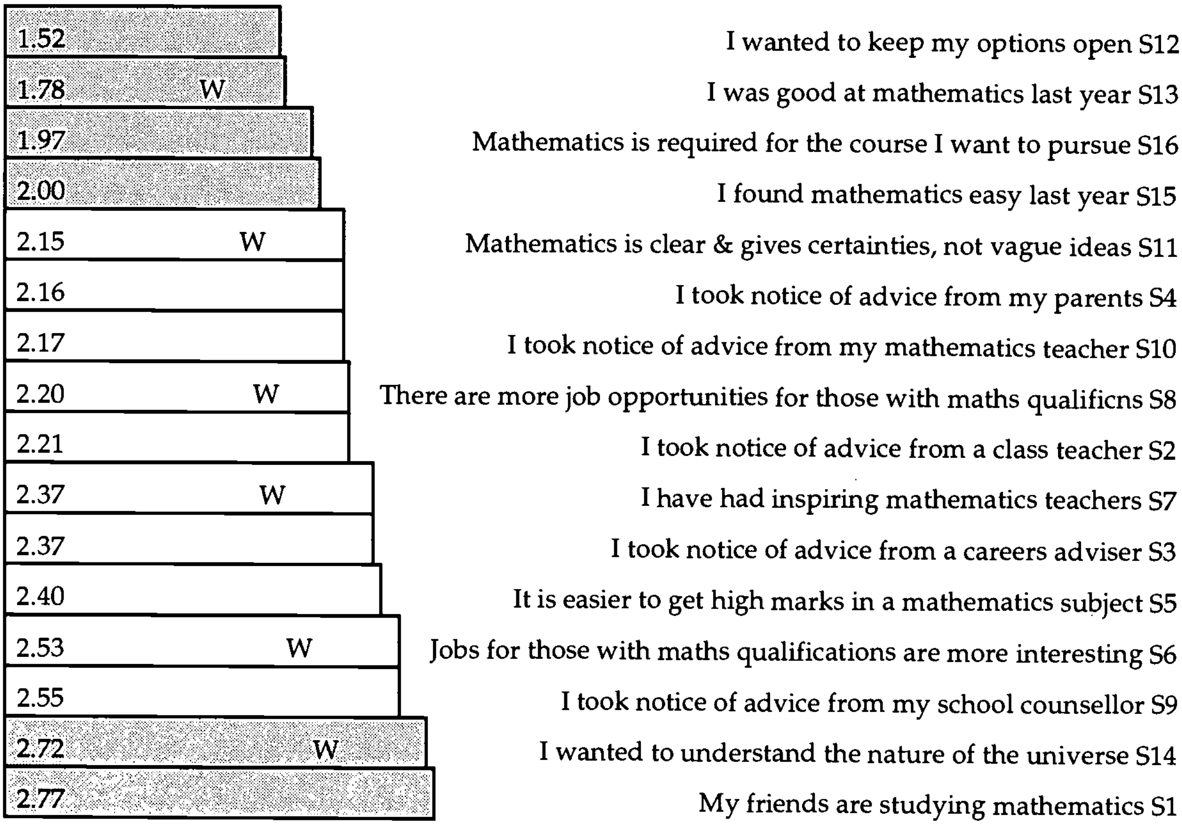
Given that mathematics teachers are immediate role models of users of mathematics, it could help their image if they were more up-front with students about their own professional lives and the part that mathematics plays in it. Just as Music departments in schools expect all their members to be practising music in some way themselves in their out of school lives, perhaps Mathematics departments should be encouraging their members to do mathematics themselves in ways beyond the classroom.

Students seem to view both mathematicians and users of mathematics as somewhat cloistered individuals who, except for their teaching and professional responsibilities, are computer-tied and office-bound with little contact with the wider community and not very concerned with social issues. This image may explain why students tended not to associate mathematics with legal or environmental studies, although it could also point to a problem with the lack of stochastic applications to social issues areas in the curriculum. (In South Australia, chance and data topics are greatly underrepresented in Year 12 subjects. They are found in the SAS mathematics subjects, particularly in Quantitative Methods, a subject in which social issues might be raised, but the few schools teaching Quantitative Methods were not included in the survey. Contrary to world-wide trends, chance and data are not included in PES mathematics subjects.)

While the actual amount of time spent by mathematicians and users travelling might be small, students have probably underestimated the extent to which time is taken for example travelling to conferences and workshops as part of the "job". All in all, students appear to have a limited view not only of the career opportunities for practitioners of mathematics but also of their roles as professional people.

6.10 Reasons for choosing to study mathematics

The following graph presents the ranking of student responses in order of the mean, calculated from assigning values of "Strong Influence" = 1, "Some Influence" = 2 and "Little or no Influence" = 3 on a three point scale. W indicates items which replicate items in the Warwick Study. The first four shaded elements in the graph correspond to the statements which at least two-thirds of the students nominated as a "Strong Influence" on their choice to study mathematics; the last two indicate statements which at least two-thirds of students nominated as of "Little or no Influence".



It is evident from looking at individual student responses that for most students, more than a few factors have influenced their choice to varying extents. The mean value of the responses disguises both the spread of the responses and the shape of the response distribution. In order to gain a more comprehensive view of the response pattern, the responses to "Strong Influence" and "Some Influence" were combined to identify factors which influenced students at least to "some" extent. The result of this is shown in Table 6.10 below.

Whereas the first four factors ranked by mean correspond to the same first four in terms of percentage of students rating them as a strong influence, conflating the "Strong" with the "Some" responses changes the order of ranking. *I took notice of advice from a class teacher* is now ranked third, indicating that there was a strong support from the students for class teachers as "Some Influence"; in fact, 53% responded this way. The factor *I took notice of advice from my mathematics teacher* only narrowly missed the two-thirds criterion, with 65% of students claiming "Strong" or "Some" influence, while *Mathematics is required for the course I want to pursue* (64%) and *I took notice of advice from my parents* (63%) also rated close behind.

By far the least influential factors are *My friends are studying mathematics* and *I wanted to understand the nature of the universe* both of which were rated lowest of the strong influences (4% and 8% respectively) and highest of the little or no influences (81% and 80% respectively). *I took notice of advice from my school counsellor* was rated by only 8% of students as a strong influence.

