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PARTICIPATION IN SCIENCE AND MATHEMATICS AT YEAR 12

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The subjects chosen by students in the senior secondary years are widely considered to be important in shaping educational and occupational futures. Differences in patterns of subject choice which are associated with the background characteristics of students are often seen as involving issues of equity between social groups. Concern over equity in subject choice is expressed in relation to mathematics and science because studies in those areas are regarded as the basis for entry to many programs of professional education. This paper examines levels of participation in science and mathematics at Year 12 and whether participation in those areas of study is associated with differences in personal, social, and school characteristics. It explores the extent to which differences in patterns of participation arise from interests and aptitudes developed earlier than the senior secondary years. Finally it investigates the extent to which students who follow science and mathematics courses in Year 12 enter higher education.

There are few studies of subject choice in Australia which are based on student level data. Two important examples are the SCOPE project in Victoria (Taylor, Alder, & Harvey-Beavis, 1989) and the study of course choices in the Australian Capital Territory by Cooksey (1990). In the SCOPE project students from Years 10, 11, and 12 in Victoria are surveyed each year about the subjects they study and other information. It examines student enrolments in ten subject areas which embrace the full range of subjects and relates those enrolments to a number of student and school characteristics. Cooksey examined course area clusters (groups of subjects) and course patterns (combinations taken by students) in the ACT but without relating participation in those patterns to student characteristics.

The present paper is based on a more recent national study which involved student level data: the ACER Study of Subject Choice (Ainley, Jones, and Navaratnam, 1990). That study was commissioned by the Commonwealth Department of Employment, Education, and Training, to provide information about subjects studied by students in the final two years of secondary school and to relate the patterns of subject choice to students' social and educational backgrounds.

BACKGROUND

The perspective adopted in this paper is that the subjects studied in the senior secondary years are shaped by the interactive influence of a range of factors which could broadly be included as interests, aptitudes, and opportunities. Opportunities can be considered as what is available in the senior years, what has been available in the junior years, or the nature of the formal and informal advice provided to students. Patterns of subjects making up the courses of senior secondary students are not seen as simply arising from decisions taken at Year 11 and Year 12. Students develop a sense of competence in various areas of the curriculum (such as mathematics), and interests in

different types of activities (such as investigative activities) in response to social influences and experiences both in and outside of school, form longer term educational and occupational ambitions, and receive advice from a range of sources. Because choice of subject depends on this wide range of influences, and constraints at the school level, subject choice would be expected to be associated with the background characteristics of students and the schools which they attend.

Students progressively make choices as they move through school. Programs of studies in secondary school usually provide an increasing element of choice as students progress from their first to their final year. In many schools it is common for the first year of secondary school to be almost wholly occupied by compulsory subjects (see Ainley, 1982:186). In the middle secondary years (Years 9 and 10) there is a balance of core and elective studies which varies between states and schools but with the proportion of time given to elective studies typically occupying a little more than one third of a student's time. In the senior secondary school years (Years 11 and 12) students typically choose the equivalent of five or six full-year equivalent subjects from about 15 to 20 subjects available in their school (although this picture is modified somewhat in those systems which operate semester length units of study as the basis for the curriculum structure).

Of course, a much wider range of subjects may be available on a state-wide basis at Year 12 but students' choices are constrained by what subjects their school offers, limitations imposed by the way the school timetable is structured, rules governing subject selection for the various certificates (eg. English is compulsory in most, but not all, states), and limitations imposed as a result of the nature of previous studies. As an indication of the extent to which students' choices at Year 12 are restricted, a study of subject choice on which this paper is based reported that some two fifths of Year 12 students nominated at least one subject which they wished to study but could not (Ainley et al, 1990). Eleven per cent of the nominations were in the science subject area. The most common reasons given for not being able to study a subject of first choice were that the subject was not offered in the school or that there were timetable clashes; only three per cent of students suggested that not completing previous studies prevented them studying a subject of their choice.

In summary the view outlined above sees the choice of science and mathematics subjects at Year 12 as shaped by interests, aptitudes, and opportunities over a wide span of a young person's development in response to educational and social influences This view shapes the potential influences on science participation which are investigated.

Subject Combinations. In terms of participation in science courses the main focus of the paper is on science-oriented combinations of subjects, referred to as course types, rather than individual subjects. Since students choose a number of subjects in Years 11 and 12, the combinations of subjects chosen are of greater interest than the individual enrolments. A particular combination of subjects says more about a student's educational orientation than does enrolment in any given subject. For example, many Year 12 students enrol in biology but only a small fraction of those students include another science subject as part of their course. Hence some biology students would be considered to taking a science-oriented course but most would not.

