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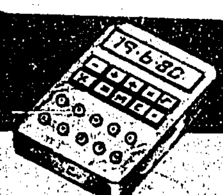
ABSTRACT

Changes in the nature and content of the Secondary Mathematics Program in Australia are revealed by data from two complex studies of mathematics education in that country. This document represents an initial exploration of the information collected, with supplementary analyses by interested researchers invited. In addition to a multitude of tables and figures, sections of this work include chapters on: Changes in the System of Mathematics Education: Data on Populations, Samples, and Administration: Tests and Questionnaires: Characteristics of Students, Teachers, and Schools: Mathematics Achievement of 13-Year-Old Students: Mathematics Achievement of Year 12 Students: Student Attitudes Towards Mathematics: and a section of selected summaries and conclusions. The report also contains four appendices which include: members of the advisory committee and state liaison officers: reproductions of 1978 International Association for the Evaluation of Educational Achievement (IEA) tests A, B, C, D, E and F: and mathematics test item statistics. The document concludes with a list of references. (MP)



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CHANGES IN SECONDARY SCHOOL MATHEMATICS IN AUSTRALIA 1964 - 1978

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CONTENTS

CONTENTS (contd)

6

LIST OF TABLES

LIST OF FIGURES

11

PREFACE

The results in this report represent an initial exploration of a large volume of data collected from two complex studies of mathematics education in Australia. Associated with this report are two technical documents (Rosier, 1980a and 1980b) and a set of data on computer tape which can be made available by the Australian Council of Educational Research to other research workers interested in undertaking supplementary analyses of the data.

Underlying the report was the idea of a 'cycle of research', starting with a description of the aims and context of the study expressed in 'normal' language, then moving to the collection of information and quantitative analyses of data, and concluding with the findings of the study and their implications expressed in normal language.

In this report the language of the initial and final stages of the research cycle uses general terms such as 'factors' and 'relationships', while in the quantitative middle stage the language of statistics is used more often. In particular the term 'variable' replaces the term 'factor', where variables have associated values derived from the data collected from the members of the survey samples. Since it was considered important to maintain the distinction between the reference to generalities and the reference to sample data, the convention was adopted of giving variables names with initial upper-case letters. For example, the sex of the students was an important factor in the study, which was represented in the quantitative analyses by the variable Sex of Student having the value of either 1 for male students or 2 for female students.

Major research studies can only be accomplished with the support of many persons, and this study was no exception. It is with gratitude that the assistance of many ACER staff members is acknowledged, and particularly of Dr John Keeves (Director of ACER) and the research staff most closely involved with the study: Miss Jill Mason, Mr Robert Priest, and Miss Claire Robinson (on secondment from the Victorian Education Department). The planning of the study was greatly assisted by members of the Advisory Committee and the State Liaison Officers, whose names have been listed in Appendix 1. Finally, grateful acknowledgment is extended to the students, teachers and school principals who participated in the testing programs in 1964 and 1978.

CHAPTER 1

INTRODUCTION

The ancient Greeks regarded the universe as being essentially stable, until Heraclitus, an obscure writer, preached the alarming doctrine that everything was in a state of flux. He characterized his doctrine by stating that a person could not step twice into the same river, since on the second occasion it was no longer the same river. Modern Western societies, acknowledging that major threads in their philosophy and culture have originated with the ancient Greeks, have accepted the inevitability of constant change both in the underlying aims of the societies and the structure erected to implement the aims.

The aims of a society may be described in terms of improving the quality of life of its citizens. In turn, in a heterogeneous society the individual citizens who constitute the society have their specific aims which they perceive will improve the quality of their own lives. For both individual citizens and for society as a whole, these aims are constantly being modified as a consequence of changes in their perceptions of desired outcomes.

Modern societies construct a variety of institutions to assist in accomplishing their aims, including parliamentary systems, commercial enterprises, communications networks and public service bureaucracies. For the young persons who are the subjects of this report, the secondary school is the major social institution through which the aims of the society are achieved. This report assumes that, in common with the wider society, the aims and structures of the system of formal education are also changing in order to accommodate changes in the society's perception of a better life. It further assumes that it is fitting to undertake a periodic evaluation of the changes occurring in this system. This evaluation has often been made difficult by the lack of clarity with which the aims have been articulated and the consequent wide range of tasks which have been assigned to schools. Nevertheless, society has always expected its schools to give major emphasis to the cognitive development of students.

Some authors, such as Coleman, would take a more extreme stance, and claim that the intellectual activity of the school was the only function for which it was adequately prepared:

> Schools are prepared to do what they have done all along: teach young people intellectual things, both by giving them information and giving them intellectual tools, such as literacy, mathematics, and foreign languages. (Coleman, 1972:436)

Even within the limited intellectual aims of the school there have been changes which have reflected changing aims of the society in which the formal education system has been established. Changes in the aims have in turn affected the content of the school curriculum. For example, one general change in society has been the increasing concern of citizens to exercise control over the institutions their society has created, by increasing their participation in the processes of making decisions which directly influence their lives. This is reflected at the school level by a move away from curriculum content defined within disciplinary boundaries and studied by all students towards content which is more responsive to the needs and interests of both individual students and the wider society outside the school.

A further example is provided by changes in curriculum content at the upper secondary level which have been necessitated by changes in the types of students enrolled at these year levels. Until the 1950s, secondary schools existed largely to serve the minority of young persons of higher ability who wished to pursue professional careers. As the holding power at these year levels increased, it was necessary to make corresponding changes in the content of the curriculum to cater for a student population with a wider range of ability.

Similar changes occurred within the primary school and lower secondary school of changing policies on the promotion of students from one year level to another. Initially, promotion was dependent on adequate performance on a tightly-defined set of intellectual skills. Gradually this policy was replaced by annual promotion, which enabled a student to remain with his peers. This policy reflected a growing realization by society of the need to consider the psychological effects of decisions on individuals. In consequence, the curriculum content at a given year level was modified to accommodate classes with students of similar age but at different levels of competency.

For this study curriculum has been used in the narrow sense of a syllabus or course of study, usually with associated printed materials for use by teachers and students. Society has traditionally assigned the task of specifying curriculum content to the appropriate authorities within the formal education system. In Australia, for students at year levels where public examinations have been held, statutory agencies have been established. For students in government schools at lower year levels, the State Education Departments have specified the curriculum content, although the degree of specificity has varied over time at different year levels in different States. Non-government schools have tended to adopt the courses developed by the State Education Departments. However, there have been recent movements to encourage the specification of curriculum content to take place at the level of the individual school.

The next stage in the sequence for implementing the curriculum is in the hands of the classroom teachers, who have the role of translating the specified curriculum content into appropriate instruction to their students.

The final stage in the curriculum sequence is the extent to which the students have learnt the material covered by the curriculum. The assessment of student performance can involve various levels of formality, ranging from the public examinations and the use of standardized test materials to teachers' informal judgments of student achievement.

In summary, the curriculum sequence is seen to have three stages: the intended curriculum as specified by authorities within the education system, the translated curriculum as interpreted by the classroom teachers, and student performance, which may be regarded as the achieved curriculum.

It follows that changes in the intended or translated curricula would usually result in changes in student performance. Conversely, any study which sought to explain changes in performance should also examine changes in earlier stages of the curriculum sequence. Thus the purpose of this study is to illuminate the public debate about current levels of educational performance by examining changes in the mathematics achievement of students in the context of changes in the mathematics curriculum and other background factors.

The data presented in this report have come from two major studies of mathematics education; the First IEA Mathematics Study and the Second IEA Mathematics Study. The First IEA Mathematics Study was co-ordinated by the International Association for the Evaluation of Educational Achievement (IEA). Twelve countries were involved in this study, for which data were collected in Australia in August 1964. The major report of the study presenting the cross-national results was edited by Husén (1967). Reports presenting certain Australian results were prepared by Keeves (1966; 1968) and Keeves and Radford (1969).

Several target populations were defined for the First IEA Mathematics Study. The two with which this report will be concerned were Population 1 and Population 3. Population 1 (which corresponded to Population 1a in the previous reports of the First IEA Mathematics Study) involved 13-year-old students. Population 3 (which corresponded to Population 3a in the previous reports) involved students at the final-year secondary level who were studying mathematics as an integral part of their course with the intention of undertaking further studies involving mathematics at the tertiary level. As well as answering a series of mathematics tests, the students in 1964 provided information about their home background and expressed their opinions on various aspects of mathematics. Other information was collected by means of a questionnaire completed by the mathematics teachers of the students in the sample, and information about the schools attended by these students was collected by means of a questionnaire completed by the school Principal. The Second IEA Mathematics Study involved the collection of data in Australia in August 1978 to enable mathematics education to be compared over the period of 14 years from 1964 to 1978.

CHAPTER 2

CHANGES IN THE SYSTEM OF MATHEMATICS EDUCATION

Before examining the data on the mathematics achievement of students in Australian secondary schools it is important to describe various characteristics of the system of mathematics education. A proper understanding of the significance of any observed changes in achievement can only be sought in the light of adequate information about changes in the context within which the education was conducted.

Most statistics about Australian education have been published at the level of the separate States, representing an appropriate level for examining the context within which mathematics teaching takes place in Australia. The mathematics curriculum followed by teachers has usually been specified at this level, under the influence of State Education Departments or of curriculum development committees within the individual States. The purpose of this chapter is to document basic statistics about the number of mathematics students in the States in 1964 and 1978, and associated information about the mathematics curricula being studied. It is not within the scope of this report to attempt a major historical analysis of the underlying reasons, but simply to summarize information available from a variety of public sources.

The information presented in this chapter is concerned with two groups of students at two points in time. The two groups of students are those of age 13, corresponding to Population 1 in the two IEA Mathematics Studies, and those in Year 12, corresponding to Population 3. The two points in time are 1964 and 1978, corresponding to the years when data were collected for the two IEA studies.

Over the period considered by this report there have been changes in definitions and terminology of official statistics. This report has adopted the convention of using the latest terminology, with appropriate initial reference to the terminology it has replaced. This is of particular importance when referring to year levels. Table 2.1 sets out the relationship between the year levels employed in 1978 and the 1964 terminology to which they have been equated for the purposes of this study. Since this study concentrates on secondary education, the equivalences were established on the basis of Year 12 as the final secondary school year. This decision

Table 2.1 Year Level Nomenclature

1978	1964 NSW & ACT	Vic.	Qld	SA & NT	WA	Tas.
Year K				Kinder-garten		Kinder-garten
Year 1	Grade K	Grade 1	Grade I	Grade I	Grade 1	Grade 1
Year 2	Grade 1	Grade 2	Grade II	Grade II	Grade 2	Grade 2
Year 3	Grade 2	Grade 3	Grade III	Grade III	Grade 3	Grade 3
Year 4	Grade 3	Grade 4	Grade IV	Grade IV	Grade 4	Grade 4
Year 5	Grade 4	Grade 5	Grade V	Grade V	Grade 5	Grade 5
Year 6	Grade 5	Grade 6	Grade VI	Grade VI	Grade 6	Grade 6
Year 7	Grade 6	Form I	Grade VII	Grade VII	Grade 7	Year I
Year 8	1st year	Form II	1st year	1st year	Year 1	Year II
Year 9	2nd year	Form III	2nd year	2nd year	Year 2	Year III
Year 10	3rd year	Form IV	3rd year	3rd year	Year 3	Year IV
Year 11	4th year	Form V	4th year	4th year	Year 4	Year V
Year 12	5th year	Form VI	5th year	5th year	Year 5	Year VI

Note: (a) The following abbreviations have been used in tables in this report: Australian Capital Territory (ACT), New South Wales (NSW), Victoria (Vic.), Queensland (Qld), South Australia (SA), Western Australia (WA), Tasmania (Tas.) and Northern Territory (NT).

(b) For 1964 the last primary year level has been underlined. For 1978 the last primary year level was Year 6 in the Australian Capital Territory, New South Wales, Victoria and Tasmania, and Year 7 in the other States.

is significant for the placement of the year levels for New South Wales (and hence the Australian Capital Territory) in 1964, since an extra year of secondary education was added to these systems in 1967.

Most of the information in this chapter has been obtained directly from public documents published by the Australian Bureau of Statistics, particularly the annual reports containing statistics about primary and secondary schools in Australia, and the associated tables giving enrolments by age in each year level, for male and female students in government and non-government schools in each of the seven States and the Australian Capital Territory. Some information pertaining to Year 12 students has also been supplied by the statutory public examination bodies in each State.

There are four parts to this chapter. The first part describes some general changes in the State education systems between 1964 and 1978. The second part outlines several important changes that have taken place in

Australian society that have had direct relevance to mathematics education. The third and fourth parts describe changes at the 13-year-old and Year 12 levels, respectively, with respect to student enrolments and the content of the mathematics curriculum.

Changes in State Education Systems

The purpose of this section is to give a brief description of some general changes that have taken place in the structure of the State education systems between 1964 and 1978. This emphasis on the State systems recognizes that the constitutional responsibility for education rests at this level of government. At the same time, the involvement of the Federal Government in education has increased considerably during the period under review.

The Federal Government involvement was formalized by the establishment of a separate Department of Education, after an initial period where education was included in a Department of Education and Science. Prior to the establishment of the Department under a separate minister, the educational responsibilities of the Commonwealth had rested with a section of the Prime Minister's Department.