Table 6.10: Distribution of responses showing % of nomination of factors influencing student choice to study mathematics (responses within each row are listed in decreasing order of frequency of agreement from left to right)

	≥66%	50 - 65%	33 - 49%
Strong influence	-	S12	S13 S16 S15
Some + strong influence	S12 S13 S2 S15	S10 S16 S4 S11 S8S3	S7 S5 S9 S6
Some influence	-	S2	S10 S4 S3 S8 S11
Little or no influence	S1 S14	S6 S9 S5 S7	S3 S8 S11 S4 S10 S15

Comparison of responses from various attribute subgroups revealed the following significant differences:

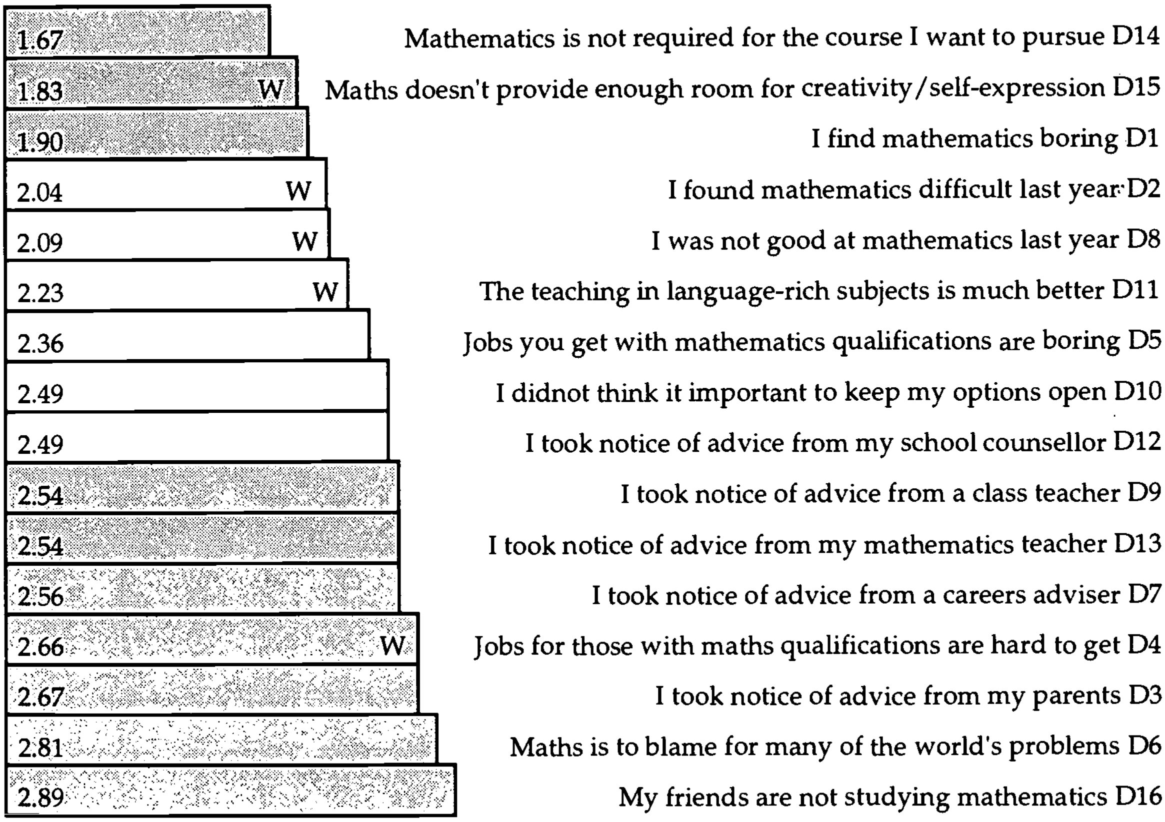
- higher achieving students are more strongly influenced than lower achieving students to study mathematics because mathematics is required for the course they want to pursue, they found mathematics easy last year, they were good at mathematics last year, it is easier to get high marks in a mathematics subject, mathematics is clear and gives certainties not vague ideas, and they had inspiring mathematics teachers. They were less strongly influenced by wanting to keep their options open or taking notice of advice from a parent or teacher.

- students in independent schools are more likely than students from state schools to be influenced by taking advice from a class teacher, although for state school students class teachers are more likely to be a strong influence or of little or no influence. Further, independent school students are less likely to be influenced by the belief that there are more job opportunities for those with mathematics qualifications or because they have had inspiring mathematics teachers.

- students in country schools are more strongly influenced than those from city schools by taking notice of advice from their class teacher, a careers adviser, a school counsellor or their mathematics teacher.

6.11 Reasons for choosing not to study mathematics

As above, these are in rank order of the means (shown) of responses, calculated from assigning values of "Strong Influence" = 1, "Some Influence" = 2 and "Little or no Influence" = 3 on a three point scale. W indicates items which replicate items in the Warwick Study. The first three shaded elements in the graph correspond to the statements which at least two-thirds of the students nominated as a "Strong Influence" on their choice to study mathematics; the last seven indicate statements which at least two-thirds of students nominated as of "Little or no Influence". Items included in the scale for the most part have corresponding items in the Reasons for choosing to study mathematics scale (S1–S16).



Conflating "Strong Influence" and "Some Influence" responses as above produces only a minor change of rank order of the most influential factors. The factor *I found mathematics difficult last year* narrowly missed the two-thirds criterion, with 63% of students indicating strong or some influence.

Table 6.11: Distribution of responses showing % of nomination of factors influencing student choice not to study mathematics (responses within each row are listed in decreasing order of frequency of agreement from left to right)

	≥66%	50 - 65%	33 - 49%
Strong influence	-	D14	D15 D1,8
Some + strong influence	D14 D1 D15	D2 D8 D11	D5 D12 D10
Some influence	-	-	-
Little or no influence	D16 D6 D4 D3 D9 D7,13	D10 D12 D5 D11	D8 D2

The only statistically significant differences among attribute subgroups were these:

- students who intend to go to university are more likely than those who don't to give as a reason for not studying mathematics that *Mathematics is to blame for many of the problems of the world.*

- lower achieving students are more likely than high achieving students to have dropped mathematics because they were not good at mathematics last year or because they found mathematics difficult.

6.12 Discussion: reasons for choosing to study or not to study mathematics

6.12.1 The Major Reasons

The only factor which rates consistently as a major influence on choice to study or not to study mathematics is whether or not the subject is required for a course the student wishes to pursue, that is, whether mathematics of some kind is a prerequisite for further study. Thus there is a strong influence on students to choose to do mathematics if it is needed for further study and to drop it if it is not needed. The only factor which rates consistently as of little or no influence is whether friends are studying or not studying mathematics. Students almost never do mathematics, or give it up, just to be with friends.

