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ABSTRACT

This bulletin discusses the mathematics and science course enrollment trends of secondary students in Australia, which are of national concern because of the low participation rates overall and because of the gender imbalance in enrollment numbers. Statistics are reported for 12th-grade mathematics and science course enrollment, and expectations and solutions are discussed. Among the recommendations are for teachers and educators to faciitate and help devise strategies that will increase participation in science and mathematics and to increase the mathematical ability of Australia's secondary school students. (MKR)

What Research Says to the Science and Mathematics Teacher

National Key Centre for School Science and Mathematics Number 12

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SECONDARY SCIENCE AND MATHEMATICS ENROLMENT TRENDS

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MOST SCIENCE and mathematics teachers throughout Australia would be aware of changes in the enrolment patterns of upper secondary students over the past decade which are now affecting both the size of their classes and the balance of male and female students. However the *magnitude* of these changes could well have escaped the attention of many teachers. Enrolment patterns in science and mathematics in Australia currently are of national concern because of the low overall participation rates in these subjects and because of the gender (im)balance in enrolment numbers. On the other hand, the number of students enrolling in certain science and mathematics subjects at the upper school level is encouraging.

The overall enrolment patterns are encouraging because they reflect a response to the specific initiatives of Australian curriculum developers to introduce programs that are more relevant to students than they have been in the past, and which enable students to cope with, and contribute to, a society that is becoming increasingly technologically oriented. Every State and Territory in Australia has introduced new mathematics and science curricula which have been designed to provide relevant subjects focussed upon the various levels of student ability and interest (Australian Science and Technology Council, 1987).

We have collected the most comprehensive data base currently available relating to enrolment patterns in upper school science and mathematics in Australia (Dekkers, de Laeter & Malone, 1991). These data include most of the enrolment statistics for each State and Territory since 1970, along with all data since 1976 in the Year 12 subjects of biology, chemistry, physics, geology and alternative science. In computing science and mathematics, most State and Territory statistics since 1970 are included, along with all data since 1980. Trends evident in these data are startling.

Figure 1 compares the total Year 12 student enrolment with the total Year 12 science and mathematics subject enrolments for both Public Examination and School Assessed Subjects for the period 1980-1990. As all teachers know, the vast majority of students – over 90% – take Public Examination Subjects (PES) as these meet entry requirements and/or selection prerequisite

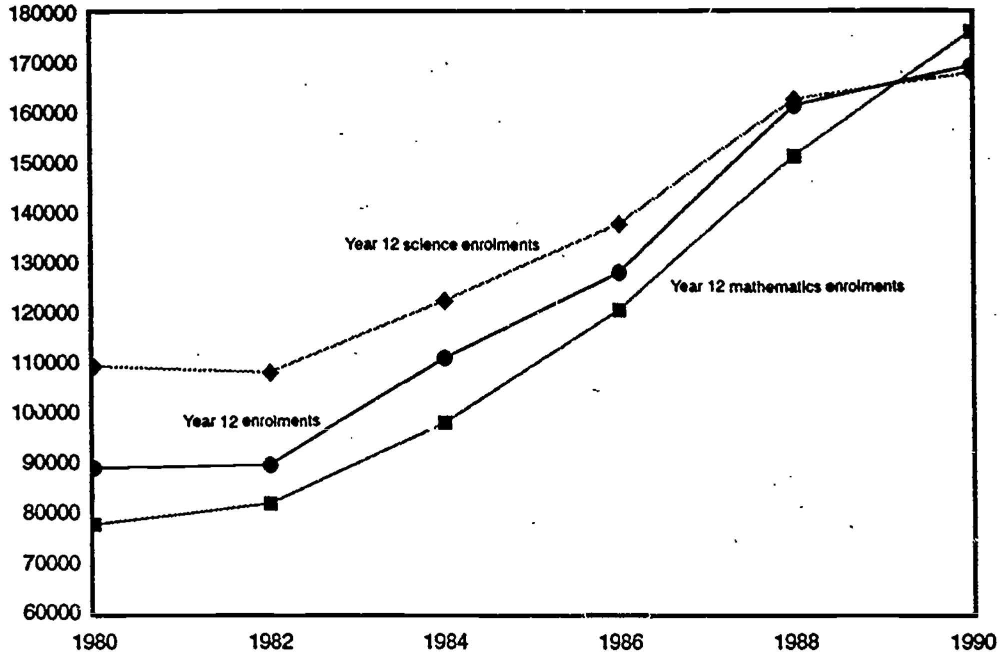

FIGURE 1. Year 12 Science, Mathematics and Total Enrolments (1980-1990)