In addition, the Federal Government established a series of statutory bodies which were concerned with primary and secondary education, including the Schools Commission (1973), the Curriculum Development Centre (1975) and the Education Research and Development Committee (originally established in 1971 as the Australian Advisory Committee for Research and Development in Education). However, these bodies have not had a direct impact on school mathematics curricula in Australia.

The following section provides some brief comments about the separate State education systems. The States will be considered in the order in which their data are presented in tables and figures in this report; that is the Australian Capital Territory followed by the seven States in order of population size. Although the Australian Capital Territory is not technically a State, it will usually be cited as such in this report in order to avoid undue verbosity. Government schools have generally been co-educational, serving the locality within which they were situated, and offering a range of courses for students of different interests and abilities. There were usually separate schools for students at the primary and secondary levels, although there were some schools, especially in non-metropolitan areas, where there were secondary year levels associated with a primary school under a common principal.

Schools in the non-government sector were classified into two types: Catholic schools and independent (non-Catholic non-government) schools. Apart from the smaller Catholic parish primary schools, the non-government schools have generally been single-sex schools, enrolling either male or female students only. Since the mid-1970s some of these schools have moved towards co-educational patterns of school organization. Within the non-government sector a higher proportion of students has been enrolled in primary-secondary schools, established to give continuity of educational experiences in a single institution rather than to increase the opportunities for secondary education to students in geographically remote areas as in the government primary-secondary schools. Some of the non-government schools have also provided residential facilities for a proportion of their students.

The following brief description summarizes the education systems as they affect the majority of students. It does not attempt to provide a thorough description of the richness and variety of the systems in the provision of ancilliary services to these students or in the facilities available to students with special needs.

Australian Capital Territory

From the time that Canberra was founded, education in government schools in the Australian Capital Territory was administered on behalf of the Commonwealth Government by the New South Wales Department of Education. Following a series of inquiries the Australian Capital Territory Schools Authority was formally established in 1977 to take responsibility for education in the Australian Capital Territory. In 1964 the structure of the education system in the Australian Capital Territory was the same as in New South Wales. In 1978 there were three tiers of government schools: primary schools (Years K to 6), secondary schools (Years 7 to 10) and secondary colleges (Years 11 to 12).

New South Wales

In 1964 there were seven primary year levels (Grades K to 6), and five secondary year levels. Although most of the government secondary schools were co-educational and comprehensive, there were several single-sex schools providing an academic program only, to a selected intake of students.

The structure of the New South Wales education system was altered under the Wyndham scheme by the introduction in 1967 of a sixth year of secondary schooling. As well as increasing the total enrolments and the mean age of the final-year secondary students, there were many subsequent adjustments to the curriculum at the upper secondary level. By 1978 the system had adjusted to these changes in the structure and curriculum. The same types of school existed, although the influence on the system of the selective single-sex academic government secondary schools had declined. Another important development in New South Wales, as the largest education system in Australia, was the effort made to decentralize some of the administrative processes of the Department of Education to the eleven Regional Directorates.

Victoria

In 1964 Victoria had 12 notional Year levels, although in practice students spent two years in Grade 1, to give an effective seven years at the primary level and six years at the secondary level. By 1978 the initial years had been formally separated into Preparatory and Year 1. As in New South Wales, there were a few selective single-sex academic government secondary schools in 1964, although the degree of selectivity had been relaxed by 1978 to enable students from the immediate geographical area to attend these schools. The most distinctive feature of the Victorian secondary school system remained the technical schools, administered by a separate division of the Education Department. The technical schools offered only the first five years of secondary schooling, and the curriculum had a strong vocational orientation. Most of the technical schools were single-sex, and most of them were for male students. It follows that the co-educational high schools have had a higher proportion of female students in areas where there were male technical schools.

Queensland

In 1964 Queensland government schools operated with seven years of primary schooling and five years of secondary schooling, having recently changed from a structure with eight primary and four secondary Year levels. This meant that much of the curriculum at the lower secondary school level was in the hands of teachers whose training and experience had been at the primary school level. By 1978 the effects of the transition had generally disappeared. The isolation of students in remote country areas has continued to represent a significant feature of education in Australia, remaining as a particularly important problem in Queensland. Apart from the Northern Territory, Queensland was the State which had the highest proportion of its school population living in non-metropolitan areas.

South Australia

In South Australian government schools in 1964 and 1978 there were seven primary school year levels and five secondary school year levels. The major change in the structure of the education system over this period was the elimination of the technical high schools by incorporating them into the normal high schools while extending the range of vocationally-oriented courses offered by the high schools. In the process, the single-sex basis of the technical high schools was replaced by the co-educational structure of the high schools.

Western Australia

There were no major changes between 1964 and 1978 in the basic structure of the Western Australian government school system, which involved seven primary year levels and five secondary year levels.

Tasmania

The Tasmanian government schools during the period 1964 to 1978 had six years of primary schooling and six years of secondary schooling. Students in Tasmania have differed from those in other States by having the option of sitting for their matriculation examination from Year 11 (Form V) as well as from Year 12 (Form VI). In 1964 only four of the government high schools, designated matriculation high schools, offered courses at Years 11 and 12. By 1978 the matriculation level courses in government schools were restricted to seven matriculation colleges, while the high schools offered courses in Years 7 to 10.

Northern Territory

In 1964 education in government schools in the Northern Territory was administered by the South Australian Education Department on behalf of the Commonwealth government. In 1977 the Northern Territory became a self-governing territory, and education was placed under the control of the Northern Territory Department of Education. The education system continued to follow the South Australian pattern of seven years of primary schooling and five years of secondary schooling. Since the small population of the State was widely dispersed, and contained a high proportion of Aboriginal students, it was not included in the IEA studies. Subsequent sections of this chapter will refer to the Northern Territory only in terms of student enrolments, as part of the total picture of Australian education.

Table 2.2 Public Examinations

State	1964 Examination	1964 Year	1978 Examination	1978 Year
ACT	(See NSW).)		ACT Accrediting Agency Year 12 Certificate[a]	12
NSW	Intermediate[b] Leaving	10 12	Higher School Certificate	12
Vic.	Intermediate[b] Leaving[b] Matriculation	10 11 12	Higher School Certificate[b]	12
Qld	Junior Public Senior Public	10 12	Board of Secondary School Studies Certificate[a]	12
SA	Intermediate Leaving Leaving Honours	10 11 12	Matriculation	12
WA	Junior[b] Leaving	10 12	Achievement Certificate (Leaving) Tertiary Admissions Examination (Matriculation)	12 12
Tas.	Schools Board Matriculation	10 11/12	School Certificate Higher School Certificate	10 12
NT	(See SA.)		(See SA.)	

Note: [a] Indicates that all of the examination or assessment was done at the level of the individual school.

[b] Indicates that part of the examination or assessment was done at the level of the individual school.

Changes in Public Examinations

A major influence on the curriculum of Australian secondary schools has been exerted by public examinations. Each State has established agencies which have been concerned with conducting public examinations or comparable procedures in order to provide certification of learning achieved during the final year of secondary schooling and for the purpose of selecting students for entry to tertiary institutions. Table 2.2 lists the major public examinations in 1964 and 1978.

From Table 2.2 it can be seen that in 1964 students in the Australian Capital Territory and the Northern Territory sat for public examinations conducted by New South Wales and South Australia, respectively. In 1978 students in the Northern Territory continued to sit for the South Australian examination. The table also indicates the States where individual schools have had some responsibility in setting and marking examinations or otherwise contributing to the assessment procedures of the public examinations.

There have been two important changes in the public examination system over the period 1964 to 1978. Firstly, public examinations below Year 12 level have been eliminated. Secondly, there has been considerable discussion and experimentation on the issue of preparing suitable assessment procedures at the end of Year 12 which would serve the purpose of selecting students for tertiary study without constraining the curriculum studies by those students at the upper secondary level who were not intending to proceed to tertiary study. By 1978 the Australian Capital Territory and Queensland had replaced the traditional system of a single examination prepared and marked under the control of the State agency by a system of school-based assessments moderated by the State agency.

General Changes in Mathematics Education

During the period under review there have been three changes in Australian society which have had very important implications for the mathematics curriculum in Australian schools: the introduction of decimal currency, the process of metrication of units of measurement, and the availability of cheap hand-calculators.

Australia converted from the English currency system of pounds, shillings and pence to a decimal system of dollars and cents on 14 February 1966. The probable effect on the mathematics curriculum was a simplification of important skills in the handling of money. Not only would students learn these skills better, but more time would be available for learning other aspects of mathematics. On the other hand, students would obtain less practical experience in handling factors of 12 and 20. Although the conversion of units of measurement from the Imperial system to the metric system has been more gradual than the conversion of currency units, it has probably had similar effects on the mathematics curriculum.

The availability of electronic hand-calculators with increasing performance/cost ratios has made it possible for all students to have access to powerful computational facilities. In general the mathematics curricula of the schools have not been modified to respond to this revolution in computational facility. There has been some ambivalence among teachers and parents as to the desirability of incorporating the use of hand-calculators into the school curriculum at the primary or lower secondary school levels, so that hand-calculators have had a greater impact at the upper secondary level in mathematics and science courses where their advantages have been more obvious.

As described by Blakers (1978) the major impact on the mathematics curriculum from 1964 to 1978 was due to the increased emphasis on the structure of the subject and an understanding of the processes of mathematical operations. The overall pattern of change during the period under review had already been initiated in the late 1950s and early 1960s. Several major curriculum development projects had been commenced in the United States and the United Kingdom; for example, the School Mathematics Study Group (Colorado), the University of Illinois Committee on School Mathematics and the School Mathematics Project (Southampton). The ideas underlying these projects were slowly disseminated in Australia as a result of visits to the projects by influential Australian mathematics educators - school administrators, curriculum development officers and tertiary-level mathematicians. Some of the leaders of the projects also visited Australia.

Associated ideas about building understanding of conceptual structures by means of operations on concrete materials were also promulgated by their advocates. The Cuisenaire rods designed by Gattegno were widely adopted in Victoria. The concrete materials designed by Dienes were introduced during the period while he was working at the University of Adelaide, and thus were widely adopted in South Australia.

Since the mathematics curriculum was generally determined at the State level, there was initially little interchange of ideas across State boundaries. Gradually more widespread discussion took place. In particular, after its formation in the mid-1960s the Australian Association of Mathematics Teachers provided a forum for mathematics teachers and others involved in mathematics education to discuss the changes in the curriculum.

The projects developed overseas were not adopted directly in Australian schools, partly due to their unsuitable cultural and linguistic emphasis, but also because the content and approach of the overseas programs were so different from the current Australian programs that a vast amount of inservice training of the Australian teachers would have been necessary for their successful implementation. Rather, the overseas project materials were adapted for use in Australia, although this still required a strong commitment by the State education systems to the inservice education of the mathematics teachers to familiarize them with the contents and methods of the new curriculum.

Changes Affecting 13-year-old Students

Enrolments

From 1964 to 1978 there was an overall increase of 18 per cent in the number of 13-year-old students in Australian Schools, as shown in Table 2.3, although the overall value fails to reflect marked changes in certain sectors. The largest percentage increases were registered in the Australian Capital Territory and the Northern Territory, but these increases were a function of the relatively low base enrolments in 1964. Of the other States, Queensland and Western Australia showed the greatest percentage growth in enrolments. The percentage increase in non-government schools relative to that in government schools showed no consistency across States. Of particular note was the low increase in New South Wales and the decreases in South Australia and Tasmania.

During the period under review there were also changes in the distribution of 13-year-old students across year levels. Table 2.4 shows the percentage of 13-year-old students in each of Years 7 to 9 for 1964 and 1978. For the Australian Capital Territory and New South Wales, the designated Year 7 in 1964 was the seventh year of schooling, whereas Year 7 in 1978 was the eighth year of schooling, with a corresponding pattern applying for Years 8 and 9.

These values show that non-government schools in 1964 and 1978 had a higher percentage of 13-year-old students at Year 9 level. This was probably due to the higher average ability of students in non-government schools; in other words, a higher percentage of the 13-year-old students in non-government schools had reached a standard of work appropriate to Year 9. By the same token, for 1978 (but not for 1964) the non-government schools had a lower percentage of students in Year 7.