The need to keep options open is the major factor influencing student choice to continue with mathematics and is closely related to whether the subject is needed or might be needed to maintain choice of study or career pathways. Another group of factors with a significant influence on student choice is whether the student finds mathematics easy or difficult or whether the student was good or not good at mathematics. These results are consistent with those of previous research by Jones (1988) and Johnston (1994).

6.12.2 Taking Notice of Advice

Class teachers, mathematics teachers and parents seem to have a moderately strong influence on students' decision to choose mathematics but have little influence on a decision to drop it. This suggests that students who choose not to study mathematics may be doing so against advice given to them because of the stronger influence of factors such as not needing it, finding the subject hard, boring and uncreative, being not good at it and finding the teaching uninspiring. Their reasons are more focussed than those given by students who are studying mathematics; seven of the factors in the list provided were rated as of little or no influence for these students, as against only two of the factors for the mathematics students.

Taking notice of advice from careers advisers or school counsellors is not very highly rated by either the mathematics or the non-mathematics students as influencing their decisions about mathematics. Does this mean that advice was given, but was less influential than advice from other sources, or does it mean that counsellors /advisers are not taken too seriously or is there some question about the quality of the service or advice provided? One possible contributing factor here is the amount of unclear information about pathways provided by universities and TAFE institutes for students regarding prerequisite or assumed mathematical knowledge required to pursue various study. It has been a common complaint among secondary school students that advice provided in careers literature is inadequate as a basis for making decisions about what choices to make regarding mathematics subjects in Years 11 and 12. This may help to explain why "keeping options open" is so significant a factor in choosing to continue with mathematics; if you don't know what mathematics you will need, you continue with as much mathematics as is tolerable.

6.12.3 Choice and Ability

Those who are good at mathematics continue with mathematics for fairly obvious reasons: not only do they find it easier to succeed in but they also do not require as much prompting from parents and teachers to stick with it. They tend to find the clarity and certainty of mathematics appealing and are more likely to acknowledge that inspirational teachers are a factor in their choice to continue with mathematics. Whether or not they make use of mathematics for study purposes beyond secondary school, their ability to do mathematics will contribute to a TER which may guarantee entrance to a tertiary institution, and since mathematics is considered to be a "hard" subject, this can give them confidence to succeed in other subjects in the curriculum. The less able students, however, have to be "encouraged" to keep doing mathematics "just in case", or they decide that the reasons for continuing are not compelling enough to overcome their negative views and experiences of the subject and they drop it.

6.12.4 Choice and Type of School

The social climate of school appears to have a role in student choice about mathematics. Why is it that in independent schools advice from a class teacher is more influential than in state schools, and why do country school students take more notice of advice from teachers, advisers, counsellors and parents than do city school students? In the case of country schools, the situation may be a product of the generally smaller size of the school or the greater sense of community that usually prevails as a product of their relative isolation from academic and other support services. One simple explanation is that in country secondary schools often the class teacher, mathematics teachers and careers adviser roles may be undertaken by the same person who works closely with parents and fellow teachers, so that the sources of advice may be concentrated significantly and in a consistent way. In the case of independent schools, it may be that class teachers take on a more significant pastoral role than those in state schools and are thus more likely to provide advice which students will follow.

6.12.5 Choice and Perception of Mathematics

One of the major reasons given for students choosing not to study mathematics is that *Mathematics doesn't provide enough room for creativity and self-expression.* 68% of the non-mathematics students stated that this had a strong or some influence on their decision to drop mathematics. Given that in Year 11 mathematics, students are normally given opportunities to undertake directed investigations and projects which provide some room for both creativity and self-expression (perhaps not enough), this statement may be more of a rationalisation than a reason for some students. Since 60% of all students believe that there's not enough creativity in Year 12 mathematics, this may in fact reflect a general *cri de coeur* about the emphasis on tests and examination preparation which generates pressure to cover the syllabus. This permits little time for creativity in Year 12, and where schools view Year 11 as the preparation for the demands of Year 12, there may be little evidence of it in Year 11. It could also indicate a preference by students for language-rich/artistic/humanities subjects over quant- itative/experimental subjects: 50% of the non-mathematics students stated that higher quality of teaching in language-rich subjects was influential in their decision to discontinue with mathematics.

Given that 51% of the mathematics students were influenced to choose to study mathematics because *Mathematics is clear and gives certainties, not vague ideas* , a position which is normally associated with the "hard" sciences, there appears to be an important issue here about the nature of mathematics courses offered at Year 12 (and possibly earlier). The 58% of all students who are enrolled in PES Mathematics subjects, which are essentially pure mathematics, are not being exposed to material which deals with social issues or related areas requiring creativity, self-expression or, for that matter, applications. It has been noted earlier that this gives students an unbalanced view of mathematics and mathematicians as regards their relationship with the community and the wider society. The inclusion of social applications and some activity involving investigations and projects in Year 12 mathematics (which to some extent occurs in the subject Quantitative Methods, students of which were not involved in this survey) might be considered as part of the solution to this problem. A higher profile for probability & statistics and computer software applications packages could also feature, although a case could also be made for the inclusion of problem solving and aspects of the history of mathematics as a way of humanising the mathematics curriculum at this level.

6.13 What happens in mathematics classes in Years 11 and 12 (homework)

See Section 6.5 for related data.

The following table indicates the frequency with which homework is assigned. This question was also asked as part of the TIMSS Study.