for entry into university. School Assessed Subjects (SAS) might not be as familiar to teachers in some Australian states as are PES. They are designed and assessed by the school at which a student is enrolled, and are generally intended for students who seek to study science/mathematics at school, but who do not intend to pursue university studies. In 1979, there were no SAS enrolments for science and mathematics subjects, but such subjects were progressively introduced into schools throughout Australia during the 1980s. The response to them has been significant – in 1990, SAS represented 6% of science and 17% of mathematics and computing enrolments.

Despite the fact that the national retention rate from Year 8 to Year 12 increased over 25% between 1980 and 1990 and is higher for girls than boys, this is not reflected in the enrolments in most science and mathematics subjects depicted in Figure 1. In biology and in the less rigorous mathematics units, female enrolments have increased over the years to the point where girls now outnumber boys. But, in the physical sciences and most difficult mathematics subjects, there remains a sharp disparity between male and female enrolments, even though some improvement has occurred over the last decade. In 1990, for example, 29% of Year 12 physics students were girls (compared with 25% in 1979), 43% of chemistry students were girls (compared with 35% in 1979) and approximately 38% of enrolments in the more difficult mathematics subjects were girls (compared with about 30% in 1979). For the newer alternative science subjects (including Physical Science, General Science, Environmental Science), the proportion of girls enrolled in 1990 was approximately 42%, which is higher than for most of the traditional science subjects.

From Figure 1 it is clear that science subject enrolments have not kept pace with the growth in Year 12 student enrolments. Overall growth in science subject enrolments can be attributed largely to increases in science SAS enrolments. For mathematics, however, a consistent growth in subject enrolments since 1982 has paralleled the growth in Year 12 student enrolments. This is in part due to increases in the range of mathematics PES and SAS offerings from which students can choose.

SCIENCE ENROLMENT TRENDS

ENROLMENT TRENDS for science subjects in Australia over the past three decades are well documented. Dow (1971), who surveyed science enrolment patterns at the upper secondary school level for the period 1960-1969, concluded that the proportion of students taking chemistry and physics in all States was decreasing. However, the decline was more than outweighed by the increasing proportion of students studying biology. The major point with data of this kind is that the *new* students (i.e. Year 12 students who in earlier times would *not* have proceeded to Year 12) are not likely to take physics and chemistry, which are recognised as being better suited for the more academically able students. Also, because the size of the school age population (Year 8) increased only about 12% since 1970, the *proportion* of students enrolling in science was bound to go down.

Details of Year 12 science enrolments in Australia for the period 1976 to 1990 are illustrated in Figure 2. The trends in the data can be summarised as follows:

- More students enrol in biology than in any of the other science disciplines. Female enrolments in biology throughout the last 10 years outnumber male enrolments by a factor of approximately two.
- Chemistry enrolments have gradually increased during the 1980s. Female enrolments currently account for approximately 43% of total chemistry enrolments.
- Enrolments in physics closely parallel chemistry. In 1990, females accounted for approximately 29% of the total physics enrolment.
- Geology has the smallest enrolment for the science disciplines. Enrolments were relatively static during the 1980s, although there was an overall drop between 1976 and 1990.
- Enrolments in Alternative Science have increased more sharply than for any of the other science areas. Alternative science subjects include Physical Science, General Science, Environmental Science and Agriculture. In 1990, females accounted for approximately 42% of the total alternative science enrolments.

For the period 1976 to 1990, Year 12 enrolments increased by approximately 95%.