From 1964 to 1978 there was a decline in the percentage of students at the last primary school year level in both government and non-government schools. In all States except South Australia this resulted in an increased percentage in Year 8. However, several of the States also had consequent increases at the Year 9 level. These changes in the distribution of students

Table 2.3 Number of 13-year-old Students[a]

Year	ACT	NSW	Vic.	Qld	SA	WA	Tas.	NT	Aus.
1964									
Government									
1-6	1	431	1,694	1,358	1,113	219	252	103	5,171
7	46	2,964	11,315	4,206	3,047	998	2,346	80	25,002
8	539	27,495	25,951	11,990	9,238	7,725	2,902	133	85,973
9	483	23,148	2,977	5,242	3,313	3,465	187	42	38,857
10	8	410	40	15	15	2	1		491
Other	12	619	250		254	299	74		1,508
Total	1,089	55,067	42,227	22,811	16,980	12,708	5,762	358	157,002
Non-government									
1-6	4	223	701	565	173	98	219	13	1,996
7	24	1,287	3,135	2,146	730	408	493	23	8,246
8	186	6,378	8,603	3,344	1,824	2,110	583	15	23,043
9	267	9,444	2,123	1,328	823	987	67	10	15,049
10	12	573	25	30	6	11			657
Other	2	72	30		5				109
Total	495	17,977	14,617	7,413	3,561	3,614	1,362	61	49,100
All schools									
1-6	5	654	2,395	1,923	1,286	317	471	116	7,167
7	70	4,251	14,450	6,352	3,777	1,406	2,839	103	33,248
8	725	33,873	34,554	15,334	11,062	9,835	3,485	148	109,016
9	750	32,592	5,100	6,570	4,136	4,452	254	52	53,906
10	20	983	65	45	21	13	1		1,148
Other	14	691	280		259	299	74		1,617
Total	1,584	73,044	56,844	30,224	20,541	16,322	7,124	419	206,102
1978									
Government									
1-6	20	592	303	187	36	23	59	114	1,334
7	1,042	23,687	8,958	2,595	674	814	1,668	237	39,675
8	1,458	36,689	37,414	15,432	9,952	10,454	4,291	696	116,386
9	93	534	1,260	9,801	8,345	5,599	182	364	26,178
10	1	2	7	151	24	7		8	200
Other	44	1,267	527	609	350	273	68	11	3,149
Total	2,658	62,771	48,469	28,775	19,381	17,170	6,268	1,430	186,922
Non-government									
1-6	8	252	123	22	5	13	12	15	450
7	269	4,523	2,466	559	126	207	303	48	8,501
8	825	13,273	14,436	5,303	1,701	2,874	911	101	39,424
9	44	448	766	3,494	1,689	1,499	78	64	8,082
10	1	3	6	11	9	8			38
Other		116	32	2	7				157
Total	1,147	18,615	17,829	9,391	3,537	4,601	1,304	228	56,652

... contd

Table 2.3 Number of 13-year-old Students (contd)

Year	ACT	NSW	Vic.	Qld	SA	WA	Tas.	NT	Aus.
All schools									
1-6	28	844	426	209	41	36	71	129	1,784
7	1,311	28,210	11,424	3,514	800	1,021	1,971	285	48,176
8	2,283	49,962	51,850	20,735	11,653	13,328	5,202	797	155,810
9	137	982	2,026	13,295	10,034	7,098	260	428	34,260
10	2	5	13	162	33	15		8	238
Other	44	1,383	559	611	357	273	68	11	3,306
Total	3,805	81,386	66,298	38,166	22,918	21,771	7,572	1,658	243,574
% increase from 1964 to 1978									
Government	144%	14%	15%	26%	14%	35%	9%	299%	19%
Non-government	132%	4%	22%	27%	-1%	27%	-4%	274%	15%
All schools	140%	11%	17%	26%	12%	33%	6%	296%	18%

Note: [a] Final primary year levels have been underlined.

were largely due to the application of policies to promote students each year so that they remained with their age peers. There was also an associated tendency to avoid accelerated promotion of very able students ahead of their peers. These changes have certain implications for mathematics curriculum. If the curriculum for each year level remained the same over the period under review but a higher percentage of 13-year-old students were at higher year levels, then there would be a greater average level of exposure of 13-year-old students to higher levels of the mathematics curriculum.

Time Spent on Mathematics

There are other aspects of the exposure of students to the mathematics curriculum, of which the foremost is the amount of time allocated to the subject at school. Table 2.5 presents estimates of the number of hours per week spent in class on mathematics in 1964 and 1978 in Years 1 to 9. It was clearly recognized that individual classes or schools may have varied from the estimates given, which were supplied by officers of the State Education Departments and applied to government schools. In the absence of further information it was assumed that the same situation applied to non-

Table 2.4 Percentage of 13-year-old Students by Year Level

Year	ACT %	NSW %	Vic. %	Qld %	SA %	WA %	Tas. %	NT %
1964								
Government								
Year 7	4	5	27	18	18	8	41	22
Year 8	49	50	61	53	54	61	50	37
Year 9	44	42	7	23	20	27	3	12
Non-government								
Year 7	5	7	21	29	20	11	36	38
Year 8	38	35	59	45	51	58	43	25
Year 9	54	53	15	18	23	27	5	16
All students								
Year 7	4	6	25	21	18	9	40	25
Year 8	46	46	61	51	54	60	49	35
Year 9	47	45	9	22	20	27	4	12
1978								
Government								
Year 7	39	38	18	9	3	5	27	17
Year 8	55	58	77	54	51	61	68	49
Year 9	3	1	3	34	43	33	3	25
Non-government								
Year 7	23	24	14	6	4	4	23	21
Year 8	72	71	81	56	48	62	70	44
Year 9	4	2	4	37	48	33	6	28
All schools								
Year 7	34	35	17	8	3	5	26	17
Year 8	60	61	78	54	51	61	69	48
Year 9	4	1	3	35	44	33	3	26

government schools. The estimates for the secondary year levels in 1964 were derived from the data collected from students in the samples, and the values for South Australia were the means of the values for the other States. For 1964, the Australian Capital Territory values were based on the New South Wales values. The table also presents estimates of the mean amount of time spent each week in class on mathematics over the primary school year levels, the secondary school year levels, and the total period from Years 1 to 9.

Table 2.5 Index of Class Time (Hours per Week) Spent on Mathematics by Year Level

Year	ACT	NSW	Vic.	Qld	SA	WA	Tas.
1964							
1	2.0	2.0	3.5	5.0	3.0	2.5	3.0
2	2.0	2.0	3.5	5.0	3.0	2.5	3.5
3	2.5	2.5	3.5	5.0	4.3	2.5	4.0
4	3.8	3.8	3.5	5.0	4.3	3.3	4.0
5	3.8	3.8	4.0	5.0	4.8	3.3	4.0
6	4.3	4.3	4.0	5.0	4.8	3.5	4.0
7	4.3	4.3	4.9	5.0	4.8	3.5	3.6
8	4.8	4.8	4.8	4.8	4.6	4.9	3.7
9	3.9	3.9	4.4	5.1	4.5	4.4	4.6
Total primary	22.7	22.7	22.0	35.0	29.0	21.1	22.5
Total secondary	8.7	8.7	14.1	9.9	9.1	9.3	11.9
Total Years 1 to 9	31.4	31.4	36.1	44.9	38.1	30.4	34.4
Mean primary	3.2	3.2	3.7	5.0	4.1	3.0	3.8
Mean secondary	4.4	4.4	4.7	5.0	4.6	4.7	4.0
Mean Years 1 to 9	3.5	3.5	4.0	5.0	4.2	3.4	3.8
1978							
1	2.5	3.8	3.8	5.0	3.0	3.3	3.5
2	2.5	3.8	3.8	5.0	3.0	3.3	3.5
3	2.5	3.3	4.0	5.0	4.0	3.3	3.5
4	3.3	3.3	4.0	5.0	4.0	3.8	4.0
5	4.3	3.3	4.0	5.0	4.3	3.8	4.0
6	4.3	4.0	4.0	5.0	4.3	4.0	4.0
7	3.5	4.0	4.0	5.0	4.3	4.0	3.5
8	3.5	4.0	4.0	3.6	4.0	4.0	3.5
9	3.5	3.3	4.0	3.6	4.3	4.0	3.5
Total primary	19.4	21.5	23.6	35.0	26.9	25.5	22.5
Total secondary	10.5	11.3	12.0	7.2	8.3	8.0	10.5
Total Years 1 to 9	29.9	32.8	35.6	42.2	35.2	33.5	33.0
Mean primary	3.2	3.6	3.9	5.0	3.8	3.6	3.8
Mean secondary	3.5	3.8	4.0	3.6	4.2	4.0	3.5
Mean Years 1 to 9	3.3	3.6	4.0	4.7	3.9	3.7	3.7
% increase from 1964 to 1978							
Mean primary	0%	10%	7%	0%	-8%	21%	0%
Mean secondary	-20%	-13%	-15%	-27%	-9%	-14%	-12%
Mean Years 1 to 9	-5%	+5%	-1%	-6%	-8%	+10%	-4%

These data show that the time spent in class on mathematics from Years 1 to 9 declined between 1964 and 1978 in all States except Western Australia. The main contribution to this decline was the large decrease in time spent on mathematics at the secondary school level.

If it were assumed that a student's capacity to learn mathematics was greater at higher year levels, and that achievement was a function of the time spent in class on mathematics, then it follows that decreases in the time allocated at higher year levels would have a more serious effect on mathematics achievement than equivalent decreases at lower levels. Other things being equal, the mathematics achievement of 13-year-old students in 1978 would be lower than in 1964 as a result of the observed decrease in time allocated to the teaching of mathematics at the secondary level.

Mathematics Curriculum

The next stage in the discussion of students' exposure through schooling to mathematics is to consider the content of the mathematics curriculum. In 1964 substantial changes in the content of mathematics courses were under consideration. The first IEA study fortuitously mapped the situation at an appropriate stage to provide baseline data for the examination of changes in content and consequent effects on achievement.

In the early 1960s some mathematics educators were suggesting new directions for the curriculum. These have been encapsulated in the term 'new' mathematics. In essence the purpose of new mathematics has been to increase the ability of students to solve problems involving mathematics which require skills other than mere computation. In order to attain these greater problem-solving skills it was considered necessary that students should learn more about the basic structures of mathematics including mathematical operations and the nature of number systems. By 1964 all States had started experimental and developmental work in preparation for a complete revision of primary level mathematics courses.

At the lower secondary level most schools in 1964 conducted mathematics courses that were strongly influenced by the syllabus outlines prepared by the public examination bodies. The courses in each State were similar but not identical. In order to analyse the curriculum in each State, a curriculum content analysis grid has been employed. The grid was initially prepared by IEA for cross-national comparisons in the 1964 study.

The first stage in preparing the curriculum grid was to specify a series of content topics, grouped for convenience into the broader areas of

B

arithmetic, algebra and geometry. It was not assumed that this grouping reflected distinct teaching areas. Although some schools still taught mathematics according to these teaching areas, most Australian schools had adopted the practice of teaching mathematics as a single subject, which involved emphasizing inter-relationships between overlapping sections of arithmetic, algebra and geometry. Each topic was then rated in terms of its objectives, emphasis and universality.

Objectives. For each topic the letters A, B, C or D were used to indicate the major objective or objectives, in terms of the type of intellectual behaviour or process to be developed in teaching that topic:

A skills and techniques of computation and manipulation;

B knowledge of definitions, notation, operations and concepts;

C translation of information into symbols and the interpretation of symbols; and

D comprehension of mathematical reasoning, the ability to form conclusions, to construct proofs and the ability to apply mathematical ideas to new problems.

Emphasis. For each topic the ratings 1, 2 or 3 were used to indicate the level of emphasis given in the mathematics course to that topic:

1 low emphasis (an unimportant part of the course);

2 moderate emphasis; and

3 high emphasis (an important part of the course).

Universality. For each topic the letters U, R, or N were used to indicate the extent to which that topic was included in the mathematics courses taken by most 13-year-old students:

U universal: that is, the topic was taught or assumed in all types of schools at this level. If the topic was included in the primary school syllabus for a given State, it was classified in this category.

R restricted: that is, the topic was taught in certain types of schools, or in courses to the students following an academic program, and may have been taught to some students following a non-academic program. If the topic was included in the course for academic students during their eighth year of schooling, it was classified in this category.

N nil: that is, the topic was not taught at all in the educational system at this level, and was not assumed from previous teaching.

Table 2.6 presents the results of the content analysis for 1964. Ratings were given for objectives and importance overall, and for universality by States. In some cases a 'restricted' rating for universality was applied to a topic in an experimental program being tested prior to more extensive use through the system.

It must be stressed that the ratings were estimates made by curriculum officers of the State Education Departments. The ratings represented the average situation in terms of the content of the mathematics curriculum to which the majority of 13-year-old students was exposed, and there would have been many individual departures from these average ratings as a function of year level placement or curriculum policy decisions at the school level. Nevertheless, the final picture that emerged was considered by experienced Australian mathematics educators to give a coherent picture of the curriculum in 1964.

By 1978 mathematics courses at the primary school level had thoroughly incorporated the changes that were being planned in 1964. By 1978 all of the students up to Year 12 would have been influenced for their entire school career by the revised mathematics curriculum. Indeed, the younger mathematics teachers in 1978 would have spent all or most of their career in mathematics under this influence.

The most marked change between 1964 and 1978 at the lower secondary school level was the gradual reduction of the influence on mathematics courses by public examination bodies. This prompted a strengthening of the services provided to schools by the curriculum development sections of the State Education Departments. By 1978 most of the Departments had prepared detailed guidelines for the types of mathematics that might be taught, but individual schools were given the responsibility for selecting the topics to be taught and often the year levels at which they were to be taught.