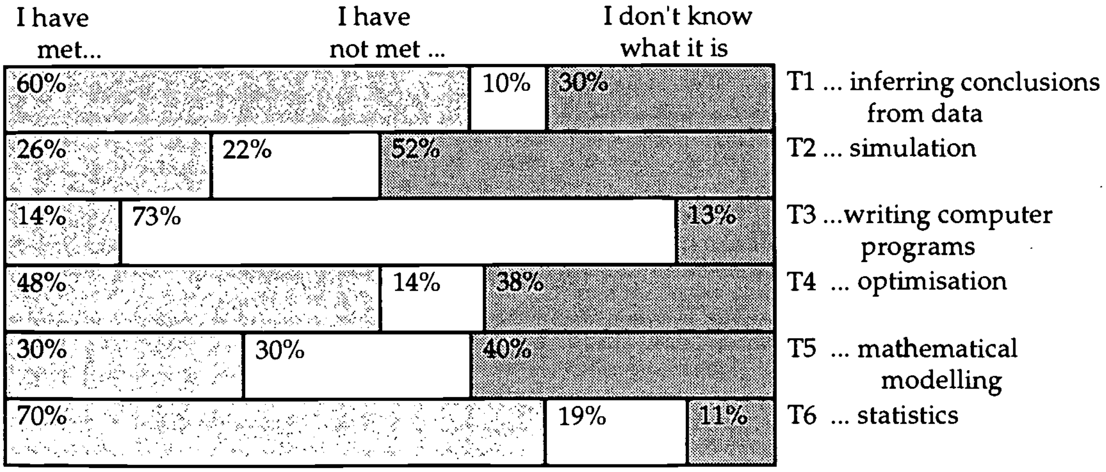
Table 6.13: The frequency with which homework is assigned in mathematics subjects at Year 12

		f	%
Never	[1]	22	5.6
less than once per week	[2]	13	3.3
once/twice per week	[3]	51	13.0
three/four times per week	[4]	126	32.2
every day	[5]	135	34.4
no response/missing		46	11.8

Note: N = 393, but 60 of these were not doing Year 12 in 1997
Mean = 3.98

6.14 What mathematical techniques have you met this year or last year?

Students were asked to indicate which of the following mathematical techniques they had met in mathematics classes *or other places* during the year or the previous year. The results are given as rounded percentages of students nominating each category.



Since writing computer programs (T3) is not normally part of mathematics courses, it is not surprising that it is unfamiliar to the great majority of Year 12 students in this study. Whether this is a positive thing is a matter for debate. Certainly mathematical explorations and investigations can be enhanced where students are able to write simple programs, for example, in BASIC or Pascal (Stevenson, 1992).

The high rating for statistics (T6) and inference from data (T1) suggests that students are being widely exposed to these ideas somewhere. Students of SAS Mathematics would probably have met statistical ideas explicitly in Year 11, and all students would have met descriptive statistics in some form prior to Year 11. But because Business Mathematics and Quantitative Methods are the only Year 12 subjects where statistics is substantially taught, and few students would have taken statistics components at Year 11, it is probably a fair assumption that what students recognise as statistics is rather elementary. The best that can be said is that they are aware of statistics and statistical ideas.

The low incidence of contact with simulation (T2), optimisation (T4) and mathematics modelling (T5) reflects the absence of Quantitative Methods students in the survey and the infrequency of students' exposure to components in the Year 11 course containing these techniques (such as statistical trends, networks and simulation). If it is accepted that such techniques and concepts are fundamental to an understanding of modern mathematics, then this result provides evidence that there is an important gap to be filled in students' mathematical background.

6.15 Questions taken from the TIMSS Study

It has not been possible to carry out comparisons of these data with those of the TIMSS Study, as the detailed results of TIMSS were not available at the time of compiling this report.

6.15.1 TIMSS: What happens in mathematics classes:

In the following table, cells contain percentages of students responding with each item frequency. The modal response for each item has been highlighted.

Item	Mean	Never	Almost never 1	Some lessons 2	Most Lessons 3	Every Lesson 4	No Response 5
C2	2·78	12·5	23·9	38·9	15·5	5·1	4·1
C3	4·2	1·5	5·1	14·5	28·0	44·8	6·1
C5	3·15	7·1	15·3	43·5	19·8	9·9	4·4
C6	3·08	7·6	19·3	36·1	24·2	8·7	4·1
C7	3·35	10·9	9·4	32·1	26·5	16·5	4·7
C9	2·45	24·9	24·7	29·5	13·2	3·8	3·9
C10	2·34	23·9	30·5	29·8	9·2	1·8	4·9

The items referred to are:

C2	We are asked to explain the reasoning behind the mathematics.
C3	We solve equations.
C5	We study problems which do not have an obvious method of solution.
C6	We memorise rules and procedures.
C7	We copy notes from the board.
C9	We practise computational skills.
C10	We apply models to data.

6.15.2 *TIMSS: Opinions about mathematics*

In the following table, percentage response to each item is given for each category of agreement. The modal response in each case has been highlighted.

Success in mathematics requires... (expressed as %)		Mean	SA 1	A 2	D 3	SD 4	?
...hard work studying at home	M5	1·95	31·6	46·1	18·6	3·3	0·6
...memorising texts & notes	M13	2·95	3·6	22·6	47·8	25·2	0·8
...good luck	M22	3·25	3·8	11·7	42·5	41·0	1·0
...lots of natural ability	M2	2·45	12·5	41·2	38·4	6·4	1·6

6.16 Questions taken from the Warwick Study

Comparisons of the following data have not been possible with data from the original Warwick study because of the way in which the Warwick data were collected. However, some generalisations could be made in due course. They are included here for identification purposes. The modal responses are highlighted.

6.16.1 *Warwick: Opinions about Mathematics (total sample)*

(Expressed as %)	Mean	SA 1	A 2	D 3	SD 4	?
M6	2·63	8·4	32·1	49·6	7·9	2·1
M8	3·28	2·8	8·4	47·3	40·5	1·1
M11	2·81	2·8	34·9	46·1	11·7	4·7
M16	2·33	15·8	44·0	32·1	4·6	3·5
M21	3·15	7·6	11·5	40·7	39·4	0·9
M24	3·10	2·3	13·0	57·8	24·7	2·3

The items referred to are:

M6 There are more jobs for people with mathematics qualifications.

M8 People who study mathematics are uncultured.

M11 People who study mathematics are unconventional.

M16 There's not ehough room for creativity in Year 12 Mathematics.

M21 People who study mathematics are dull.

M24 Jobs for those with mathematics qualification are more interesting.

7. SUMMARY & IMPLICATIONS

7.1 Major Findings

The survey was conducted in response to the perceived problems of growing non-participation rates of students in mathematics courses particularly at Year 12 and beyond, and the decline in skill levels of students in science and mathematics entering tertiary courses. It goes without saying that any attempts to improve the quality of teaching and learning, the quality of teachers and the resources they use, and the levels of interest and motivation among students by offering curricula more appropriate to their needs ought to be rewarded with a positive response to studying mathematics. However, the cause of the problem goes much deeper. There are worrying signs that mathematics has been devalued by society and the education system, one effect of which has been the decreased amount of time devoted to mathematics in the secondary curriculum which, combined with other factors, has led to a decrease in the number of students wishing to continue with mathematics or to pursue careers involving mathematics. **The major consequence is the dearth of students and graduates able to "feed the IT revolution" within the state.**

So, the survey addressed the following questions:

- What factors are most influential on student choices to study or not to study mathematics in Year 12?
- What are students' views about mathematics as a subject of study, as a subject for further study, and as a means of enhancing their employment prospects? What has influenced their views and choices?