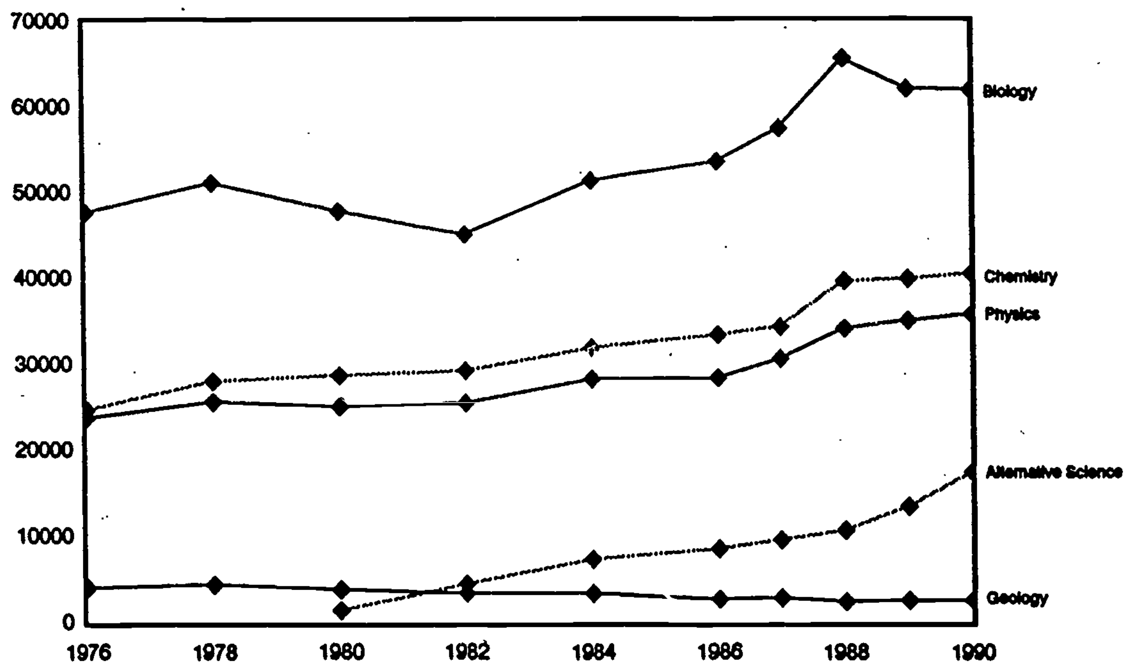

FIGURE 2. Year 12 Science Enrolments in Australia (1976-1990)

The comparable increases for biology, chemistry and physics were 30%, 64% and 51%, respectively, whereas geology enrolments actually declined by 34%.

MATHEMATICS ENROLMENT TRENDS

PUBLIC EXAMINATION mathematics enrolments in Year 12 for the period 1975-1990, together with SAS enrolments for 1985-1990, are shown in Figure 3. Although there was a slight reduction in mathematics enrolments in Year 12 between 1979 and 1981, the numbers have grown steadily since then. The total number of students in Year 12 studying a mathematics subject also has grown since 1982 and the pattern of growth roughly has paralleled that for the total Year 12 population. The pool of students with at least one mathematics subject has increased significantly after suffering a decline over 1980 and 1981.

Until 1985, the pool of Australian students taking a mathematics subject generally was made up of those studying the most rigorous, or 'advanced', mathematics subjects and those taking other levels of mathematics subjects which could be classified as 'ordinary' level subjects. Since 1985, the presence of School Assessed Subjects has had a large effect on enrolments in advanced level mathematics subjects, including those subjects which provide the grounding for extensive study in mathematics or related areas in higher education. 'Advanced' level mathematics subjects at the Year 12 level are defined as those which lead on to tertiary courses requiring rigorous secondary mathematics as a prerequisite – engineering and pure mathematics, for example – whilst 'ordinary' level mathematics subjects are defined as comprising all other types of mathematics courses taken at that level. The 'ordinary' level group is made up of those Year 12 subjects in mathematics which clearly are designed as 'consumer' type courses and which are not suitable as a preparation for any further study in mathematics in higher education.

A significant feature of the trends is that there has been only a marginal growth over the 10-year period in the total number of Year 12 students taking an advanced mathematics subject, whilst since 1982 there has been a substantial growth in the number with an ordinary level mathematics subject.