This devolution of responsibility for curriculum specification to the school level meant that it was more difficult to obtain confident estimates for the ratings in the curriculum content analysis grid for 1978, also given in Table 2.6. It was clearly recognized that the richness and diversity of a carefully prepared course could not be fully represented by forcing its elements into such a grid. It was also recognized that the individual variations from the cell entries may have been larger in 1978 than in 1964. However, the completed grids for 1964 and 1978 did serve the important purpose of enabling a systematic examination of the changes in the

Table 2.6 Content Analysis of Mathematics Courses for 13-year-old Students

	1964								1978							
	Objective	Emphasis	NSW	Vic.	Qld	SA	WA	Tas.	Objective	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Arithmetic																
1 Reasonable competence in the four operations on natural numbers	AB	3	U	U	U	U	U	U	AB	3U	3U	3U	3U	3U	3U	3U
2 Ability to carry out simple operations involving decimal fractions	AB	3	U	U	U	U	U	U	AB	3U	3U	3U	3U	3U	3U	3U
3 Ability to carry out simple operations involving vulgar fractions	AB	2	U	U	U	U	U	U	AB	2U	3U	3U	2U	3U	3U	2U
4 Understanding of the concept of fractions (vulgar and decimal)	CD	3	U	U	U	U	U	U	AB	3U	3U	3U	3U	3U	2U	3U
5 Application of operations with natural and rational numbers in everyday situations	CD	3	U	U	U	U	U	U	AC	3U	3U	1U	3U	2U	2U	3U
6 Measurement of quantities (length, area, volume capacity, time, speed, money)	AB	3	U	U	U	U	U	U	AB	3R	3U	2U	3U	3U	2U	3U
7 Notion of ratio and proportion including percentages	AC	3	R	R	R	R	R	R	ABC	3U	3U	2U	3U	2R	3U	3R
8 Notion of arithmetic mean	AC	2	R	U	U	U	U	U	AB	2U	3U	2U	2U	2R	1R	2R
9 Interpretation and making of simple practical graphs and tables	ABC	3	R	R	R	R	R	R	ABC	3U	3U	2R	3U	3U	3U	3U
10 Intuitive understanding of associative, distributive and commutative properties of operations	AD	2	R	U	R	R	R	U	B	3U	2R	1R	3U	2R	2U	2U
11 Expression of these laws by means of letters	BC	1	R	N	R	N	R	R	BC	1R	2R	2R	1R	1R	2U	N
12 Prime factors, divisors, multiples	AB	2	R	U	U	U	U	U	AB	3U	2U	N	2U	3U	2U	2U
13 Notions of powers and simple calculations of areas and volumes	AC	2	R	U	R	R	R	U	ABC	2U	3U	2U	2U	3U	3U	2R
14 Notions of number systems other than the decimal system	AD	2	R	N	N	N	N	R	B	1R	2R	1R	2U	1R	1R	1R
15 Notions of square roots	A	1	R	R	U	R	R	U	AB	2U	2U	2U	2U	2U	2U	2R

... contd

Table 2.6 Content Analysis of Mathematics Courses for 13-year-old Students (contd)

	1964								1978							
	Objective	Emphasis	NSW	Vic.	Qld	SA	WA	Tas.	Objective	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Algebra																
16 Notions of positive and negative numbers, number line	AC	3	R	R	N	R	R	U	B	3U	3U	3U	2U	2U	3U	3U
17 Extension of the four fundamental operations to positive and negative numbers	AB	2	R	R	N	R	R	R	AB	3U	3U	3U	1R	2U	3U	2U
18 Negative and zero exponents	AC	1	R	R	N	R	R	R	B	3R	2R	1R	1U	2U	N	N
19 Formulae and algebraic expressions	AC	3	R	U	R	R	R	U	BC	3U	3U	2U	2U	3U	2U	3U
20 Numerical evaluation of formulae and algebraic expressions	B	3	R	U	R	R	R	U	A	2U	3U	2U	2U	2U	2U	3U
21 Operations with polynomials and monomials	AB	2	R	R	R	R	R	R	AB	2R	2R	1U	2R	1R	3U	2R
22 Simple algebraic identities e.g. $(x+y)^2$, $(x-y)^2$, $(x-y)(x+y)$	AB	1	N	N	N	N	N	N	AB	2R	2R	2R	2R	N	1R	1R
23 Notions of the equation	A	3	R	U	R	R	R	U	B	3U	3U	3U	2R	2U	2U	3U
24 Equations of the first degree with numerical coefficients	B	3	R	U	R	R	R	U	AB	3U	3U	3U	2R	3U	3R	3U
25 Simple problems using equations of the first degree	C	3	R	U	R	R	R	R	AB	2U	2R	3U	1R	2U	1R	3R
26 Simple systems of linear equations with two unknowns	AB	1	N	R	N	N	N	R	A	1R	N	1R	N	1R	N	1R
27 General notions of functions	AC	2	N	R	N	N	N	R	B	1R	2U	2R	1R	3U	N	N
28 Graphical representation of functions of type $y=ax$, $y=ax+b$, $y=\frac{a}{x}$, $y=ax^2$	BC	2	N	R	N	N	N	R	A	1R	N	1R	1R	1R	N	N
29 Elementary notions of sets	AC	3	R	N	N	N	R	R	BC	2U	2U	2U	2U	2U	3U	2U

... contd

Table 2.6 Content Analysis of Mathematics Courses for 13-year-old Students (contd)

	1964								1978							
	Objective	Emphasis	NSW	Vic.	Qld	SA	WA	Tas.	Objective	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Geometry																
30 Intuitive treatment of simple geometrical figures	A	3	U	U	U	U	U	U	B	3U	3U	2R	3U	3U	3U	3U
31 Intuitive treatment of straight line, opposite angles, perpendicular and parallel lines	A	3	R	U	R	R	R	U	B	3U	3U	2U	3U	3U	3U	3U
32 Intuitive treatment of symmetry and congruence	A	3	R	R	N	R	N	U	B	3U	3U	2R	2U	3U	3U	2U
33 Intuitive treatment of translation and rotation	A	1	N	N	N	N	N	N	B	2U	3U	2R	2R	3U	3U	N
34 Measurement of distances and angles	AB	3	U	U	R	R	R	U	AB	3U	3U	3U	2U	3U	3U	3U
35 Simple construction with graduated ruler, compasses, protractor	B	3	U	U	R	R	R	U	AB	3U	1R	2U	2U	3U	3U	2U
36 Intuitive treatment of similarity; scale drawing	ABC	3	R	U	N	R	N	R	B	3U	2R	1R	1R	3R	3U	2R
37 Properties of simple solids	A	2	R	U	N	N	N	N	B	3U	2U	1R	2U	1R	1U	2U
38 Calculation of area and volume	BC	2	R	R	R	U	R	R	AB	2R	2U	1U	2U	3U	1U	2R
Simple deductive reasoning based on:																
39 (a) properties of angles determined by parallel lines and transversal and sum of angles of a triangle	AD	3	R	R	R	R	R	R	ABD	2U	2R	1R	1R	3U	2U	3R
40 (b) symmetry of isosceles triangle and rhombus	AD	3	N	N	R	N	N	N	BD	2U	2R	1R	N	3U	1U	3R
41 (c) fundamental conditions of congruence of two triangles	AD	3	N	N	N	N	N	N	B	2R	2R	1R	N	2R	N	3R
42 (d) inequality of triangles	AD	3	N	N	N	N	N	N	-	1R	N	1R	N	2U	N	N
43 (e) properties of the parallelogram	AD	3	N	R	R	N	N	R	B	1R	2R	1R	N	3U	N	3R
44 Simple deductive reasoning based on the properties of the inscribed angle of a circle	AD	1	N	N	R	N	N	N	-	1R	N	N	N	N	N	N
45 The theorem of Pythagoras for solving simple practical problems	ABC	2	N	R	N	N	N	R	ABC	3R	3U	2R	1U	2R	N	3R

mathematics curriculum from 1964 and 1978. More information was available in 1978, so that ratings for emphasis and universality have been given for each State, in conjunction with a rating for objectives for Australia overall.

Arithmetic. There was substantial coverage in both 1964 and 1978 of the basic arithmetic topics 1 to 6. The coverage of most of the other arithmetic topics was extended from 1964 to 1978. This may have involved spending less time on the basic arithmetic in 1978 in order to make more time available for the advanced arithmetic topics.

Algebra. There was an increase by 1978 in the inclusion of algebra topics dealing with formulae and equations (19, 20, 23 to 25). Work with functions (27, 28) remained a limited part of the course in 1964 and 1978. Topics dealing with negative and zero exponents (18), polynomial operations (21) and algebraic identities (22), had a fairly low level of acceptance in 1964, and had increased slightly by 1978. Graphical representation of functions (28) remained at a low level in both 1964 and 1978.

Geometry. In the 1964 grid, the only topic covered by all students dealt with the intuitive treatment of simple geometrical figures (30). By 1978 eight of the topics in the grid were universally accepted by a majority of States. This reflected the changing place of geometry, from a rigorous and axiomatic treatment reserved for academic students to a more general introduction to spatial relationships.

The topics accepted as universal or restricted in most States in 1978 were concerned with intuitive treatments of basic geometrical ideas (30 to 33, 36), and with simple constructions and calculations (34, 35, 38). There was only a low place accorded to simple deductive reasoning.

In summary, the topics which were generally included in the 1978 curriculum covered a much wider range than in 1964. This probably gave students a wider exposure to the richness encompassed by the discipline of mathematics but the variety may have been achieved at the expense of time spent on a thorough understanding of basic skills and concepts.

New Mathematics

The curriculum grid also contained various topics associated particularly with new mathematics, including various properties of operations (topics 10 and 11), number systems other than the decimal system (14), the use of positive and negative numbers (16 and 17), and the notions of sets (29). It can be seen from the table that topics 10, 11 and 14 increased their place in the curriculum, although they did not receive universal acceptance across all States. The other three topics all moved from a restricted or experimental position to become universally accepted in all courses.

In summary, the period from 1964 to 1978 was marked by an increase in the number of 13-year-old students. By 1978 few of these students were at primary school, and Year 8 had become the modal year for this age group. The students had moved to a more varied curriculum under the influence of revisions associated with new mathematics, although less time was devoted in class at the secondary school level to the teaching of mathematics.

Changes Affecting Year 12 Students

Enrolments

Any analysis of changes in the mathematics curriculum and performance at the Year 12 level must take account of the large growth in enrolments at this level between 1964 and 1978, as presented in Table 2.7. For Australia overall the enrolments virtually doubled over the period, although growth in the government sector was greater than in the non-government sector. There were probably several factors contributing to the growth. In part it reflected increasing aspirations of students to obtain more education for its own sake or to obtain certification to facilitate entry to the work-force or to tertiary institutions. The growth may also have been partly due to the phasing out of public examinations at Years 10 and 11, so that some students remained at school until they could obtain a certificate from the public examination at Year 12, a trend that may have been encouraged by a tendency of employers to require higher entry qualifications for particular employment areas. Finally, the growth may have been supported by increasing affluence in the society, so that more families could afford the costs associated with keeping their children at school until the final year of secondary schooling.

Mathematics Courses

The student enrolments provide the general context for the examination of mathematics courses and achievement at the final-year secondary level.

Table 2.7 Number of Students in Year 12

	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Aus.
1964-								
Government	390	13,543	5,952	3,786	1,643	1,635	325	27,274
Non-government	260	7,583	5,034	3,023	929	1,260	207	18,296
All schools	650	21,126	10,986	6,809	2,572	2,895	532	45,570
1978								
Government	1,608	22,003	12,837	9,489	6,575	5,017	1,667	5[illegible]96
Non-government	709	9,273	10,209	5,329	2,549	2,526	432	31,027
All schools	2,317	31,276	23,046	14,818	9,124	7,543	2,099	90,223
% increase 1964 to 1978								
Government	312%	62%	116%	151%	300%	207%	413%	117%
Non-government	173%	22%	103%	76%	174%	100%	109%	70%
All schools	256%	48%	110%	118%	255%	161%	295%	98%

Attention will now be given to the students who studied mathematics at Year 12, since this level of participation varied across the States. This represented one important difference with respect to the 13-year-old students, where it could be assumed that 100 per cent of the year cohort studied mathematics.

The extent to which Year 12 students included mathematics in their studies depended largely on requirements specified by the public examination bodies for matriculation, defined as the minimum requirement for entry to a university, or on requirements specified by particular faculties of the universities or other tertiary institutions. Table 2.8 lists the names of the Year 12 certificates issued by the public examination bodies in 1964 and 1978, together with an indication of the minimum requirements for mathematics.

In most States in 1964 the matriculation requirements tended to exert pressure on students to include mathematics among the subjects studied in Year 12. By 1978 a pass in a mathematics subject was no longer a formal requirement for matriculation, although faculties like Engineering and Science at tertiary institutions often specified mathematics as a prerequisite.