Student Background. This investigation examines the role of a range of potential influences on participation in science courses. Other literature suggests that it is important to consider

characteristics of students such as gender and social background. A number of studies have examined gender differences in participation in individual science subjects and have shown substantial differences in favour of males, although in some areas it appears the size of these differences may reduced in recent times (Dekkers, De Laeter, and Malone, 1986). Explanations for differences have often invoked ideas related to occupational aspirations, social influences in school and outside, and the nature of science curricula in schools. The role of social background in science course participation is less clear. Given that some mathematics and science subjects are seen as prestigious, in the sense of the access provided for professional preparation, it is argued that students from high socioeconomic, and culturally enriched, home backgrounds would participate to greater extent than other students in those courses (Teese, 1989). Contrary to this, it is also argued that the orientation of those courses to applied science and engineering career provides an appeal for working class males (Teese, 1989). A lack of data linking socioeconomic background and subject choice means that these issues are difficult to resolve. There is even less evidence relating ethnic background to science participation. Comparatively high retention rates to Year 12 among students of non-English speaking background have been attributed to the educational aspirations held for children by migrants (Ainley, Batten, and Miller, 1984). Those aspirations might be expected to be manifest also in participation in science-oriented courses; especially since those subjects might be less dependent on language and literature than humanities subjects. For these reasons the paper examines the influence of gender, socioeconomic status, and ethnic background on participation in science.

Systemic Influences. Other influences on participation in science courses, reflecting aspects of an educational and social environment, considered in the paper include state, school type and location. State differences in participation in science and mathematics subjects over time have been considered extensively by Dekkers et al (1986), and have usually been interpreted in terms of curricula differences in both the senior school years and in Years 7 through 10 (Ainley, 1978). Taylor et al (1989) report small differences at Year 11 in Victoria in science participation between government and non-government schools (differences in participation in the humanities are far larger) and between urban and rural schools. In terms of school system differences Teese (1989) argues that these reflect the expectations held by schools for the types of courses in higher education which their students will enter. Differences between urban and rural schools in science participation could be interpreted as arising from either the social influences in a rural environment or from limited resources in rural schools associated with their small size.

Aptitudes. A missing element in discussions of participation in science courses at senior secondary school is the role of developed competencies and interests; together referred to as aptitudes. Either because students study in areas in which they feel capable, or because high achieving students are advised to study in the sciences to maximize their subsequent choices of study and career, it would be expected that science course participation would be higher among high achieving students. Jones (1988) reports results consistent with this pattern.

Interests would similarly be expected to be linked to subject choice whether that choice was predominantly shaped by intrinsic interest or by occupational plans, or a combination of both. Given an association between interests and occupations, together with a knowledge that subject choice was linked to intended occupation, it seemed likely that there would be an association between interests and subject choice.

As noted by Lokan and Taylor (1986) there is a tradition in vocational psychology of relating personality and interests to occupational choice. One of the better known recent approaches within this tradition is the theory of careers developed by Holland (1985). According to this theory interests can be grouped into six general areas: realistic (building, repairing, making); investigative (experimenting, analysing, inquiring); artistic (painting, dancing, playing music); social (helping others, teaching); enterprising (organising, selling); and conventional (record keeping). Based on the nature of the categories it would be expected that investigative and realistic interests would be associated with participation in science-oriented courses (Lokan and Taylor, 1986).

METHODS

Studies of subject choice require student level data showing all subject enrolments, and other student characteristics, for each student. Such data allow not only an analysis of associations between subject choice and characteristics of students and their schools but also an examination of the subject combinations taken by students. The present paper is based on the student level data used in the ACER study of Subject Choice (Ainley et al, 1990).

Data

Analyses reported in this paper are based on two sets of data: The Subject Choice Data and the Youth in Transition Data. The Subject Choice Data was a large representative data set from the six Australian states which drew on two sources of information. Firstly, it made use of information about subject choice from a survey of a large sample of students who studied in Year 11 and 12 in 1990. Secondly, this survey was supplemented with data from other sources collected in 1989. These supplementary data were obtained from the SCOPE survey for Victoria and from data held by the Secondary Education Authority for the government schools of Western Australia. These supplementary data were merged, after appropriate weighting, with the survey data to form the national data set which is referred to as the Subject Choice Data. In total the Subject Choice Data includes information from 22,000 students (weighted down to 13,770 for analyses) who studied Year 12 in either 1989 or 1990 in each of the six Australian states (see Ainley et al, 1990). The data set is sufficiently large to enable participation in small enrolment areas to be measured with stability and was gathered in a way which was sensitive to structural and terminology differences between states but which enabled compatibility at a national level. It is these data which form the basis of the analyses of associations between subject choice and student characteristics.

The Youth in Transition Data were collected as part of an ongoing national longitudinal study of youth (Williams, 1987). They have the advantage of containing a rich array of background information about students including their achievement in late primary school and their interests in various activities in early secondary school. Youth in Transition is the name of a project through which samples drawn from several cohorts of young people are followed through secondary school and beyond. The cohort relevant to the present paper was that group who were born in 1970, who took part in a study of literacy and numeracy in 1980 when they were then ten years old (see Bourke, Mills, Stanyon & Holzer, 1981), and who were contacted subsequently by survey at the end of each year from 1985 onwards. The 1988 YIT survey contains responses from 2006 18-year-olds. In that year respondents indicated (among other things) the highest year level they had attained at school, the year

when they left school, the subjects which they had studied in that year, and the marks they had obtained. There were 1319 respondents who had completed Year 12 and who provided information about the subjects which they studied. From previous years' tests and surveys information such as early school achievement in numeracy and literacy, occupational interests, ethnic background, gender, home location, social background (including socioeconomic status), type of secondary school attended, and other information relevant to the experience of schooling (eg. occupational and educational plans) was available. It provides the basis for analyses incorporating measures of achievement and interests.