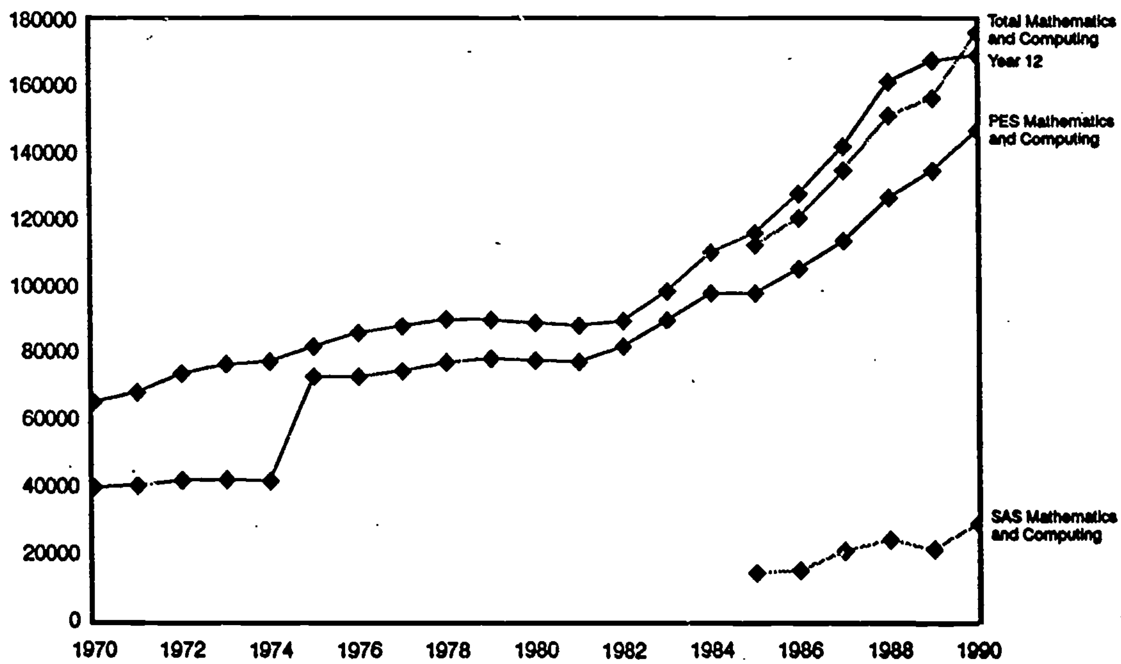

FIGURE 3. Year 12 Mathematics and Computing Enrolments in Australia (1970-1990)

For example, in Western Australia, the proportion of the Year 12 population with advanced mathematics decreased approximately 19% from 54% in 1976 to 35% in 1991 (Alguire, 1992; Dekkers, de Laeter & Malone,1991). The proportion in ordinary mathematics increased from 22% in 1976 to 65% in 1991 – a 43% increase overall. This change can be attributed to the wider range of subjects offered in the ordinary level mathematics courses as well as the increased participation of females in Year 12.

Thus the number of students with a mathematics background suitable for higher education studies in the science, technology and mathematics areas has remained relatively constant despite the increase in the number of students studying mathematics in Year 12. Nationally the proportion of the Year 12 population with Year 12 advanced mathematics decreased approximately 5% from 22% in 1976 to 17% in 1990.

Unlike the science data in Figure 2, enrolment trends for both Year 12 enrolments and mathematics enrolments are very similar (Figure 3). The proportion of students studying SAS mathematics and computing increased from 13% in 1985 to 17% in 1990. This strong growth in enrolments possibly explains the view, held in the late 1980s by many mathematics teachers and educators, that almost every student at the Year 12 level in Australia was studying some type of mathematics unit. Although there appears to be almost as many mathematics and computing enrolments as there are Year 12 enrolments, it should be remembered that students may choose to study more than one mathematics unit.

In summary, participation in mathematics over the last decade in Australia is characterised by a number of features:

1. There has been an overall increase in enrolments and retention at Year 12, which has resulted in an increased pool of students, especially females, who study a mathematics subject in their Year 12 course.
2. The enrolment growth has been more pronounced in ordinary level mathematics subjects than in advanced subjects.
3. The participation rate in advanced mathematics has decreased over the last decade.
4. The participation rate in ordinary level mathematics courses – that is, those subjects which are not usually regarded as an adequate form of preparation for higher education study in mathematics, technology and science – is increasing.
5. The proportion of females taking up advanced mathematics since 1976 has increased. Females now outnumber males in the ordinary level mathematics subjects, while males outnumber females in the advanced level mathematics subjects.
6. The intakes in Year 8 have been decreasing steadily since 1985. A corresponding decrease in the pool of well-qualified students with Year 12 advanced mathematics is likely to occur despite the general continuing increase in retention to Year 12.

WHAT CAN WE EXPECT AND WHY?