The 393 students surveyed came from Year 12 classes in 10 South Australian secondary schools, and provided a sample tolerably representative of the whole Year 12 cohort, including schools which were large/small, urban/rural, state/independent/Catholic, and boys only/girls only/mixed.

The major findings of the survey are as follows:

Choices

- The factors which have the most influence on students' choice to study mathematics at Year 12 are (in order) keeping options open, being good at mathematics last year, requiring mathematics for further study and finding mathematics easy last year. Taking advice from a class teacher was also considered influential by a significant majority of students.

- The factors which have the most influence on students' choice not to study mathematics at Year 12 are (in order) not requiring mathematics for further study, believing that mathematics does not provide enough room for creativity/self-expression and finding mathematics boring.

- **Thus the major factor influencing students' choice to study or not to study mathematics is whether they consider that mathematics is, or may be, needed for further study. For those who do mathematics at Year 12, their ability to do mathematics is the other major factor, while for those who don't, it is the lack of appeal of the subject rather than their inability to do it.**

- Taking notice of advice from class or mathematics teachers was a secondary but moderate influence on students' choice to study mathematics, while taking advice from parents is much less important for students who are not studying mathematics at Year 12 than for those who are. Taking advice from careers advisers and school counsellors was not a significant factor on student choice either way, as was whether or not friends are studying mathematics.

Beliefs

- **Students believe that mathematics is a relatively uncreative subject,** more usefully related to scientific or numerical/financial pursuits than to language-rich or humanistic/creative ones. It is somewhat connected to computing, and while based on the study of number, space and logic, is only moderately concerned with the study of general relationships. **It is not essential for succeeding in life, but is a necessary stepping stone for most students to future study or careers; that is, it is useful, but more in an instrumental than a practical way.**

- **Students believe that to succeed in mathematics does not require memorising textbooks and notes nor good luck, and see little relationship between mathematics and areas of knowledge dealing with human or social issues.** People who study mathematics are not considered to be dull or uncultured. However students do not accept that jobs requiring mathematics qualifications produce higher status in society nor do they find them more interesting, and they are not particularly attracted to jobs involving higher mathematics as a result of perceptions that they are numerous or better paid.

- **Students believe that there is very little difference between (professional) mathematicians and users of mathematics** (like middle managers and teachers who have normally studied some mathematics at tertiary level and need to be able to use it but in ways which have been developed by others). The only perceived difference is that mathematicians spend a significant amount of their working time assessing the work of other professionals and making new discoveries. What they have in common is their time spent teaching, working in groups to solve problems, sitting and thinking, writing computer programs and working with computer models. Neither group is believed to spend much time dealing with important social issues or travelling.

- **Students have a very limited view of teachers as users of mathematics and of the career opportunities for practitioners of mathematics. They also have a distorted view of mathematicians and users of mathematics, whom they see as somewhat cloistered individuals who, except for their teaching and professional responsibilities, are computer-tied and office-bound with little contact with the wider community and not very concerned with social issues.**

Other

- There is circumstantial evidence to suggest that what students believe about what mathematics is and how it is used in various jobs and careers indirectly influences their choices about any mathematics subjects they enrol in. These beliefs appear to be related to what and how mathematics has been taught to them.

- There were relatively few significant differences among the various subgroups with respect to beliefs and reasons given for studying or not studying mathematics. Level of achievement (higher vs lower) was associated with more differences than any other attribute.

7.2 Implications

It is possible to propose some courses of action which are consistent with the above findings and which ought to make some difference in encouraging students to positively change their views about mathematics and thereby become more disposed to choose to continue with mathematics.

This survey points to three main kinds of problem associated with the issue of studying or not studying mathematics in Year 12:

- **an *information* problem – many students are not adequately informed about the positive values of mathematics and its role in study and careers;**

- **an *image* problem – many students have limited and distorted views of mathematics and those who use it;** and

- **a *curriculum and teaching* problem – many students are not being exposed to appropriate content and methods of mathematics which will better inform their views of the nature and relevance of mathematics.**

The following proposals are an attempt to address those problems in ways in which teachers can make a significant contribution.

- That there are students who have inaccurate perceptions of the mathematical/statistical requirements of higher education courses suggests a **need for clearer pathways to be defined relating school mathematics subjects to specific university and TAFE courses**. This could be achieved by redesigning courses at Year 11 and 12, and by spelling out more clearly the pre-requisites and assumed knowledge for courses at Year 12 and beyond. [*information*]

- Since many students seem unaware of the requirements and advantages of studying mathematics appropriate to a wide range of careers, particularly in the humanities and the social sciences, **more up-to-date and informed advice about career options involving mathematics should be made available to students**. Such advice should be communicated effectively with the aid of credible role models of people working in a variety of careers. [The video *More than Plus and Minus* produced by AAMT is a move in the right direction.]
[*image* and *information*]

- Because there is a significant proportion of students doing mathematics beyond specific expectation,that is,to just keep their options open, the **mathematics courses in which they enrol** (in this sample, mainly Mathematics 1 Single) **should be not only worthwhile exemplars of mathematics in its own right, but should provide students with a view of mathematics as a creative and socially relevant subject**, the study of which will enhance their prospects of an interesting and rewarding career. While this means redesigning Year 12 courses, it would probably mean redesigning Year 11 and possibly Years 8–10 courses as well, so that appropriate pathways and cultural expectations can be defined. [*curriculum and teaching*]

- One positive way to redesign courses would be to introduce topics which include contemporary applications, particularly those relevant to social issues and a variety of career clusters. Suitable topics could include probability and statistics, networks, simulations and computer application packages. There are existing components at Year 11 which already fulfil such a role to some extent. [*curriculum and teaching*]

- Activities suggested by Spangler (1992) can help to clarify and modify students' beliefs about mathematics. She poses a number of questions (pp. 149–151) which students can discuss with a view to teachers' planning instruction and structuring the classroom environment in ways which will develop more enlightened beliefs:

    - "If you were playing 'Password' and you wanted a student to guess the word *mathematics*, what clues would you give? ('Password' clues must be one word and may not contain any part of the word being guessed.)"