Variables and Measures

A major purpose of this paper is to examine the ways in which participation in science-oriented course types is related to various characteristics of Year 12 students, their background, and the schools which they attended. Although variables such as gender and state are self explanatory there is a number of independent variables for which the measures need to be outlined.

Socioeconomic Background. Respondents to the Subject Choice Survey indicated which of a list of ten general occupational categories (with numerous examples) was closest to the present or last main occupation of their mother or their father. Socioeconomic status was assigned as the most prestigious of the two, according to the ANU scale of occupational prestige (Broom et al, 1977). For this paper it has been collapsed to four categories: low (unskilled or semi-skilled), lower middle (skilled trades), upper middle (clerical, service, small business, shop proprietor), and high (professional and managerial). The SCOPE data from Victoria obtained data about parents' occupations in a similar way and therefore it could be merged with those data obtained from the survey. Information on parental education was also obtained and relevant analyses have been reported elsewhere (Ainley et al, 1990). In brief, analyses based on parental education provide very similar results to those based on socioeconomic background.

Ethnic Background. Two indicators of ethnic background were gathered; one based on parental birthplace and the other on language spoken at home. Language spoken at home had the advantage of being compatible with the Victorian data obtained from the SCOPE survey, but the disadvantage of not including a wide range of students who might be considered to be of non-English speaking background even though they mainly spoke English at home. Parental birthplace provides a wider basis for capturing ethnic background associated with migrancy.

For the analyses based on the Subject Choice Data reported in this paper the language most often spoken at home, classified as English or other, is used as the main indicator of ethnic background. Comparable analyses using parental birthplace yield similar results and have been reported elsewhere (Ainley et al, 1990). Analyses based on the Youth in Transition data have used parental birthplace as an indicator of ethnicity.

School System. School system refers to the type of secondary school attended and is classified as government, Catholic, or non-Catholic independent (for convenience referred to as independent).

Location. Location refers to where the student lived as indicated by questionnaire response. For this report students place of residence was classified as a capital city, a provincial or other city (more than 25,000 people), and a country town or area (less than 25,000 people).

Achievement. Achievement in literacy and numeracy was measured when the students were ten years old and in late primary school in 1980.

The tests were tests of basic competency (see Bourke et al., 1981). For this paper the variables are represented in quartile form, with the quartiles being defined in relation to those students who reached Year 12.

Students' Interests. In 1985, when aged 14 years, respondents indicated how they felt about about a range of 24 different activities. For each activity they indicated whether it was an activity which they "like very much", "like somewhat", "dislike somewhat", or "dislike very much". The activities were chosen to represent the six major interest fields elaborated in Holland's (1985) theory of vocational choice: realistic (eg. "building things"), investigative (eg. "thinking your way through problems"), artistic (eg. "going to live theatre {plays}"), social (eg. "talking with friends"), enterprising (eg. "getting other people to do things your way/influencing others"), and conventional (eg. "doing office work"). A factor analysis of the responses confirmed six factors corresponding to the proposed categories. Satisfactory scales of three or four items were constructed for all except the social scale (for which there was only two items).

PARTICIPATION RATES IN SCIENCE AND MATHEMATICS

Just over two thirds (69 per cent) of all Year 12 students studied at least one full-year equivalent science subject in Year 12; 30 per cent included at least one subject from the physical sciences (ie. physics or chemistry) and 45 per cent included at least one subject from the biological and other sciences. This examination of participation in science subjects begins with a consideration of individual subjects before moving to an exploration of the combinations of subjects which are studied. It is the combinations of science subjects which define the main science-oriented course types investigated in the remainder of the paper. Relevant data are recorded in Table 1.

Science Subjects

Three main subjects accounted for most participation in science in Year 12. Biology was the most popular science subject and was studied by some 35 per cent of Year 12 students, 24 per cent of students studied chemistry and 22 per cent of students studied physics. In addition 14 per cent of students studied another science subject such as human biology, geology or earth science, environmental science, marine studies, or general or multi-strand science.

Combinations of Science Subjects

This paper focuses on those students who studied two or more science subjects. The study of two or more full-year equivalent subjects from a designated subject area can be taken as an indication of the course type being followed by a student (see Ainley et al, 1990). Overlapping participation in Biology, Chemistry, and Physics is illustrated in Figure 1.