Table 2.8 Year 12 Certificates and Minimum Mathematics Matriculation Requirements

State	Year	
ACT	1964	NSW Leaving Certificate (see below).
	1978	ACT Accrediting Agency Year 12 Certificate: Mathematics is not required for matriculation but is required for certain faculties at ACT tertiary institutions.
NSW	1964	Leaving Certificate: Mathematics III or General Mathematics or a foreign language is compulsory for matriculation.
	1978	Higher School Certificate: Mathematics is not required for matriculation but is required for certain faculties at NSW tertiary institutions.
Vic.	1964	Matriculation Examination: Mathematics is not required for matriculation but is required for Engineering and Science faculties.
	1978	Higher School Certificate: Mathematics is not required for matriculation but is required for certain faculties at Victorian tertiary institutions.
Qld	1964	Senior Public Examination: Mathematics I required for all faculties except Arts, Law and Education.
	1978	Board of Secondary School Studies Certificate: Mathematics is not required for matriculation but is required for certain faculties at Queensland tertiary institutions.
SA	1964	Leaving Honours Examination: Leaving Mathematics I or Mathematics II (at Year 11) or a foreign language is compulsory for matriculation.
	1978	Matriculation Examination: Mathematics is not required for matriculation but it is assumed knowledge in certain faculties at South Australian tertiary institutions.
WA	1964	Leaving Examination: Subjects from three out of four groups of subjects are required; Mathematics and Music constitute one of the groups.
	1978	Tertiary Admissions Examination: Mathematics is not required for matriculation but is required for certain faculties at Western Australian tertiary institutions.
Tas.	1964	Matriculation Examination: Mathematics (ordinary level) or a foreign language is compulsory. Students may sit for the examination from Year 11 (Year V) and/or Year 12 (Year VI).
	1978	Higher School Certificate: Mathematics is not required for matriculation but is required for certain faculties at Tasmanian tertiary institutions. Students may sit for the examination from Year 11 and/or Year 12.

During the period 1964 to 1978 there was a shift in the range of mathematics courses offered at the Year 12 level. Table 2.9 summarizes these courses, indicating also the function of the different courses or sets of courses. These functions have been described in terms of the types of tertiary courses which could be undertaken following their successful completion. Type 1 were 'terminal' mathematics courses which were not designed to provide a foundation for any future tertiary studies involving mathematics. Type 2 were courses involving a higher level of mathematical competence, providing a satisfactory background for tertiary studies for which mathematics provided a 'service' component. This was normally associated with the discipline being following but not an integral part of it; for example, architecture, economics, biological science or medicine. Type 3 were 'specialized' mathematics courses leading to tertiary studies where mathematics was an integral part of the discipline, as in pure or applied mathematics, or physical science.

In 1964 there was little provision for 'terminal' Year 12 mathematics courses. By 1978 each State had one or more such courses. Most of the students in 1964 who wished to study some mathematics without intending to specialize in it took one of the pair of mathematics courses designed primarily for the students planning to specialize.

Enrolment of Mathematics Students

Although it was not possible to obtain precise enrolment figures, estimates of the number of students studying mathematics have been provided in Table 2.10. These estimates were obtained from public examination bodies, and indicated the number of candidates who sat for the examinations. This would generally have underestimated the number of mathematics students in Year 12 at secondary schools, although in Western Australia in 1964 the value was an overestimate since a relatively large but unknown number of the Leaving Certificate candidates were not studying at centres classified as secondary schools.

The table also includes estimates of the total numbers of students in Year 12 whose courses could lead to tertiary studies involving mathematics with either a 'service' or a 'specialized' function. These were the 'mathematics students' defined by Population 3 in the First and Second IEA Mathematics Studies. Many of these mathematics students were taking both components of a complementary pair of mathematics courses; for example, Mathematics I and Mathematics II in South Australia. For such pairs of

Table 2.9 Range and Function of Year 12 Mathematics Courses[a]

	1964 Course	Type 1	Type 2	Type 3	1978 Course	Type 1	Type 2	Type 3
ACT	Included with NSW				Double major Mathematics			✓
					Major-minor Mathematics			✓
					Major Mathematics		✓	
					Minor Mathematics	✓		
NSW	Mathematics I		P	H	Four-unit Mathematics			✓
	Mathematics II		P	H	Three-unit Mathematics			✓
	Mathematics III		✓		Two-unit Mathematics		✓	
	Applied Mathematics			✓	Two-unit (2A) Mathematics	✓		
	General Mathematics	✓						
Vic.	Pure Mathematics			✓	Pure Mathematics			✓
	Calculus and Applied Mathematics			✓	Applied Mathematics			✓
	General Mathematics		✓		General Mathematics	✓	✓	
					General Mathematics (Computing Option)	✓	✓	
Qld	Mathematics I		✓	✓	Mathematics I		✓	✓
	Mathematics II			✓	Mathematics II			✓
					Social Mathematics	✓		
SA	Mathematics I	L	✓	✓	Mathematics 1			✓
	Mathematics II	L		✓	Mathematics 2			✓
					Mathematics 1S	✓	✓	
WA	Mathematics A		✓	✓	Mathematics I		✓	
	Mathematics B			✓	Mathematics II			✓
					Mathematics III			✓
					Mathematics IV	✓		
Tas.	Mathematics A	O	A	A	Analysis and Statistics Level III			✓
	Mathematics B			✓	Algebra and Geometry Level III			✓
					Mathematics Level III	✓	✓	

Note: [a] Type 1 = no further mathematics, Type 2 = further service mathematics, Type 3 = further specalized mathematics.

P = Pass, H = Honours, L = Leaving Certificate, O = Ordinary, A = Advanced

Table 2.10 Number of Students in Year 12 Mathematics Courses

State	1964 Course	Number	Popn 3	%	1978 Course	Number	Popn 3	%
ACT					Double major Mathematics	141	141	9%
					Major-minor Mathematics	209	209	14%
					Major Mathematics	1,190	1,190	77%
					Minor Mathematics	450	-	
					Total		1,540	
NSW	Mathematics I	8.046	8,046	69%	Four-unit Mathematics	621	621	3%
	Mathematics II	8,007			Three-unit Mathematics	5,516	5,516	24%
	Mathematics III	3,528	3,528	30%	Two-unit Mathematics	16,384	16,384	73%
	Applied Mathematics	39	39	< 1%	Two-unit (2A) Mathematics	9,294	-	
	General Mathematics	9,989	-					
	Total		11,613		Total		22,521	
Vic.	Pure Mathematics	3,315	3,315	64%	Pure Mathematics	4,096	4,096	36%
	Calculus and Applied Mathematics	2,967			Applied Mathematics	3,774		
					General Mathematics	7,047	7,047	61%
	General Mathematics	1,832	1,832	36%	General Mathematics (Computing Option)	319	319	3%
	Total		5,147		Total		11,462	
Qld	Mathematics I	6,067	6,067	100%	Mathematics I	8,326	8,326	100%
	Mathematics II	3,823			Mathematics II	3,423		
					Social Mathematics	3,287	-	
	Total		6,067		Total		8,326	
SA	Mathematics I	1,651	1,651	100%	Mathematics 1	2,152	2,152	45%
	Mathematics II	1,373			Mathematics 2	2,145		
					Mathematics 1S	2,653	2,653	55%
	Total		1,651		Total		4,805	
WA	Mathematics A	2,801	2,801	100%	Mathematics I	3,407	3,407	70%
	Mathematics B	1,764			Mathematics II	1,445	1,445	30%
					Mathematics III	1,444		
					Mathematics IV	1,240	-	
	Total		2,801		Total		4,852	
Tas	Mathematics A	636[a]	210[b]	100%	Analysis and Statistics Level III	76[a]	184[b]	27%
	Mathematics B	94[a]	-		Algebra and Geometry Level III	184[a]		
					Mathematics Level III	976[a]	488[b]	63%
	Total		210		Total		672	

Note: [a] Includes Years 11 and 12 students. [b] Estimated number of Year 12 mathematics students.

courses, the enrolments of the more popular course were assumed to include the enrolments of the less popular component. This assumption avoided the error of counting some students twice, but could not take account of the smaller but unknown number of students who took only the less popular course of the pair.

On the basis of the official statistics it was not possible to separate the number of candidates in Tasmania for the Matriculation Examination (1964) and Higher School Certificate (1978) into those in Year 11 and those in Year 12, so that it was necessary to estimate the number in Year 12. Due to the structure of the assessment system at the end of Year 12 for students in Queensland in 1978, it was difficult to obtain statistics that would have been comparable to those in other States. Instead it was decided to use the numbers of students in the defined mathematics courses in August 1978, which were available as a result of the Australian Scholastic Aptitude Test program in that State.

The next stage in the discussion is to set the enrolment figures for all Year 12 students and the mathematics students at this year level into the context of the overall secondary education system by reference to the 'year cohort'. The year cohort was defined as the number of students in each State at the first secondary school year level in the relevant earlier year. For example, for the students in Year 12 in Victoria in 1964, the relevant year cohort was the number of students in Year 7 in 1959. Table 2.11 shows the relevant numbers of students, the percentage of the year cohort in Year 12, the percentage of Year 12 studying mathematics, and the percentage of the year cohort studying mathematics at Year 12.

In each State the holding power of the system at Year 12 level increased, from an overall Australian value of 22 per cent in 1964 to 35 per cent in 1978. Although the holding power in Tasmania in 1978 was lower than the Australian average, this figure was more than three times higher than the 1964 one. The overall percentage of Year 12 students studying mathematics remained fairly constant with an Australian average of about 60 per cent on both occasions, although there was some variation in the extent of change across the States. The net effect was an increase in the percentage of the year cohort studying mathematics at Year 12 in all States, while recognizing that a large proportion of the 1978 mathematics students were not undertaking courses leading to subsequent specialized studies involving mathematics.

Table 2.12 draws attention to an important change in the structure of the group of Year 12 mathematics students. Only a few States have kept

Table 2.11 Holding Power for Year 12 Mathematics Students

	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Aus.
1964								
Number of year cohort students		77,815[a]	54,103[b]	32,045	18,500	14,932	7,200[b]	204,595
Number of Year 12 students		21,776[a]	10,986	6,809	2,572	2,895	532	45,570
Number of Year 12 mathematics students		11,613[a]	5,147	6,067	1,651	2,801	210	27,450
% of year cohort in Year 12		28%	20%	21%	14%	19%	7%	22%
% of Year 12 studying mathematics		53%	47%	89%	64%	97%	40%	60%
% of year cohort studying mathematics		15%	10%	19%	9%	19%	3%	13%
1978								
Number of year cohort students	3,418[b]	87,474[b]	69,790[b]	39,595	25,527	22,028	8,579[b]	256,411
Number of Year 12 students	2,317	31,276	23,046	14,818	9,124	7,543	2,099	90,223
Number of Year 12 mathematics students	1,540	22,521	11,462	8,326	4,805	4,852	672	54,178
% of year cohort in Year 12	68%	36%	33%	37%	36%	34%	24%	35%
% of Year 12 studying mathetics	66%	72%	50%	56%	53%	64%	32%	60%
% of year cohort studying mathematics	45%	26%	16%	21%	19%	22%	8%	21%

Note: [a] Includes figures for the Australian Capital Territory

[b] The year cohort is Year 7; otherwise, the year cohort is Year 8.

Table 2.12 Number of Male and Female Year 12 Mathematics Students

	Number of students Year 12		% Male	Number of mathematics students Year 12		% Male
	Male	Female		Male	Female	
1964						
Victoria	6,442	4,544	57%	3,931	1,216	76%
Queensland	4,169	2,640	61%	4,140	1,927	68%
Western Australia	1,649	1,246	57%	2,011	790	72%
1978						
Australian Capital Territory	1,212	1,105	52%	1,070	915	54%
Victoria	10,316	12,730	45%	6,647	4,815	58%
Queensland	7,337	7,481	50%	5,161	3,165	62%
South Australia	4,366	4,758	48%	2,868	1,937	60%
Western Australia	3,614	3,929	48%	2,495	2,357	51%

separate statistics for male and female candidates for the public examinations. The available statistics show that the percentage of female mathematics students increased between 1964 and 1978 both for Year 12 enrolments and for the numbers of Year 12 mathematics students. This change was at least in part, another result of the provision of less-specialized mathematics courses. There remained a tendency for a higher percentage of the students in specialized mathematics courses to be males.

Mathematics Curriculum

The final stage in examining changes affecting Year 12 mathematics students was to analyse their exposure to mathematics in 1978 relative to 1964. This analysis was more difficult at Year 12 than for 13-year-old students due to the wider range of courses of varying degrees of difficulty. This meant that it was not possible to provide overall estimates for the time spent in class on mathematics, as was done for the 13-year-old students. This aspect will be considered as part of the subsequent discussion of empirical results from the two IEA mathematics studies, where individual students in the samples provided this information.

The mathematics curriculum was documented by completing a content analysis grid for each of the courses. Topics were grouped under several headings, and ratings were given for each topic for each course in terms of objectives, emphasis and universality. The categories for objectives and emphasis were the same as for the 13-year-old students. The following definition was given to the ratings for universality:

Universality.

U universal: this topic is taught or assumed in all schools teaching the mathematics course listed;

R restricted: this topic is taught or assumed in some schools teaching the mathematics course listed; and

N nil: this topic is not at all in the mathematics course listed.

The content analyses are set out in Table 2.13. The 1964 grid has a global rating for emphasis while the 1978 grid has a rating for emphasis associated with each rating for universality. The keys identifying the 1964 and 1978 courses have been placed in boxes in the tables.

Special care should be taken in examining the 1978 content analyses for the Australian Capital Territory and Queensland since public examinations were no longer held at Year 12 level in these States. In the Australian Capital Territory each individual school prepared mathematics courses for acceptance by the ACT Accrediting Agency, which was a section of the ACT Schools Authority. In Queensland there were 11 separate modules. Mathematics I students studied one module in each of the two semesters in each of Year 11 and Year 12. For Mathematics II they studied an additional module in each of these four semesters.