COMPARED TO two decades ago, the Year 12 student body in Australia now represents a wider range of abilities and aspirations than ever before. The Dekkers, de Laeter and Malone data (1991) indicate that the recent increase in the Year 12 population is likely to taper off as the Year 8 enrolments drop. However the large age cohort, coupled with the trends in retentivity, should have a significant impact on the number of students entering Year 12 in the immediate future. Consequently, this increasing pool of students presents substantial flexibility for both teachers and employers in mathematical, technological and scientific areas assuming that the 'quality' of those who complete Year 12 does not decline. Yet evidence presented by several researchers (Dekkers, de Laeter & Malone, 1991; Jones, 1988a, 1988b) suggests that this quality *has* declined, that there has been in fact a 'swing' away from advanced mathematics, physics and chemistry in the senior secondary school years from the more rigorous mathematics and science units available to the less rigorous ones in each Australian State. The authors believe that such data can be misinterpreted. The truth is that the population has changed. Although a smaller proportion of Year 12 students is studying the more rigorous science and mathematics units, enrolments in biology, other science units and the ordinary mathematics subjects are most encouraging.

The changing nature of enrolments in mathematics and science at the senior secondary school level can be attributed to the interplay between a number of factors, including:

- the increase in the number of mathematics and science subjects now available in most States;
- the relative difficulty of these subjects;
- interest and enjoyment in these subjects;
- the career relevance of the subjects;
- the changing mix of the student population.

Also, the increased tendency for females to remain at school until Year 12 can be attributed to a number of interrelated factors, including:

- greater acceptance of females in professions that previously have been male-dominated, particularly those that require a university education;
- the increase in youth unemployment;
- a concerted effort by professional associations and Government at both State and Federal levels to encourage females to complete school to Year 12.

It is evident from the data presented in this issue that many upper secondary school students do not study school science and mathematics. A number of studies has identified reasons for this situation (Dekkers & de Laeter, 1983; Queensland Board of Secondary School Studies, 1985; Wood & de Laeter, 1986):

- an increase in the choice of non-science and mathematics subjects;
- the perceived relative difficulty of science and mathematics;
- a lack of interest and enjoyment by students studying science and mathematics;
- career relevance of science and mathematics;
- peer pressure, parental influence and advice given by school counsellors and teachers.

WHAT CAN BE DONE?

THERE IS a growing body of opinion that relevant aspects of science should be reinstated in the curriculum, even if it means that students might not cover the same depth of theoretical and mathematical content. A greater emphasis on laboratory work also would be desirable in many cases. The trends in mathematics parallel those in science, and the influence of female students on these trends has been significant because of the greatly increased retentivity of females over the past 15 years. Specialist mathematics and science subjects traditionally have attracted a higher proportion of male students, in part because more males have undertaken careers in engineering and the physical sciences.

The increasing attraction of commerce and business-oriented courses (including information technology) at the tertiary level in recent years has been a contributing factor in the sense that these courses today do not require the most rigorous mathematics and science subjects. Many students with the capacity to study the more rigorous mathematics and science subjects are diverted away from such study by a variety of influences, not least of which is peer-group pressure. The teacher has a role to play in countering these influences.

Authorities increasingly are concerned at the paucity in the number of young people now studying advanced mathematics and science at the upper secondary school level. This concern has been fuelled by our economic difficulties and the importance of technological development as one means of reversing present economic trends. While we do not believe that the enrolment situation is as depressing as sometimes depicted, we acknowledge that the immediate challenge for teachers and educators is to facilitate and help devise strategies that will increase participation in science and mathematics, particularly physics, chemistry and the more advanced mathematics subjects. There also must be a more concerted effort to instil an understanding in the Australian community of the social significance of technological development and processes in an industrial society. While the latter is not solely the teacher's responsibility, he or she can go a long way in providing a sound background in science and mathematics education at the secondary level – an important component in any plan to enable Australia to compete successfully in an increasingly technological society – while at the same time addressing both the cultural and professional needs of students.

There is also a need to increase the scientific and mathematical ability of the majority of the nation's secondary school students, and the onus for this seems to fall squarely on the shoulders of the teacher. It implies the need to cater in a more appropriate manner for the wider range of abilities which now exist in the upper secondary school. The evidence presented in this publication suggests that this latter objective is being accomplished to an increasing extent, and that this trend is likely to continue. If Australia is to sustain its position as a developed country, it is essential that young people should be acquainted with the variety of careers in mathematics, science and technology at professional and paraprofessional levels, and also with the need for a skilled technological workforce within the country to meet the challenges of the future.

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