Fifteen per cent of students included both physics and chemistry as part of their Year 12 course. This group was made up of 13 per cent who included just physics and chemistry and two per cent who included physics, chemistry, and biology in their Year 12 course. In this paper this group of students is described as following a physical science course type.

An additional nine per cent included two science subjects other than the combination of physics and chemistry. This is made up of five per cent who combined biology and chemistry (without physics), one per

cent who combined biology and physics (without chemistry), two per cent who combined biology with another science (eg. physical science, earth science), and just over one per cent who combined either chemistry or physics with another science (eg. human biology, geology) or who combined two other science subjects. For the purpose of this paper this second group is described as following a biological and other science course type.

Participation in Mathematics

As shown in Table 2 more than four out of every five students (83 per cent) study at least one equivalent full-year mathematics subject at Year 12. Nearly two thirds (65 per cent) of all students studied just one mathematics subject with a further five per cent taking one and one half subjects (eg. 3-unit mathematics in New South Wales). The 65 per cent who studied one mathematics subject was made up of 34 per cent taking an "ordinary" level (such as 2-unit mathematics in NSW or mathematics A in Victoria) and 31 per cent taking a "fundamental" level subject (such as mathematics in society or business mathematics) (see Ainley et al, 1990). About one student in eight (13 per cent) takes two mathematics subjects; almost all of these being a combination of "advanced" mathematics (in the sense of providing the basis for specialised mathematics study in higher education.

Combinations of Science and Mathematics

It can be seen from Table 2 that, of the 15 per cent of students whose course included both chemistry and physics, more than half also studied two mathematics subjects. Some students also studied one and one half mathematics subjects in a system where that combination is considered to form an advanced mathematics program. If they are included with those taking two mathematics subjects as an advanced mathematics category it can be concluded that two thirds of the students in physical science course also studied advanced mathematics. Almost all of the remaining students from the physical science course type (ie one third of the group) studied one mathematics subject.

An overwhelming majority of students from the biological and other science course type studied just one mathematics subject. A few students from this course type (0.8 per cent overall or about one in ten of the group) studied two mathematics subjects and a similar proportion studied no mathematics.

There was a small group of Year 12 students (3.7 per cent) who studied two mathematics subjects without taking two or more science subjects. Some of these had combinations of subjects which showed a major study pattern in another (non-science) subject area but most of them (3.1 per cent of Year 12 students) had two mathematics subjects as the only major emphasis in their Year 12 course. This structure has been considered to constitute a mathematics major course type. The other subjects most frequently included in this course type were from the science or economics and business areas. One third of these students also included one science subject and one economics and business subject, just under one half included one science subject and a subject other than one from the economics and business area, one sixth included an economics subject and a non-science subject, and the remaining one sixth had neither a science nor an economics subject in their course.

Three Science-oriented Course Types

An examination of combinations of science and mathematics subjects in the courses studied by Year 12 students suggests three course types. These are a physical science course type based on the conjoint study of physics and chemistry, a biological and other science course type based on the inclusion of two other science subjects in a Year 12 course of study, and a mathematics major course type based on two mathematics subjects without two subjects from any other subject area.

COURSE-TYPE PROFILES

An important indication of whether these course types actually differ from each other in terms of subject combinations is contained in subject area profiles. These show the average percentage subject load taken from each broad subject area. Subject area profiles of each of the course types are recorded in Table 3 with a profile for a humanities course type being included for comparison. Average loads for all students in a given course type are shown in the profiles. The defining "major" area was shown as the dominant subject area, usually between 30 and 40 per cent of a course (for the biological and other science course type the biological and physical sciences need to be added together to see the dominant area clearly).

The subject area profiles of the course types also indicate how much specialisation was involved in these course types. The average percentage load (weighted according to the participation rates) in the dominant subject area was 34 per cent. In other words students in these course types had about one third of their subject lo d in the dominant subject area with the remaining two thirds in supporting or other subject areas.

PARTICIPATION AND STUDENT BACKGROUND

Table 4 records information about the association between participation rates in various science-oriented course types and characteristics of Year 12 students: gender, social background, ethnic background, school type, location and state. It can be seen from those data that the largest associations concerned participation in the physical science course type. Data referring to participation in the physical science course type have been displayed in Figure 2.

Physical Science Course Type

The results in Table 4 clearly suggest that a number of student characteristics were associated with participation in a physical science course type. Gender is strongly associated with participation in a physical science course type. Nearly one quarter of males (23 per cent) but less than one tenth of females (eight per cent) were in the physical science course type; male participation in this course type was nearly three times greater than that of females. Participation in a physical science course type was also strongly associated with ethnic background with the participation rate for those whose home language was not English being almost double that of their peers of an English speaking background. It was also found that participation in a physical science course was much greater for the high (professional-managerial) group than for the other three socioeconomic groups; in other words the trend across socioeconomic groups was non-linear.