Sets. This topic (1) was covered only in Tasmania in 1964, but in all States by 1978.

Arithmetic. Tasmania was the only State to deal with general properties of number systems (2) in 1964, but by 1978 it was offered in the Australian Capital Territory, Victoria, Queensland and South Australia as well. Natural, integer and real numbers (3 to 5) continued to be available in all States. Complex numbers (6), available only in New South Wales and Tasmania in 1964, were also available in Victoria and South Australia in 1978.

Table 2.13 Content Analysis of Mathematics Courses at Year 12

1964	Object-ive	Emph-asis	NSW (1)	NSW (2)	NSW (3)	NSW (4)	NSW (5)	Vic. (1)	Vic. (2)	Vic. (3)	Qld (1)	Qld (2)	SA (1)	SA (2)	WA (1)	WA (2)	Tas. (1)	Tas. (2)
Sets																		
1 Notions of sets; intersection union, inclusion	AC	3	N	N	N	N	N	N	N	N	N	N	N	N	N	N	U	U
Arithmetic																		
2 General treatment of number systems in terms of letters	ABC	3	N	N	N	N	N	N	N	N	N	N	N	N	N	N	U	U
3 Natural numbers	AD	1	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
4 Integers	AD	1	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
5 Real numbers	AB	2	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
6 Complex numbers	ABD	1	R	R	N	U	N	N	N	N	N	N	N	N	N	N	N	U
Algebra																		
7 Polynomials, operations and factorization	AC	2	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
8 Equations and inequalities	ABCD	3	N	N	N	N	N	U	U	U	U	U	U	U	U	U	U	U
9 Irrational equations	ABC	1	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
10 Systems of equations	ABCD	3	R	U	U	U	N	U	U	U	U	U	N	N	N	N	U	U
11 Matrices and determinants	AB	1	R	R	N	N	U	N	N	N	N	N	N	N	N	N	N	U
12 Groups, rings and fields	AD	1	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Relations and functions																		
13 Conditions in two variables	ACD	3	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
14 Relations, sets of ordered pairs	ACD	3	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
15 Polynomial functions	AB	3	U	U	N	U	U	U	U	U	U	U	U	U	U	U	U	U
16 Rational functions	AB	2	U	U	U	U	U	U	U	N	N	N	U	U	N	N	U	U
17 Irrational functions	AB	1	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
18 Circular functions	ABCD	3	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
19 Inverse circular functions	AB	1	R	R	N	U	U	N	N	N	N	N	N	U	N	N	U	U
20 Logarithmic and exponential functions	ABCD	3	R	R	N	U	N	N	N	N	N	N	N	U	N	N	N	N

Key to 1964 courses		
NSW	(1)	Mathematics I
NSW	(2)	Mathematics II
NSW	(3)	Mathematics III
NSW	(4)	Applied Mathematics
NSW	(5)	General Mathematics
Vic.	(1)	Pure Mathematics
Vic.	(2)	Calculus and Applied Mathematics
Vic.	(3)	General Mathematics
Qld	(1)	Mathematics I
Qld	(2)	Mathematics II
SA	(1)	Mathematics I
SA	(2)	Mathematics II
WA	(1)	Mathematics A
WA	(2)	Mathematics B
Tas.	(1)	Mathematics A
Tas.	(2)	Mathematics B

.../contd

Table 2.13 Content Analysis of Mathematics Courses Year 12 (contd)

1964	Objective	Emphasis	NSW (1)	NSW (2)	NSW (3)	NSW (4)	NSW (5)	Vic. (1)	Vic. (2)	Vic. (3)	Qld (1)	Qld (2)	SA (1)	SA (2)	WA (1)	WA (2)	Tas. (1)	Tas. (2)
Calculus																		
21 Limits	ABCD	3	U	U	U	U	N	U	U	N	N	N	U	U	N	N	U	U
22 Continuity	AD	2	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
23 Derivatives	ABD	3	U	U	U	U	N	N	U	U	U	U	U	U	N	U	U	U
24 Integrals	ABD	2	U	U	U	U	N	U	U	U	U	U	U	U	N	U	N	N
25 Series	AB	1	R	R	N	U	N	N	N	N	N	N	N	N	N	N	N	U
26 Differential equations	ABC	1	N	N	N	N	N	N	N	N	N	N	N	U	N	N	N	N
Geometry																		
27 Euclidean geometry	ABCD	2	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
28 Non-Euclidean geometry	ABD	1	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
29 Trigonometry	ABC	1	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
30 Co-ordinate geometry	ABCD	2	N	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
31 Vectors	ABC	1	N	N	N	N	N	N	N	N	N	U	N	N	N	N	N	U
Probability and Statistics																		
32 Descriptive statistics	ABC	2	N	N	N	N	U	N	N	U	N	N	N	N	N	N	N	N
33 Probability	ABCD	1	U	U	N	U	N	N	N	U	N	N	N	N	N	N	N	U
34 Distributions	AD	1	N	N	N	N	N	N	N	U	N	N	N	N	N	N	N	N
35 Statistical inference	A	1	N	N	N	N	N	N	N	U	N	N	N	N	N	N	N	N
Logic																		
36 Elementary formal logic	ACD	1	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
37 Deductive systems	AD	1	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Applied Mathematics																		
38 Kinematics			N	N	N	U	N	N	U	N	N	U	N	N	N	N	N	N
39 Statics			N	N	N	U	N	N	U	N	N	U	N	N	N	N	N	N
40 Dynamics			N	N	N	U	N	N	U	N	N	U	N	N	N	N	N	N

.../contd

Table 2.13 Content Analysis of Mathematics Courses at Year 12 (contd)

1978	Objective	ACT (1)	ACT (2)	ACT (3)	ACT (4)	NSW (1)	NSW (2)	NSW (3)	NSW (4)	Vic. (1)	Vic. (2)	Vic. (3)	Vic. (4)	Qld (1)	Qld (2)	Qld (3)	SA (1)	SA (2)	SA (3)	WA (1)	WA (2)	WA (3)	WA (4)	Tas. (1)	Tas. (2)	Tas. (3)
Sets																										
1 Notions of sets; intersection union, inclusion	ABCD	1U	1U	1U	N	1U	1U	1U	2U	1U	1U	1U	1U	1U	1U	N	2U	2U	2U	3U	3U	N	N	2U	2U	3U
Arithmetic																										
2 General treatment of number systems in terms of letters	ABC	2U	2U	2R	N	N	N	N	2R	1U	N	N	N	2U	1U	3U	3U	3U	2U	N	N	N	2U	1U	3U	3U
3 Natural numbers	ABD	3U	2U	2U	2U	N	N	N	3U	N	1U	N	N	1U	1U	3U	3U	3U	3U	2U	2U	N	2U	1U	3U	2U
4 Integers	ABCD	3U	2U	2U	2U	3U	N	N	3U	N	1U	N	N	2U	1U	3U	3U	3U	3U	2U	2U	N	3U	1U	3U	2U
5 Real numbers	BD	3U	2U	2U	2U	2U	2U	2U	3U	3U	1U	1U	1U	3U	1U	3U	3U	3U	3U	2U	2U	N	3U	1U	3U	2U
6 Complex numbers	ABC	3U	3U	N	2U	3R	N	N	N	3U	N	N	N	N	3U	N	3U	N	3U	N	N	N	N	3U	3U	1U
Algebra																										
7 Polynomials, operations and factorization	AB	3U	3U	2U	N	3U	3U	2U	3U	3U	1U	1U	1U	2U	1U	2U	3U	2U	3U	2U	3U	N	N	3U	3U	3U
8 Equations and inequalities	ABC	3U	3U	2U	2U	2U	2U	2U	3U	1U	1U	1U	1U	2U	1U	2U	3U	3U	1R	3U	3U	N	N	3U	3U	3U
9 Irrational Equations	AB	2U	3U	2R	N	2U	2U	2U	N	1U	N	1U	1U	2U	N	N	3U	2U	N	N	N	N	N	1U	1U	1U
10 Systems of equations	AB	3U	3U	2R	N	2U	2U	2U	N	3U	N	2U	2U	2U	1U	2R	3U	1U	3U	1U	2U	N	N	2U	3U	3U
11 Matrices and determinants	ABC	3U	N	N	N	3R	N	N	N	3U	N	2U	2U	N	3U	N	3U	N	3U	N	N	N	N	N	3U	N
12 Groups, rings and fields	B	2R	N	N	N	1U	N	N	N	N	N	N	N	N	3R	N	1U	1U	N	N	N	N	N	N	N	N
Relations and functions																										
13 Conditions in two variables	ABC	3U	3U	3R	N	2U	2U	2U	2U	1U	1U	1U	1U	2U	1R	N	3U	3U	3U	2U	2U	N	2U	2U	3U	3U
14 Relations, sets of ordered pairs	ABC	3U	3U	3R	N	2U	2U	2U	2U	1U	N	1U	1U	2U	1U	N	3U	3U	3U	2U	2U	N	2U	2U	3U	3U
15 Polynomial functions	ABC	3U	3U	3R	N	3U	3U	N	2U	3U	1U	1U	1U	2U	1R	N	3U	3U	3U	1U	2U	N	1U	3U	3U	3U
16 Rational functions	ABC	3U	3U	2R	N	2U	2U	2U	N	3U	1U	N	N	2U	1U	N	N	3U	3U	N	1U	N	2U	3U	N	3U
17 Irrational functions	ABC	2U	2U	N	N	2U	2U	2U	N	3U	N	N	N	2U	N	N	N	1R	N	N	1U	N	N	1U	N	1U
18 Circular functions	ABC	3U	3U	3U	N	3U	3U	3U	N	3U	1U	2U	2U	2U	N	N	N	2U	1R	2U	3U	N	2R	3U	2U	3U
19 Inverse circular functions	ABC	3U	3U	N	N	3U	3U	N	N	2U	1U	N	N	2U	N	N	N	N	N	N	N	N	N	3U	N	2U
20 Logarithmic and exponential functions	ABC	3U	3U	3R	N	3U	3U	3U	N	3U	1U	2U	2U	2U	N	N	N	3U	N	1U	3U	3U	1U	3U	N	2U

Key to 1978 courses

ACT	(1)	Double Major Mathematics
ACT	(2)	Major-Minor Mathematics
ACT	(3)	Major Mathematics
ACT	(4)	Minor Mathematics
NSW	(1)	Four-unit Mathematics
NSW	(2)	Three-unit Mathematics
NSW	(3)	Two-unit Mathematics
NSW	(4)	Two-unit (2A) Mathematics
Vic.	(1)	Pure Mathematics
Vic.	(2)	Applied Mathematics
Vic.	(3)	General Mathematics
Vic.	(4)	General Mathematics (Computing Option)
Qld	(1)	Mathematics I
Qld	(2)	Mathematics II
Qld	(3)	Social Mathematics
SA	(1)	Mathematics 1
SA	(2)	Mathematics 2
SA	(3)	Mathematics 1S
WA	(1)	Mathematics I
WA	(2)	Mathematics II
WA	(3)	Mathematics III
WA	(4)	Mathematics IV
Tas.	(1)	Analysis and Statistics Level III
Tas.	(2)	Algebra and Geometry Level III
Tas.	(3)	Mathematics Level III

.../contd

Table 2.13 Content Analysis of Mathematics Courses at Year 12 (contd)