- "If given a choice, when solving a problem would you prefer to have (a) one method that works all the time or (b) many methods that work all the time?"

- "Is it possible to get the right answer to a mathematics problem and still not understand the problem? Explain."

- "How do you know when you have correctly solved a mathematics problem?"

- "Describe someone in your class or school who you think is mathematically talented."

- "Can you think of any television characters who are mathematically talented?"

- "Close your eyes and try to picture a mathematician at work. Where is the mathematician? What is the mathematician doing? What objects or instruments is the mathematician using? Open your eyes and draw a picture of what you imagined."

- "What businesses in our town might employ a mathematician? What would the mathematician do?"

These questions could be easily modified to explore other issues and beliefs. [*image*]

7.3 A Final Comment

The results recorded and discussed in this report are not the whole story, but they do shed some new light on the needs of schools and their students, and provide the basis for possible interventions to address the problems of low participation rates and insufficient skill levels in mathematics. In a real sense, this is a progress report in that it represents a preliminary analysis only; there is still much to be done in processing, interpreting and disseminating the data, and drawing implications for action.

Further (comparative) work needs to be done on the results of questions which replicate those used in the Third International Mathematics and Science Study (TIMSS) once the TIMSS results become available. It is proposed also that comparisons will be made between responses of South Australian and U.K. students to those questions adapted from and included in the Warwick study.

It is intended that further more detailed analysis of the data will be undertaken and disseminated where possible and appropriate. Already a series of tightly focussed articles is being prepared in order to make the results more widely known to the mathematics education community and to educational decision-makers. Publication will be sought for these in professional journals and newsletters such as *Australian Mathematics Teacher, Australian Senior Mathematics Journal, Möbius* and *The Mathematics Education Research Journal*, and in conference proceedings of organisations such as AAMT and MERGA.

Copies of this report are being sent to all schools participating in the survey, as well as to education sector authorities and other people and bodies judged to have a vested or potential interest in the outcomes of the survey, in the hope that the results and implications will receive serious consideration and be acted upon.

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Thanks especially to our wives for their support and forebearance, yet again.

Peter Brinkworth
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APPENDIX

a. Background Notes for Teachers: Procedures for Administration

b. The Survey Instrument

a

Procedures for Administration

Thank you for agreeing to help us conduct this survey. We know that schools are very busy places and that teachers have many demands on their time. We have tried to make this survey as simple to administer as possible, and we hope that its findings will be of help in improving mathematics education.

The questionnaire should take about 15 - 20 minutes to administer. Please pass the booklets out to students and ask them not to open them until asked. Then read the following paragraphs to them.

> This class has been asked to assist some people from Adelaide's three universities to find out more about students' appreciation of mathematics. The results will be used to make suggestions about how mathematics might be best presented in schools and tertiary institutions. Please help these people by doing your best to answer the questions clearly and accurately.
>
> On the first page you will be asked to provide some information about yourself. Your names are not required, and the information you give will not be made public nor told to me or other members of the staff here. I will place your responses directly into this envelope after you have finished and post them to the organisers without reading them myself.
>
> In some cases you are asked to provide specific information by filling in a box, or writing on a dotted line. In other cases you will be asked to place a circle around *one* of a number of different possibilities. Please read all the possibilities before replying and make your answers as clear as possible. If you make a mistake, just make a clear correction, perhaps by writing a note to explain what you meant to say. In some questions there are square brackets which will be used by the organisers to code your answers. Please do not write in these brackets. If you do not want to answer any question, leave it and go on to the next one. If you finish early shut your booklet ands wait till the others have finished.
>
> Are there any questions? ... Please start filling out your answers now.

The questionnaire is straight-forward, so you should have no trouble in helping students with difficulties. It is the students' responses we want, so if they need help from you to make them clear, then that is quite all right.

When everyone has finished, please collect the papers and place them in the reply paid envelope provided and seal the envelope in front of the class. Please thank the class on your behalf and on behalf of the organisers. Then post the envelope to the organisers later the same day. Thank you for your co-operation. We shall send you our findings in a few weeks time.

Peter Brinkworth
John Truran

This survey is being conducted under the auspices of the Flinders University of South Australia in co-operation with the Adelaide Consortium for Mathematics Education.

A SURVEY ABOUT MATHEMATICS

Please wait until you have been given instructions before opening this booklet.

School ....

Group ....

Date ....

Thank you for answering this questionnaire.
Your answers will remain confidential.
They will help us to understand how students feel about mathematics.

How to Answer these Questions

Two Examples

Most of your answers will be entered directly into a computer. To help us do this quickly please answer the questions in the ways requested.

There are two main types of questions. One gives you a set of possibilities and asks you to circle one of the numbers. Put you circle around the number, not the description in this way

1. What *one* of the following best describes the way you usually travel to school in the morning? Place a ring around one matching number only.

car	[1]
public transport	[✓ [2]]
Bicycle	[3]
other, please specify	
....	[ ]

If our options do not match your situation then write a brief description in the "other, please specify" space, and we will code your response in the square bracket.

The other type asks you to select a level of agreement with various statements.

Circle one letter only

	Strongly Agree	*Agree*	*Disagree*	*Strongly Disagree*	*Don't Know*
2. The weather forecasts provided on the television each evening are usually correct.	1	2	[✓ 3]	4	5

Notice that in some cases there is a "Don't Know" option so that you do not have to express opinions about ideas which you do not know about.

Personal Details

P1. In which year were you born? 19______

P2. Are you male or female?

Male	[1]
Female	[2]

P3. What is the postcode of your usual home address? (If you are boarding away from home we do not want that postcode.) If your home is not in Australia, write the country where your home is.

☐

P4. Are you in Year 12 or Year 13 or a mature age student?

Mature age	[1]
Year 13	[2]
Year 12	[3]

P5. What is the highest Year level in school that you have studied mathematics in? **Include this year.** So if you are doing mathematics this year, write "Year 12" or "Year 13".

Year ☐

P6. Which of the following words best describes your mathematics achievement so far? Place a ring around one matching number only.

excellent	[1]
above average	[2]
average	[3]
just a pass	[4]
poor	[5]

P7. What grade and/or mark did you get for your *last* end of term assessment in *mathematics*? If you did more than one mathematics subject, choose the one in which you did best. Place a ring around the appropriate letter, or fill in the two boxes. If you were given a letter grade and a numerical grade, then please give both of them.