In contrast to these associations home location (city or rural) and school type (government, catholic, independent) had only small associations with participation in a physical science course type. Differences between states in participation rates are also comparatively

small; except that participation is low in Victoria and Tasmania. The low figure for Tasmania is partly a consequence of the structure of the Higher School Certificate in that state, as enrolment levels in individual subjects from the physical sciences subject area are not noticeably lower than elsewhere (Ainley et al, 1990). Students simply organise their studies over two years a little differently.

Biological and Other Science Course Type

As shown in Table 4 there were only small associations between participation in biological and other science course types and the characteristics of students and their schools recorded in Table 4. There was a tendency for participation to be slightly lower in government than non-government schools, and for participation to be higher in provincial cities (especially when considered in conjunction with a similar small effect for the physical science course type) compared to either capital cities or rural areas. Since many of the students from the provincial city category are from larger industrial centres this may well reflect the types of study which are valued in those settings. There were two states where participation in this course type was noticeably higher than elsewhere. These states were Western Australia, where human biology attracts considerable enrolments, and Queensland where biological science is very popular and a range of other science studies attract significant numbers of students.

Mathematics Major Course Type

Within the generally low participation rates in this course type associations with gender and ethnicity were similar to those for the physical science course type. Participation rates for males were double those of females, and rates for those of non-English speaking background were double those for students of an English speaking background. However, there was no association between participation in this course type and socioeconomic background. There were associations with location, in the direction of higher participation in the more urban environments, and state, with a relatively high participation rate in Victoria.

Coeducational and Single Sex Schools

There was a small effect of the coeducational status of a school on propensity of females to participate in a physical science course types. The Subject Choice Data involved 214 schools of which 159 were coeducational, 33 were girls schools, and 22 were boys schools. Information on coeducational status was not available for the the government schools of Western Australia. Table 5 records participation rates for three science-oriented course types. The first part of the table shows participation rates for all students. It clearly shows that the participation rate in a physical science course type was greatest in all boys schools and least in all girls schools; a direct reflection of the different participation rates for males and females. A similar trend was evident for the mathematics major course type but not for the biological and other science course type, where there was a slight trend in the reverse direction. The second part of the table shows participation rates for female students by the coeducational status of the school which they attend. Those data show that the participation rate in a physical science course type for females from all girls schools was greater (about 3.4 percentage points) than for those from coeducational schools. However, although there was a detectable

difference it was small. The third part of the table shows the participation rates for males by the coeducational status of the school which they attend. Those data show that there was almost no difference in participation rates for males in all boys schools or coeducational schools.

The data in Table 5 make no allowance for the influence of concomitant factors such as school type, socioeconomic background, or achievement. Mean socioeconomic level for students in single sex schools is significantly higher than for those in coeducational schools; and a higher percentage of Catholic (48 per cent) and independent schools (24 per cent) than government schools (5 per cent) were single sex. When a statistical allowance was made for these influences, and ethnic background, the difference in female participation rate in a physical science course type attributable to the coeducational status of the school was reduced from 3.5 to 2.5 percentage points. It was not possible to allow for differences in early school achievement, although it might be anticipated thatmaking such an allowance would further reduce the effect size for the coeducational status of a school.

ACHIEVEMENTS AND INTERESTS

The Youth in Transition data enabled an examination of relationships between participation in science-oriented course types and early school achievements and interests. Such an examination formed an important part of our exploration of science course participation by enabling an assessment of the relative influence of aptitudes and other student characteristics, and interpretations of differences in participation between social groups. In general the results suggest that early school achievements and interests were strongly associated with participation in science-oriented course types, especially the physical science course type.

Achievement and Science Participation

Data relating early school achievement and participation in various course types are recorded in Table 6. Those data relating to numeracy are also displayed as part of Figure 3. It is evident that there was a large, and clearly significant, difference in the percentages of students from each achievement quartile who participated in a physical science course. More than one third of those from the top achievement quartile participated in this course type compared to one twentieth of those from the bottom quartile. Expressed in a different way participation rates from the top quartile of numeracy achievement were seven times the rates for those from the bottom quartile. Interestingly, a similar trend of participation in a physical science course type with achievement in literacy to that for numeracy was observed although the gradient was less regular and less pronounced with a flattening between the top two literacy quartiles.

The associations between early school achievement and participation in the biological and other science course type was much smaller (but in the same direction). No regular association was detected between achievement and participation in the mathematics major course type although it should be noted that the size of this group in this sample is rather small.

Interests and Participation

Scores on several of the six interest scales were clearly associated with participation in science-oriented courses at Year 12; especially

for the physical science course type. Relevant data are recorded in Table 7. Positive associations with participation in this course type were observed for the investigative and realistic scales. The strongest positive association involved investigative interests. Some 27 per cent of those from the top quartile of scores on the investigative interest scale participated in a physical science course type at Year 12. In contrast only seven per cent of those from the bottom quartile were in this course type. Realistic interests were also positively associated with physical science participation rates; the rate for the top quartile was (27 per cent) was double that from the bottom quartile. These are displayed along with the numeracy data in Figure 3. Negative associations were observed between physical science participation and the conventional and enterprising scales. In terms of conventional interests only eight per cent of the top quartile, compared to 25 per cent of the bottom quartile, participated in a physical science course type. The association between physical science participation and artistic interests was negative but irregular.