1978	Objective	ACT (1)	ACT (2)	ACT (3)	ACT (4)	NSW (1)	NSW (2)	NSW (3)	NSW (4)	Vic. (1)	Vic. (2)	Vic. (3)	Vic. (4)	Qld (1)	Qld (2)	Qld (3)	SA (1)	SA (2)	SA (3)	WA (1)	WA (2)	WA (3)	WA (4)	Tas. (1)	Tas. (2)	Tas. (3)
Calculus																										
21 Limits	AB	3U	3U	2R	N	1U	1U	1U	N	2U	1U	1U	1U	2U	N	N	N	3U	3U	N	N	3U	N	3U	N	2U
22 Continuity	AB	3U	2U	N	N	1U	1U	1U	N	2U	1U	N	N	2U	N	N	N	1R	N	N	N	2U	N	3U	N	2U
23 Derivatives	AB	3U	3U	2R	N	3U	3U	3U	N	3U	3U	2U	2U	3U	N	N	N	3U	2U	N	N	3U	N	3U	N	3U
24 Integrals	AB	3U	3U	2R	N	3U	3U	3U	N	3U	3U	2U	2U	3U	N	N	N	3U	2U	N	N	3U	N	3U	N	1U
25 Series	AB	3U	N	N	N	2U	2U	3U	2U	N	1R	1U	N	2U	2R	N	N	N	N	N	N	N	N	3U	N	1U
26 Differential equations	AB	3U	N	N	N	2U	1U	1U	N	1U	3U	N	N	N	N	N	N	1R	N	N	N	N	N	3U	N	2U
Geometry																										
27 Euclidean geometry	B	2U	2U	2U	N	N	N	N	N	N	N	N	N	N	N	3R	N	1R	N	1U	1U	N	N	N	3U	1U
28 Non-Euclidean geometry	AB	1R	N	N	3U	N	N	N	2U	N	N	N	N	N	2U	1R	2U	1R	1R	N	N	N	2U	N	N	N
29 Trigonometry	ABD	3U	3U	3U	3U	2U	2U	3U	3U	3U	N	2U	N	2U	1U	3R	3U	3U	1R	2U	3U	N	2U	3U	3U	3U
30 Co-ordinate geometry	ABCD	3U	3U	3R	N	3U	3U	3U	N	2U	1U	1U	N	3U	2U	N	3U	3U	3U	2U	3U	N	N	2U	3U	3U
31 Vectors	ABD	2R	N	N	N	N	N	N	N	N	3U	N	N	3U	3U	N	3U	1R	1R	N	N	N	N	N	1U	N
Probability and Statistics																										
32 Descriptive statistics	ABD	2R	N	N	3U	N	N	N	N	N	1U	3U	3U	N	2R	3U	1R	1R	1R	2U	N	2U	2U	3U	N	2U
33 Probability	ABD	3U	3U	3R	3U	3U	3U	3U	3U	N	3U	2U	2U	N	3R	3U	2U	N	2U	2U	N	3U	2U	3U	N	2U
34 Distributions	ABCD	1R	N	N	1U	N	N	N	N	N	3U	2U	2U	N	3R	1R	N	N	N	1U	N	2U	2U	3U	N	2U
35 Statistical inference	ABD	1R	N	N	N	N	N	N	N	N	3U	N	N	N	2R	2U	N	N	N	N	N	N	N	2U	N	N
Logic																										
36 Elementary formal logic	ABD	1R	N	N	N	N	N	N	N	N	N	N	N	N	2R	N	N	N	N	N	N	N	N	N	N	N
37 Deductive systems	BCD	1R	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	3U	N
Applied Mathematics																										
38 Kinematics	ABCD	2R	2R	1R	N	3U	3U	3U	N	N	3U	N	N	N	3U	N	N	N	N	N	N	N	N	N	N	N
39 Statics	ABCD	2R	N	N	N	N	N	N	N	N	3U	N	N	N	3U	N	N	N	N	N	N	N	N	N	N	N
40 Dynamics	ABCD	2R	2R	N	N	3U	3U	N	N	N	3U	N	N	N	3U	N	N	N	N	N	N	N	N	N	N	N
Computing Studies																										
41 Flowcharts	BCD	N	N	N	2U	N	N	N	2R	N	N	N	3U	N	3R	2R	N	N	N	N	N	N	2U	N	N	N
42 Computer languages and progamming	BCD	N	N	N	2U	N	N	N	2R	N	N	N	3U	N	3R	2R	N	N	N	N	N	N	2U	N	N	N
43 Algorithms	BCD	N	N	N	1U	N	N	N	N	N	N	N	3U	N	3R	1R	N	N	N	N	N	N	1U	N	N	N
44 Data Processing	BCD	N	N	N	N	N	N	N	N	N	N	N	3U	N	3R	3R	N	N	N	N	N	N	2U	N	N	N

Algebra. Polynomials (7) and irrational equations (9) were included in both 1964 and 1978. Equations and inequalities (8) and systems of equations (10) moved towards inclusion in all courses in 1978. Matrices, determinants, groups, rings and fields (11 and 12) were generally not covered in 1964, although by 1978 they were included in at least one course in most States.

Relations and Functions. Conditions in two variables (13), polynomial functions (15) and circular functions (18) were universally covered in 1964 and 1978. Rational, irrational, logarithmic and exponential functions (16, 17 and 20) were all covered better in 1978. The topic relations and sets of ordered pairs (14) was not included in 1964 but was available in all States by 1978. Inverse circular functions (19) were given limited coverage on both occasions.

Calculus. Some calculus was offered in all States on both occasions, especially derivatives (23) and integrals (24). There was an increase in the coverage of limits (21) and continuity (22) which may have reflected a change in methods of introducing and teaching calculus topics. Series (25) and differential equations (26) were included to a greater extent although they were still not commonly included in 1978 courses.

Geometry. There were major changes in this area from 1964 to 1978. Euclidean geometry (27) was universally taught in 1964 but was absent from most of the courses in 1978. On the other hand, non-Euclidean geometry (28) was not included in 1964 but was introduced into courses in several States by 1978. Trigonometry (29) and co-ordinate geometry (30) were universally available on both occasions. Vectors (31) were taught only in Queensland and Tasmania in 1964, but this topic was included in courses in most States by 1978.

Probability and Statistics. It was only in the General Mathematics course in Victoria that the topics in this area were covered in 1964. By 1978 all States offered probability (33), and most offered courses involving the other topics (32, 34 and 35). These topics were often included in the terminal courses, reflecting the more practical orientation of these courses.

Logic. The logic topics (36 and 37) were generally not covered in Australian schools in 1964 and 1978.

Applied Mathematics. This area has generally received little attention in Year 12 mathematics courses in Australia, with the exception of courses in New South Wales, Victoria and Queensland taken by the specialist mathematics students.

Computing Studies. No analysis of these topics was undertaken in 1964. By 1978 most States had included formal studies in this area as part of mathematics courses, although this content analysis did not reflect the rapidly increasing availability of computing services in secondary schools, and the consequent use of these services by students in mathematics and other subject areas.

The above documentation of the content of Australian mathematics courses in 1964 and 1978 permits an analysis of changes over this period. The number of courses available in 1978 was larger than in 1964, with a consequent increase in the range of topics covered. Any discussion of changes in student achievement in mathematics at this level should take account of the increased variety of topics and courses from which students can make their choices.

Summary

This report is concerned with the mathematics achievement of students attending Australian secondary schools in 1964 and 1978 at two levels - the lower level represented by 13-year-old students and the upper level represented by Year 12 students. In order to provide information about the educational context within which the teaching of mathematics was taking place in 1964 and 1978, this chapter has documented major characteristics of the structure of the State educational systems and the content of the mathematics curriculum.

During this period teachers of mathematics and their students have had to adjust to three changes determined by the wider society. Firstly, the change to a decimal system of currency took place in 1966. Secondly, the change to metric weights and measures was taking place during the mid-1970s. Thirdly, inexpensive hand-calculators were becoming widely available. In addition, 'new' mathematics was introduced at the beginning of the period under review and had permeated all the mathematics courses by 1978. It was expected that these changes would simplify the learning of basic money and measurement skills, and permit more time to be spent on the development of other skills or the deepening of understanding of other mathematical concepts.

There was also a substantial decline in the influence of the public examining bodies. In 1964 there were public examinations in most States at the end of both Year 10 and Year 12. Associated with these examinations were closely-defined courses of study which consequently determined course content throughout the secondary school. By 1978 the public examinations were limited to the end of Year 12, so that the lower levels of the secondary school were largely freed from the influence of external examinations in determining the content of the mathematics courses they offered.

To replace courses specified by these examining bodies, the State Education Departments issued guidelines for courses, although individual schools in most States were authorized to prepare their own courses of instruction. At the lower secondary school level this resulted in the coverage of a much wider range of topics in mathematics courses, although this was associated with a decrease in the time spent in class on mathematics.

Between 1964 and 1978 the number of 13-year-old students in Australia increased by 18 per cent. There was also a shift in the distribution of these students across year levels, so that there was a lower proportion of 13-year-old students in primary year levels, and a higher proportion in Year 8. This probably meant that more 13-year-old students would have been exposed to the wider range of mathematics taught at these higher year levels.

The number of Year 12 students in Australia doubled from 1964 to 1978, with a relatively larger component of this increase taking place in the government sector. There was a consequent increase in the percentage of mathematics students relative to the size of the year cohort. In order to cater for this influx of students, the range of mathematics courses in each State was widened, so that students could choose among terminal courses or courses designed to lead to further mathematics studies at the tertiary level.

The specialist mathematics courses had traditionally attracted a higher proportion of male students, as a function of the tendency for more males to undertake careers in engineering and physical science. The increased availability of non-specialist mathematics courses contributed to the increasing proportion of female students studying mathematics at the Year 12 level.

CHAPTER 3

POPULATIONS, SAMPLES AND ADMINISTRATION

The results presented in this report have been derived from data collected in two separate studies, the First IEA Mathematics Study (1964) and the Second IEA Mathematics Study (1978). For each of these studies samples were drawn from populations of 13-year-old students (Population 1) and Year 12 students (Population 3). The purpose of this chapter is to define the populations from which the samples were drawn, to describe the design and execution of the sampling procedures, and to provide a brief description of the administrative procedures which were used.

The studies were based on the populations as defined by IEA for the 1964 data collection. The populations were not selected arbitrarily, but in order to examine mathematics achievement at two particular terminal points of the system of primary and secondary education. In Australia and the other countries, Population 1 was the last point in 1964 where all students in an age cohort would still be undergoing full-time education. In order to convert this decision into practical terms, it was agreed to define Population 1 in terms of 13-year-old students (corresponding to Population 1a in the reports of the First IEA Mathematics Study). The use of an age-based definition meant that the corresponding populations for all the IEA countries or for the several Australian States were equivalent, which facilitated the making of generalizations from results derived from the samples. The disadvantage of an age-based definition was the lack of equivalence in terms of the exposure of students to schooling, either in terms of particular year levels or in terms of total years of schooling.

The second terminal point of interest to IEA was the final year of the secondary school system. This present study has been concerned only with Population 3 (corresponding to Population 3a in the reports of the First IEA Mathematics Study) containing the students in Year 12 who were currently studying mathematics at a level which would enable them to continue with the study of mathematics at the tertiary stage. It was obvious that particular populations at this year level would not be directly equivalent across the IEA countries or the Australian States, so that any analyses of the data for Population 3 would need to take account of the composition of the populations. Nevertheless, it was considered worthwhile by IEA to investigate this group of students in order to obtain data which would enable the whole primary-secondary system to be examined in terms of the 'yield' of mathematics achievement at the terminal secondary school stage.

This chapter initially considers the populations, samples and administration for Population 1 for 1964 and 1978, and then considers the same aspects for Population 3. There was one important distinction between the 1964 and 1978 studies. The 1964 study was restricted to students in government schools in only five of the Australian States. The 1978 study involved students in both government and non-government schools in seven Australian States. In order to make comparisons with the 1964 results, a subsample of the 1978 sample has been defined. Throughout the report this subsample has been referred to as the 1978 restricted sample (1978R sample) containing only students from government schools from the five States which participated in the 1964 study. Further details of the populations, the samples and the administration of the First IEA Mathematics Study have been reported in Husén (1967), and Keeves (1968), and for the Second IEA Mathematics Study in Rosier (1980a).

Population 1: 1964

IEA defined Population 1 as all students who were aged 13:0 to 13:11 years old at the date of testing (Husén, 1967, Vol. 1:46). IEA also recommended that the date of testing should be within three months of the end of the school year. It was decided to undertake the testing in Australia in the first week of August 1964, since the annual date for the official census of school enrolments falls on the Friday of the first week of August each year. This meant that enrolment data for the student population were available at the same time as data were being collected from the samples of students, so that certain characteristics of the samples would be compared with corresponding characteristics of the population (marker variables).

This was the first major study of its kind conducted in Australian secondary schools, so that it was decided to simplify the administrative procedures by including only students in government schools. Only five States were involved since South Australia was unable to participate. Also excluded from the study were students in the Australian Capital Territory, which in 1964 was still functioning as a distinct educational system but was still administratively associated with the New South Wales system. The study excluded students with handicaps, located in special classes or special schools. The study was further limited to students in the three year levels containing the majority of the 13-year-old students. Hence the following definition of the target population for Population 1 in 1964 was adopted:

> all students of age 13:0 to 13:11 years on 1 August 1964 in normal classes in Year 7, Year 8 and Year 9 in government schools in New South Wales, Victoria, Queensland, Western Australia and Tasmania.

The number of students covered by this target population, and consequently by the excluded population in each State, is given in Table 3.1. It can be seen that the target population included primary school students in three States. The sampling design was therefore based on eight strata, consisting of primary students in Year 7 in three of the States and secondary students in all five States.

For each stratum a two-stage sampling design was prepared, involving the selection of a random sample of schools from each stratum at the first stage and a random sample of students from these schools at the second stage. The sample design was based on about 20 secondary schools per State. However, in States with both primary and secondary level strata, the number of secondary schools was reduced and an appropriate number of primary schools was chosen to ensure that approximately the same number of students was obtained in each State sample.