Grade A B C D E Fail

Mark ☐ out of a maximum possible score of ☐

If your grade was given in a different way, please write it here. (The square brackets at the end are for our coding purposes. Do not write inside these brackets.)

....

.... [ ]

P8. Please give the exact name of *all* the subjects you are studying this year and place a ring around whether they are PES, PAS or SAS subjects. If you do not know which type they are then do not ring any of them. The brackets at the end are for our coding purposes. Do not write inside these brackets.

1. .... PES PAS SAS [ ]
2. .... PES PAS SAS [ ]
3. .... PES PAS SAS [ ]
4. .... PES PAS SAS [ ]
5. .... PES PAS SAS [ ]
6. .... PES PAS SAS [ ]
7. .... PES PAS SAS [ ]

P9. Please list those *mathematics* subjects which you are studying for a second time in Year 12/13.

1. .... PES PAS SAS [ ]

2. .... PES PAS SAS [ ]

P10. What *one* of the following are you likely to be doing next year? Place a ring around one matching number only.

work	[1]
study	[2]
work & study	[3]
other, please specify	
....	[ ]

P11. If you will be studying next year what type of institution do you hope to enrol in? Place a ring around one matching number only.

School	[1]
TAFE	[2]
University	[3]
Don't Know	[4]
other, please specify	
....	[ ]

If you do intend to study in the future (either next year or later) please answer questions P12 - P15 on page 7.

If you do not intend to study ever again, please go to Question M1 on page 8.

Questions P12 - P15 are for those who intend to study in the future (which might be next year or might be after a break to do other things).

P12. In your *next* year of study (next year or later) do you expect to be studying any statistics course? Place a ring around the matching number.

Yes	[1]
No	[2]

P13. In your *next* year of study do you expect to be studying any mathematics course apart from statistics? Place a ring around the matching number.

Yes	[1]
No	[2]

P14. In your *next* year of study do you expect to be studying any science or technology type courses apart from mathematics and/or statistics? (Science/applied science type courses would include subjects like physics, chemistry, biology, geology, computing, but not arts/social science type courses like economics or geography.) Place a ring around the matching number.

Yes	[1]
No	[2]

P15. Do you believe that careers are available for people who graduate from a university with a major study in mathematics?

Yes	[1]
No	[2]

Opinions about Mathematics

In the section below we list a number of statements which are sometimes made about mathematics. You are asked to state whether you

- strongly agree,
- agree,
- disagree, or
- strongly disagree

Take time to consider each statement carefully and then place a ring around the number in the column which most closely corresponds to your opinion.

Circle one number only

		Strongly Agree	*Agree*	*Disagree*	*Strongly Disagree*
M1.	Mathematics is useful for understanding chance.	1	2	3	4
M2.	It is important to discuss mathematics with others to clarify your thinking.	1	2	3	4
M3.	The study of geometry is an important part of mathematics.	1	2	3	4
M4.	The best way to learn mathematics is by working through exercises.	1	2	3	4
M5.	To succeed in mathematics requires hard work studying at home.	1	2	3	4
M6.	There are more jobs for people with mathematics qualifications	1	2	3	4
M7.	Mathematics is useful for understanding computers.	1	2	3	4
M8.	People who study mathematics are uncultured.	1	2	3	4
M9.	Mathematics is useful for understanding the Internet.	1	2	3	4
M10.	Jobs for those with mathematics qualifications produce higher incomes.	1	2	3	4
M11.	People who study mathematics are conventional.	1	2	3	4
M12.	The study of counting is an important part of mathematics.	1	2	3	4
M13.	To succeed in mathematics requires memorising textbooks and notes.	1	2	3	4
M14.	Computers are essential for learning mathematics nowadays.	1	2	3	4

Circle one number only

	Strongly Agree	*Agree*	*Disagree*	*Strongly Disagree*
M15. Without mathematics you can't solve simple problems.	1	2	3	4
M16. There's not enough room for creativity in Year 12 mathematics.	1	2	3	4
M17. The study of general relationships is an important part of mathematics.	1	2	3	4
M18. Mathematics is useful for understanding economics.	1	2	3	4
M19. Mathematics is useful for understanding literature.	1	2	3	4
M20. Mathematics is useful for understanding legal studies.	1	2	3	4
M21. People who study mathematics are dull.	1	2	3	4
M22. To succeed in mathematics requires good luck.	1	2	3	4
M23. The study of logic is an important part of mathematics.	1	2	3	4
M24. Jobs for those with mathematics qualifications are more interesting	1	2	3	4
M25. You don't need mathematics to solve everyday problems well.	1	2	3	4
M26. You can either do mathematics or you can't.	1	2	3	4
M27. Jobs for those with mathematics qualifications produce higher status in society.	1	2	3	4
M28. Mathematics is useful for understanding science.	1	2	3	4
M29. To succeed in mathematics requires lots of natural ability.	1	2	3	4
M30. Mathematics is useful for understanding environmental issues.	1	2	3	4
M31. Success in mathematics can be gained by learning its basic rules.	1	2	3	4
M32. Mathematics is useful for understanding information technology.	1	2	3	4
M33. Mathematics is essential for succeeding in life.	1	2	3	4

Opinions about Users of Mathematics

In the section below we list a number of statements which are sometimes made about the work of *users* of mathematics, like middle managers and teachers. Such people have normally studied some mathematics at tertiary level and need to be able to use it, but in ways which have been developed by others. Once again, you are asked to state your level of agreement. In this case there is an other option available—Don't Know. Please use this option where appropriate.

Users of mathematics spend a significant amount of their working time ...

Circle one number only

		Strongly Agree	*Agree*	*Disagree*	*Strongly Disagree*	*Don't Know*
U1.	communicating results to the community.	1	2	3	4	5
U2.	dealing with important social issues.	1	2	3	4	5
U3.	travelling.	1	2	3	4	5
U4.	writing computer programs.	1	2	3	4	5
U5.	doing administration.	1	2	3	4	5
U6.	sitting and thinking.	1	2	3	4	5
U7.	working in groups to solve problems.	1	2	3	4	5
U8.	assessing the work of other professionals.	1	2	3	4	5
U9.	making useful new discoveries.	1	2	3	4	5
U10.	earning a large salary.	1	2	3	4	5
U11.	influencing community decisions.	1	2	3	4	5
U12.	working with computer models.	1	2	3	4	5
U13.	teaching.	1	2	3	4	5

U14. Other (please specify)

....