Participation in a biological and other science course type was also positively associated with investigative and realistic interests but the strength of the association was considerably weaker than those noted for the physical science course type. Participation in the mathematics major course type was associated with a slightly different pattern of interests. For this course there was a strong positive association between participation and both investigative and enterprising interests. A pattern consistent with the course profile which often involved an economics and business subject, and a science subject, taken with the two mathematics.

ACHIEVEMENT AND INTERESTS IN CONTEXT

Achievement and interests are not necessarily independent of student background and school characteristics. For example, many interest scores were associated with gender (eg. males expressed greater interest in realistic and investigative activities than females whereas females expressed greater interest in artistic, conventional, and social activities), achievement was positively associated with socioeconomic background, investigative interests were associated with numeracy, socioeconomic background was associated with school system, and some interest scores were associated with socioeconomic background (positively for artistic, negatively for conventional interests). In a situation such as this it was necessary to extend beyond a description of the simple associations between each factor and science participation to explore the major influences (in a relative sense) on participation and to make allowance for interconnections between these influences.

One technique appropriate for such an investigation is discriminant function analysis. Through the application of this technique the study sought to establish the linear combination of variables which would discriminate best between two or more previously defined groups (see Hair, Anderson & Tatham, 1987). The present discussion reports on the results of applying discriminant analysis separately to the differences between each of physical science and biological and other science course types and the rest of Year 12. The analysis was not conducted for the mathematics major course because the number of members of that group in this sample is small. Table 8 shows the main variables contributing to the discriminant function, the structure coefficient, and the function coefficient. Structure coefficients are the simple correlation coefficients between the variables and the discriminant functions. It is the structure coefficients which are used to interpret the

discriminant function (Tatsuoka, 1988). Function coefficients are standardised regression coefficients (beta coefficients) and show the strength of the relationship, when other things are equal, between the variable and the discriminant function. When there was a difference in the magnitude of the function and structure coefficients for a variable it provided an indication that the variable was associated with one or more other variables in the discriminant function. In addition, the table provides an indication of how accurately the function would classify students into each course type; how far apart are the groups on the discriminant function and the percentage of the cases actually in the designated course type which would be correctly classified.

Physical Science

The factors which distinguished students in the physical science course type from other students were high early school achievement (especially in numeracy), stronger interest in investigative activities, gender (the negative sign indicates that males predominated), and lower interest in conventional. An examination of the function coefficients suggested that, when allowance was made for associations between the independent variables (eg. that females expressed less interest in investigative activities), the influence of gender was reduced a little but remained important. In other words the smaller percentage of females in physical science course types was not only attributable to patterns of interests expressed in early secondary school. It can be noted also that the contribution of literacy achievement was reduced when allowance was made for numeracy achievement, with which it was correlated, and similarly the contribution of realistic interests was reduced if allowance was made for other variables such as gender and investigative interests. On the basis of this discriminant function one could correctly classify over three quarters (76 per cent) of the students who were actually in a physical science course type.

Biological and Other Science

Interest in investigative activities was a major contributor to the discriminant function distinguishing students in biological and other science course types from their peers. There was also evidence of contributions from state influences (measured relative to New South Wales, Queensland and Western Australia had higher participation levels due to the popularity of biology and, in Western Australia, human biology), social background (higher participation from the upper than the lower socioeconomic groups), and school system influences (independent schools had higher participation rates than government schools). The discriminant function correctly classified 71 per cent of those who were actually in biological and other science course types.

Interactive Influences

There was evidence of an interactive influence of numeracy achievement, gender and socioeconomic background on participation in a physical science course type. Table 9 records participation rates for students in each of four possible combinations of numeracy achievement and socioeconomic background separately for males and females. The first part of the table shows results for all students, the second part of the table shows results for male students only, and the third part of the table shows results for female students only. Data from Table 9 are also displayed in Figure 4.

The results for all students confirm the strong association between participation in a physical science course type and both achievement and gender with a weaker association between participation in this course type and socioeconomic background. For male students the results show a strong influence of achievement and almost no influence of socioeconomic background on participation in this course type. For females there was evidence of an overall effect of both achievement and socioeconomic background. Of even greater interest was evidence of an interactive influence of achievement and socioeconomic background on participation. There was a strong influence of socioeconomic background on participation in this course type among girls of high numeracy achievement but none (in fact a small reversal) among girls of low numeracy achievement. An alternative way of expressing this result would be to say that among girls of high socioeconomic background higher achievement levels were associated with participation in mathematics-science course types, but among girls of low socioeconomic background no association was observed.

STUDY BEYOND SCHOOL

An analysis of the Youth in Transition Data suggested that just over half (52.3 per cent) of the Year 12 cohort proceeded to higher education by the age of 19 years and one in five had participated in a course of technical and further education. It was evident also that there were large differences in the percentages of students from each course type who participated in higher education. More than four out of every five (83 per cent) of those in physical science courses, but only some 57 per cent of those in a biological and other science course type, continued to higher education. It should not be concluded that differences in participation in post-school education are necessarily a consequence of the type of course undertaken at Year 12. Apart from gender, the strongest influences on participation in physical science courses are reflected in variables measured early in the process of schooling: achievement in numeracy and investigative interests. Both numeracy achievement and investigative interests may reflect a sense of competence, interest, and even excitement about these fields and be indicative of a disposition towards further study of the type offered in higher education.

IN CONCLUSUION

In this paper we sought to explore the patterns of participation in science oriented course types among students in Year 12 in Australian schools. Three main course types were identified; a physical science course type, a biological and other science course type, and a mathematics major course type. It is evident that there are differences between groups of students in their participation in these course types; especially in the physical science course type which involves the concurrent study of both chemistry and physics.

There are quite large differences in the patterns between males and females and between those of an English speaking and non-English speaking background. There are also differences in the patterns between socioeconomic groups but only small differences between different types of school and between city and rural areas.

The largest differences in the patterns of subject choice are between different levels of early school achievement and different patterns of interests which emerge in early secondary school. This suggests that policies to increase student participation in physical science courses need to be directed at early school experiences as well

as at senior school curricula. If curriculum and teaching in the earlier years of school can influence the extent to which students are interested in investigative activities, and feel competent in mathematical skills, it might result in increased and more equitably spread participation in the physical sciences.

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TABLES

Table 1 Participation in Science Subjects at Year 12 (Subject Choice Data)a

	Total	Percent in Combination With				Single
	Percent	Biol	Chem	Phys	Other	Percent
Biologyb	35.1	*	5.2b	1.0b	1.8	24.8
Chemistryc	23.9	5.2b	*	15.2c	0.5	3.0
Physicsc	21.6	1.0b	15.2c	*	0.3	6.1
Other Sci.d	14.4	1.8	0.5	0.3	0.5e	11.3

a Figures shown are the percentage of all Year 12 students. Nweighted=13770
b The figures for Biology with Chemistry and Biology with Physics do not include the 2.3 per cent of students who studied Biology, Chemistry and Physics.
c The figure for the combination of Chemistry with Physics includes 2.3 per cent who studied Biology, Chemistry, and Physics.
d Figures for combinations in this row do not include a very small number of students who studied an "other" science in addition to two subjects from Biology, Chemistry, or Physics.
e A small number of students (0.5 per cent) studied two "other"

science subjects.

Table 2 Percentages of Year 12 Students Participating in Different Combinations of Mathematics and Science (Subject Choice Data)a

Mathematics Subjects	Science Course Type			All Students
	Physical Science	Biological & other Science	None	
Two Maths	8.1	0.8	3.7b	13
One or 1.5 Maths	7.0	7.3	55.9	70c
No Maths	0.1	0.7	16.3	17
Total	15.2	8.8	76.0	

a Based on a weighted sample of 13,770 Year 12 students from six states. Percentages refer to the total group.

b The 3.7 per cent includes 3.1 per cent for whom mathematics is the major area of study.

c The 70 per cent is made up of 4.8 per cent taking 1.5 mathematics subjects, 34.2 per cent taking ordinary level mathematics and 31.4 per cent taking fundamental mathematics.

Table 3 Average Percentage Load from Various Subject Areas For Different Course Types

Subject Area	Course Type				All Courses
	Physical Science	Biological Science	Maths	Humanities	
English	16	17	18	18	19
Mathematics	28	18	37	13	17
Humanities	3	7	4	30	15
Economics & Bus	4	6	10	13	12
Biol & Other Sci	3	22	9	9	9
Physical Sciences	35	14	11	1	8
Creative & Perf Arts	2	3	4	4	7
Home Economics	0	2	0	2	3
Technical Studies	3	2	1	1	2
Languages	2	2	4	1	2

Physical Education	1	2	1	1	2
Computer Studies	1	2	2	1	2
Agriculture	0	0	0	1	1

Note N=13770

Table 4 Year 12 Participation Rates in Science-Oriented Course Types by Various Characteristics (Subject Choice Data)

Variable	Categories	Course Type		
		Physical Science	Biological & Other Science	Mathematics
Gender	Male	23.3	8.4	4.2
	Female	8.4	9.1	2.2
Socioeconomic Background	Upper	19.2	9.5	2.8
	Upper-mid	12.8	7.5	3.1
	Lower-mid	11.1	9.6	4.5
	Lower	12.5	7.5	3.2
Ethnicity	Eng.speaking	13.9	8.6	2.8
	Other	25.9	8.4	6.3
Location	Cap. city	15.3	7.8	3.8
	Other city	16.4	10.5	2.9
	Rural	13.6	8.6	2.2
School Type	Government	15.0	8.5	3.0
	Catholic	14.6	9.2	2.9
	Independent	16.8	9.7	3.4
State	NSW	15.8	7.3	2.0
	Vic	12.1	7.7	5.3
	Qld.	17.8	11.2	2.4
	SA	15.0	8.7	3.4
	WA	18.0	12.4	1.6
	Tas.	8.9	8.0	0.1

Note: Data on socioeconomic background, ethnicity, and location were not available for Western Austalian government schools.