.... [ ]

Opinions about Mathematicians

In the section below we present similar statements which are sometimes made about the work of professional mathematicians.

Professional mathematicians spend a significant amount of their working time …

Circle one number only

		Strongly Agree	*Agree*	*Disagree*	*Strongly Disagree*	*Don't Know*
A1.	communicating results to the community.	1	2	3	4	5
A2.	dealing with important social issues.	1	2	3	4	5
A3.	travelling.	1	2	3	4	5
A4.	writing computer programs.	1	2	3	4	5
A5.	doing administration.	1	2	3	4	5
A6.	sitting and thinking.	1	2	3	4	5
A7.	working in groups to solve problems.	1	2	3	4	5
A8.	assessing the work of other professionals.	1	2	3	4	5
A9.	making useful new discoveries.	1	2	3	4	5
A10.	earning a large salary.	1	2	3	4	5
A11.	influencing community decisions.	1	2	3	4	5
A12.	working with computer models.	1	2	3	4	5
A13.	teaching.	1	2	3	4	5

A14. Other (please specify)

....

.... [ ]

Note Carefully

If you are studying mathematics *this year* go to question S1 on p. 12.

If you are not studying mathematics *this year* go to question D1 on p. 13.

Reasons for Studying Mathematics

If you are currently studying a mathematics subject answer questions 101 to 117. If not, go to questions 121 - 135 on p. 13.

Please indicate which of the following factors helped to influence you in enrolling for the mathematic course you are now studying. Place a ring around one of the numbers for each of the following possible reasons.

		Circle one number only		
		Strong Influence	*Some Influence*	*Little or no Influence*
S1.	My friends are studying mathematics.	1	2	3
S2.	I took notice of advice from a class teacher.	1	2	3
S3.	I took notice of advice from a career adviser.	1	2	3
S4.	I took notice of advice from my parents...	1	2	3
S5.	It is easier to get high marks in a mathematics subject.	1	2	3
S6.	Jobs for those holding mathematics qualifications are more interesting.	1	2	3
S7.	I have had inspiring mathematics teachers.	1	2	3
S8.	There are more job opportunities for those with mathematics qualifications.	1	2	3
S9.	I took notice of advice from my school counsellor.	1	2	3
S10.	I took notice of advice from my mathematics teacher.	1	2	3
S11.	Mathematics is clear and gives certainties, not vague ideas.	1	2	3
S12.	I wanted to keep my options open.	1	2	3
S13.	I was good at mathematics last year.	1	2	3
S14.	I wanted to understand the nature of the universe.	1	2	3
S15.	I found mathematics easy last year.	1	2	3
S16.	Mathematics is required for the course I want to pursue.	1	2	3

S17. Other (please specify)

....

.... [ ]

Please omit the next section and go to question C1 on page 14.

Reasons for Not Studying Mathematics

Please indicate which of the following factors helped to influence your decision not to enrol in a mathematics course this year. Place a ring around one of the numbers for each of the following possible reasons.

Circle one number only

		Strong Influence	*Some Influence*	*Little or no Influence*
D1.	I find mathematics boring.	1	2	3
D2.	I found mathematics difficult last year.	1	2	3
D3.	I took notice of advice from my parents.	1	2	3
D4.	Jobs for those holding mathematics qualifications are hard to get.	1	2	3
D5.	The jobs you can get with a mathematics qualification are boring.	1	2	3
D6.	Mathematics is to blame for many of the problems of our world.	1	2	3
D7.	I took notice of advice from a career adviser.	1	2	3
D8.	I was not good at mathematics last year.	1	2	3
D9.	I took notice of advice from a class teacher.	1	2	3
D10.	I did not think it important to keep my options open.	1	2	3
D11.	The teaching in language-rich subjects is much better.	1	2	3
D12.	I took notice of advice from my school counsellor.	1	2	3
D13.	I took notice of advice from my mathematics teacher.	1	2	3
D14.	Mathematics is not required for the course I want to pursue.	1	2	3
D15.	Mathematics does not provide enough room for creativity and self-expression.	1	2	3
D16.	My friends are not studying mathematics.	1	2	3

D17. Other (please specify)

....

.... [ ]

Mathematics Classes

In this section we make some statements about what happens in your mathematics classes. If you are not studying mathematics this year, please answer in terms of your most recent mathematics classes. this year.

		Circle one number only				
		Never	*Almost Never*	*Some Lessons*	*Most Lessons*	*Every Lesson*
C1.	Relationships between variables are presented to us using tables, charts or graphs.	1	2	3	4	5
C2.	We are asked to explain the reasoning behind the mathematics.	1	2	3	4	5
C3.	We solve equations....................	1	2	3	4	5
C4.	We write equations to represent relationships.	1	2	3	4	5
C5.	We study problems which do not have an obvious method of solution.......................................	1	2	3	4	5
C6.	We memorise rules and procedures.	1	2	3	4	5
C7.	We copy notes from the board..	1	2	3	4	5
C8.	The reasoning behind the mathematics is explained to us.	1	2	3	4	5
C9.	We practise computational skills.	1	2	3	4	5
C10.	We apply models to data.	1	2	3	4	5

C11. How often is mathematics homework assigned to you? Place a circle around your answer.

Never	[1]
Less than once a week	[2]
Once or twice a week	[3]
Three or four times a week	[4]
Every day	[5]

Mathematical Techniques

Which of the following mathematical techniques have you met in mathematics classes *or other places* during this year or last year?

T1. Inferring conclusions from data

Met	[1]
Not met	[2]
Don't know what it is	[3]

T2. Simulation

Met	[1]
Not met	[2]
Don't know what it is	[3]

T3. Writing computer programs

Met	[1]
Not met	[2]
Don't know what it is	[3]

T4. Optimisation

Met	[1]
Not met	[2]
Don't know what it is	[3]

T5. Mathematical modelling

Met	[1]
Not met	[2]
Don't know what it is	[3]

T6. Statistics

Met	[1]
Not met	[2]
Don't know what it is	[3]

There is space on page 16 for you to make any other comments you would like to add.

Any Other Comments

Please feel free to tell us any other views which you have on mathematics, its use, or its teaching..

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