Table 5 Year 12 Participation Rates in Science Courses at Year 12 by Co-educational Status of Schoola (Subject Choice Data)

Coeducational Status

	Girls School	Coed School	Boys School	All Schools
All Students				
Physical science	10.9	14.7	23.6	15.1
Other Science	10.4	8.4	7.5	8.6
Mathematics	2.1	3.2	4.2	3.2
Female Students				
Physical science	11.0	7.6	---	8.4
Other Science	10.4	8.3	---	8.8
Mathematics	2.1	2.2	---	2.2
Male Students				
Physical science	---	23.6	23.1	23.2
Other Science	---	8.5	7.5	8.3
Mathematics	---	4.4	4.2	4.3

a Table does not include data from government schools in Western Australia and therefore overall figures may not match data in Table 4 precisely.

Table 6 Year 12 Participation Rates in Science Courses By Early School Achievements (Youth in Transition Data)

Achievement Test	Category	Physical Science	Biological & Other science	Mathematics
Numeracy	Top quartile	36	13	3
	3rd quartile	17	13	2
	2nd quartile	13	12	4
	Bot quartile	5	9	1
Literacy	Top quartile	24	16	3
	3rd quartile	24	10	5
	2nd quartile	17	13	1
	Bot quartile	8	8	3

Table 7 Year 12 Participation Rates in Science Courses By Early School Interests (Youth in Transition Data)

Interest Scale	Categories	Physical Science	Biological & Other science	Mathematics

Investigative	Top quartile	27	15	6
	3rd quartile	18	14	4
	2nd quartile	20	10	1
	Bot quartile	7	7	1
Realistic	Top quartile	27	14	3
	3rd quartile	16	12	4
	2nd quartile	19	12	1
	Bot quartile	13	10	3
Conventional	Top quartile	8	11	2
	3rd quartile	15	10	2
	2nd quartile	21	12	3
	Bot quartile	25	14	2
Artistic	Top quartile	15	10	2
	3rd quartile	19	14	4
	2nd quartile	16	11	4
	Bot quartile	22	13	1
Enterprising	Top quartile	10	12	6
	3rd quartile	17	9	2
	2nd quartile	24	14	1
	Bot quartile	21	13	3

Table 8 Discriminant Functions Distinguishing between Students in Science-Oriented Course Types and Remaining Students (Youth in Transition Data)

Physical Science			Biological & Other Science		
Variable	Function coefft.	Structure coefft.	Variable	Function coefft.	Structure coefft.
Numeracy	.55	.56	Investigative	.64	.53
Gender	-.38	-.46	Queensland	.61	.47
Investigative	.50	.37	Realistic	.16	.33
Conventional	-.29	-.35	Socioeconomic	.26	.31
Literacy	.13	.29	West Australia	.39	.24
Social	-.06	-.27	Gender	-.23	-.08
Enterprising	.40	-.26	Literacy	.19	.20
Realistic	.06	.19	Indep. School	.19	.19
Means					
Group	0.94			0.59	
Rest	-0.22			-0.08	
% Classified Correctly				76%	71%

Notes: 1 Function coefficient is a standardised regression coefficient.

2 Structure coefficient is a correlation coefficient between a variable and the linear discriminant function.
3 Variables for which both the structure coefficient and the function coefficient were less than 0.20 have not been shown. Variables with a structure coefficient greater than 0.30 have been shown in bold.

Table 9 Interactive Influences of Achievement and Socioeconomic Background on Participation in a Physical Science Course Type for Male and Female Year 12 Studentsa (YIT Data)

	Numeracy Achievement								
	Persons			Males			Females		
Socioeconomic Background	Low	High	Total	Low	High	Total	Low	High	Total
Low	10.4	22.3	16.6	14.5	36.8	27.2	7.7	8.7	8.2
High	9.5	26.3	19.8	16.6	36.9	28.0	3.4	17.7	11.7
All	9.4	25.3		15.4	37.7		5.0	14.9	

a The figures shown are percentages of students in each cell whose course was characterised as a physical science type. Total figures may not correspond precisely to other tables because of missing data and weighting.

Chemistry

Biology

All Year 12 Physics

Figure 1 Overlapping Participation in Biology, Chemistry and Physics

Figure 2 Physical Science Participation Rates by Various Characteristics

1=Bottom Quartile
2=Second Quartile
3=Third Quartile
4=Top Quartile

Figure 3 Physical Science Participation by Achievements and Interests

1=Bottom Two Quartiles
2=Top Two Quartiles

Figure 4 Interactive influences of Gender, Numeracy, and Socioeconomic Background on Participation in Physical Science Courses