For each stratum the probability of selecting a student from a school in the population was given by the product of the probability of selecting a school and the probability of selecting a student from that school; that is:

p(student) = p(school) x p(student within school)

The value of p(student) differed from each stratum in order to obtain a constant sample size for each State. The value of p(student within school) was taken as 1/3 for the secondary school strata in order to increase the number of schools in the stratum and hence decrease the intraclass correlation. For the primary school strata the value of p(student within school) was taken as unity; that is, all 13-year-old students in Year 7 in the selected primary schools were included in the sample since the mean number of these students in a given primary school was relatively low. For this kind of sampling design it is necessary to apply weighting procedures when combining results from strata; for example, when combining results from students in the primary school and secondary school strata in a State to give estimates of the values of variables for that State. The numbers of schools and students in the designed samples have been included in Table

Table 3.1 Population and Sample Sizes for Population 1: 1964

	NSW	Vic.	Qld	WA	Tas.
Population					
Total population	55,067	42,227	22,811	12,708	5,762
Target population	53,607	40,243	21,438	12,188	5,435
Excluded population	1,460	1,984	1,373	520	327
% excluded population	2.7%	4.7%	6.0%	4.1%	5.7%
Designed samples					
Schools					
Primary	15		21	16	
Secondary	15	21	16	12	21
Total	30	21	37	28	21
Estimated number of students (1963)					
Primary	49		166	70	
Secondary	689	855	597	587	484
Total	738	855	763	657	484
Achieved samples					
Schools					
Primary	8		19	9	
Secondary	13	19	15	9	16
Total	21	19	34	18	16
Students					
Primary	44		154	46	
Secondary	600	668	566	429	410
Total	644	668	720	475	410
Teachers	65	54	90	50	39
Estimated response rates					
Students					
Primary	90%		93%	66%	
Secondary	87%	78%	95%	73%	85%
Total	87%	78%	94%	72%	85%

3.1, where the number of students represented estimates based on 1963 statistics.

In order to execute the sampling, schools were selected from the most recently available lists of schools, which represented the 'sampling frame' prepared for the occasion. On grounds of economy a further practical simplification was undertaken for the primary school strata, by considering only the larger primary schools: Class I schools in New South Wales, Class I, II and III schools in Queensland, and Class I primary schools and the primary sections of district (junior) high schools in Western Australia.

Invitations were sent to the selected schools to request their participation in the study. The schools in the secondary strata were also asked to select the sample of students, following defined random procedures based on the date of birth of the students. Table 3.1 also records the size of the achieved samples of schools which participated, and the size of the achieved samples of students from whom data were obtained for the analyses. The teachers of mathematics to the students in the sample were also asked to complete questionnaires; the table includes the size of the achieved samples of teachers. Finally, estimated response rates for students have been given; that is, the size of the achieved samples in 1964 expressed as a percentage of the designed samples using 1963 statistics.

The testing program was administered in each participating school by members of the school staff. Students entered their responses to test items on to answer sheets designed for processing by optical sensing equipment. The responses of students, teachers and schools to their respective questionnaires were entered on the booklets themselves. The completed instruments were returned to ACER for editing and checking by clerical staff, and for the coding of open-response items in the tests and questionnaires. The answer sheets and the cards punched with questionnaire data were then forwarded to the IEA data processing staff at the University of Chicago for the building of computer files and the running of analyses for the main IEA report.

Population 1: 1978

The Second IEA Mathematics Study was designed to enable comparisons with the results of the First IEA Mathematics Study, so that the 1978 Population 1 was defined to match the 1964 definition.

Firstly, the date of testing would be during the first week of August 1978. Secondly, students in the Northern Territory would not be included in the target population, since the population was relatively small especially at the Population 3 (Year 12) level, and it was an atypical State in terms of the large proportion of Aboriginal students. Thirdly, students in both government and non-government schools in the other seven States would be included. The following definition for the target population for 1978 Population was therefore adopted:

> all students of age 13:0 to 13:11 years on 1 August 1978 in normal classes in Year 7, Year 8 and Year 9 in all States except the Northern Territory.

Table 3.2 sets out the size of the target population and the consequent excluded population for each State.

The sampling design was different from that adopted in 1964, although it was designed to produce comparable sampling errors. The design was based on three primary school strata and seven secondary school strata. The basic design involved a two-stage sample. At the first stage 40 schools were to be selected at random from each State, and at the second stage 25 students were to be chosen at random from each of the selected schools. In practice the design was modified to take fewer schools from the two smaller States (the Australian Capital Territory and Tasmania), and to include primary schools in Queensland, Western Australia and Tasmania. The planned sampling error for mean values for this design was about six per cent of the standard deviation for between-students analysis on a given variable for each State.

As in 1964, the probability of selecting a student from a school in the stratum was given by the equation:

$$p(\text{student}) = p(\text{school}) \times p(\text{student within school})$$

For the selection of secondary schools in 1978 the value of p(school) was not constant for the stratum but varied with the size of the school. Schools were to be selected at the first stage of sampling with a probability proportional to the size of the target population in the school. At the second stage of sampling a constant-sized cluster of 25 students was to be selected regardless of the size of the school. The net effect was to ensure that the <u>product</u> of p(school) and p(student within school) remained constant for the stratum:

$$p(\text{school}) = \frac{N(\text{school})}{N(\text{stratum})}$$

$$p(\text{student within school}) = \frac{25}{N(\text{school})}$$

$$p(\text{student}) = \frac{N(\text{school})}{N(\text{stratum})} \times \frac{25}{N(\text{school})}$$

$$= \frac{25}{N(\text{stratum})} = \text{constant for the stratum}$$

Table 3.2 Population and Sample Sizes for Population 1: 1978

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Population							
Total population	3,805	81,386	66,298	38,166	22,918	21,771	7,572
Target population	3,731	79,154	65,300	37,184	22,487	21,447	7,433
Excluded population	74	2,232	998	982	431	324	137
% excluded population	1.9%	2.7%	1.5%	2.6%	1.9%	1.5%	1.8%
Designed samples							
Schools							
Primary				11	12	15	
Secondary	20	40	40	37	38	38	36
Total	20	40	40	48	50	53	36
Students							
Primary				84	47	56	
Secondary	500	1,000	1,000	925	950	950	900
Total	500	1,000	1,000	1,009	997	1,006	900
Achieved samples							
Schools							
Primary				7	3	7	
Secondary	14	37	36	34	36	33	30
Total	14	37	36	41	39	40	30
Students							
Primary				45	5	20	
Secondary	343	886	853	801	874	799	698
Total	343	886	853	846	879	819	698
Teachers	83	235	180	281	268	199	171
Response rates							
Students							
Primary	69%			54%	11%	34%	
Secondary	69%	89%	85%	91%	92%	84%	78%
Total	69%	89%	85%	88%	88%	81%	78%

where N(stratum) = size of target population for the stratum
N(school) = size of target population for the school

Detailed information about this method of sampling, which was previously employed in the IEA Science Project in 1970, has been given in Rosier and Williams (1973).

The primary schools were to be selected at random at the first stage, with all the 13-year-old students in the selected schools being included at the second stage of sampling. This part of the 1978 design followed the procedure used in 1964. The sizes of the designed samples of schools and students have been recorded in Table 3.2

The primary and secondary schools for the 1978 study were selected from the ACER Sampling Frame, which was a list of all primary and secondary schools in Australia with certain associated enrolment data for each school. As in the 1964 study, only larger primary schools were considered for selection: Class 1 and 2 schools in Queensland, Group 1 and 2 schools in South Australia and Class 1A and 1 schools (including the corresponding district high schools) in Western Australia.

The first step in executing the sampling design was to invite the selected schools to participate in the study. The participating secondary schools provided a list of all 13-year-old students at the defined Population 1 year levels. From these lists, sample clusters of 25 students were selected at random by ACER staff using a method based on students' birthdates.

The tests and questionnaires for the designated students, and for their mathematics teachers and the school principal were then forwarded to the schools for administration by the member of the school staff who had accepted responsibility for administering the testing program. The completed instruments were then returned to ACER for the various stages of the preparation of data for analysis, including editing, post-coding and the building of computer files. Details of these operations have been reported in associated technical documents (Rosier, 1980a, b).

The results for individual sample students were calculated and returned to the respective schools shortly after the testing program, and prior to the conduct of any other analyses for the study. This prompt feedback was considered to be very important so that the testing program could have some beneficial educational effects for the participating students, and also to increase the involvement of the schools as partners in the study.

The final section of Table 3.2 presents the numbers of schools, students and teachers in the achieved samples, and the response rates for the achieved samples relative to the designed samples. The overall response rates were similar to those in 1964. However there were very low response rates for the primary school strata, for several reasons. Firstly, the number of 13-year-old students in Year 7 was much lower in practice than was anticipated from the preliminary sampling design calculations. Secondly, the 13-year-old students at primary school were of relatively low ability, so that the Principals of many of the selected primary schools decided that the IEA tests were far too difficult for these students, and decided to withdraw them from the testing program rather than to subject them to a potentially disheartening experience.

Population 3: 1964

IEA defined Population 3 as the students studying mathematics as an integral part of their course for their future training or as part of their pre-university studies; for example, mathematicians, physicists, engineers, biologists, etc. or all those being examined at that level (Husen, 1967, Vol. I:46). It was then necessary to specify the target population definition more precisely for each State in terms of the appropriate mathematics courses at the final year secondary level taken by full-time students in government schools.

New South Wales. All 5th Year students taking the following courses for the Leaving examination: Mathematics I and/or Mathematics II (Pass or Honours), or Mathematics III, or Applied Mathematics.

Victoria. All Form VI students taking the following courses for the Matriculation examination: Pure Mathematics and/or Calculus and Applied Mathematics, or General Mathematics.

Queensland. All 5th Year students taking the following courses for the Senior Public examination: Mathematics i and/or Mathematics II.

Western Australia. All Year 5 students taking the following courses for the Leaving Certificate examination: Mathematics A and/or Mathematics B.

Tasmania. All Year V or Year VI students taking the following courses for the Matriculation examination: Mathematics A (Advanced Level) and/or Mathematics B.

A two-stage sampling design was used, with a random sample of schools selected from each State at the first stage, and a constant proportion of the mathematics students in these schools selected at random at the second stage. The first and second stage sampling fractions were held constant within each State, but differed across States in order to achieve samples of students which were approximately equal in each State.

c

Tabl[illegible] the sizes of the target populations, of the designed and achie[illegible] and of the estimated response rates. In Western Australia [illegible] there were more students in the set of selected schools i[illegible] been expected from the preliminary sampling calculati[illegible] 1963 statistics resulting in estimated response rates greater t[illegible] per cent. The table also shows the numbers of teachers who taught ma[illegible] the students in the samples and who provided data for the study[illegible]

Data [illegible] collected in Tasmania from Year 11 students who were candidate[illegible] for the Matriculation Examination in 1964, and were thus [illegible] mathematics at the same level as their Year 12 colleagues. For the a[illegible] presented in this report it was decided to include the data from the [illegible] members in order to obtain a higher level of accuracy [illegible] Tasmania results.

Population 3: 1978

The targe[illegible] for Population 3 for the Second IEA Mathematics Study in 1978 w[illegible] separately for the various States, and included full-time stud[illegible] both government and non-government schools.

Aust[illegible] Territory. All Year 12 students taking the following mathemati[illegible] which were recognized by the Australian National University as being [illegible] level of conceptualization to be appropriate for tertiary [illegible] accredited Tertiary Entrance course): a double major course, [illegible] major course, or a major course.

New [illegible] All Year 12 students taking the following mathematics courses [illegible] School Certificate examination: a four-unit course, or a thre[illegible] or a two-unit course.

Vic[illegible] All Year 12 students taking the following courses for the Higher S[illegible] examination: Pure Mathematics and/or Applied Mathemati[illegible] Mathematics, or General Mathematics (Computing Option).

Quee[illegible] All Year 12 students taking at least four units of the Board of [illegible] School Studies Mathematics I course, including Unit 1, Unit II a[illegible] III.

Sou[illegible] All Year 12 students taking the following courses for the [illegible] examination: Mathematics 1 and/or Mathematics 2, or Mathemat[illegible]

Table 3.3 Population and Sample Sizes for Population 3: 1964

	NSW	Vic.	Qld	WA	Tas.
Population					
Target population	11,613	5,147	6,067	2,801	210[a]
Designed samples					
Schools	15	14	16	9	4
Estimated number of students (1963)	259	236	259	219	195[b]
Achieved samples					
Schools	14	14	16	8	4
Students	234	177	243	235	199[b]
Teachers	29	24	41	19	14
Estimated response rates					
Students	91%	75%	94%	107%	102%

Note: [a] Estimated number of Year 12 mathematics students.

[b] Includes Year 11 and 12 students.

Western Australia. All Year 12 students taking the following courses for the Tertiary Admissions examination: Mathematics II and/or Mathematics III, or Mathematics I.

Tasmania. All Year 12 students taking one of the following courses for the Higher School Certificate: Algebra and Geometry (Level III) and/or Analysis and Statistics (Level III), or Mathematics (Level III).

The same sampling design was used in 1978 as in the First IEA Mathematics Study. It was decided to adjust the first-stage sampling fractions to give about 20 schools per State, and the second-stage sampling fractions to give about 25 students per school, to provide an overall sample size of about 500 mathematics students per State. After adjustment for design effects, these sample sizes would give sampling errors of about 10 per cent of a standard deviation for between-students analysis on a given variable for each State.

In responding to their invitation to participate in the study, the selected schools provided a complete list of all their Year 12 mathematics students who were included in the target population definition. The specific

Table 3.4 Population and Sample Sizes for Population 3: 1978

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Population							
Target population	1,540	22,521	11,462	8,326	4,805	4,852	672
Designed samples							
Schools	10	20	20	20	20	20	20
Estimated number of students	266	985	549	562	693	517	369
Achieved samples							
Schools	9	16	19	19	17	20	14
Students	192	677	462	479	413	496	266
Teachers	37	49	38	38	37	48	30
Estimated response rates							
Students	72%	69%	84%	85%	60%	96%	72%

students for the sample were selected at random at ACER, according to the sampling fraction for students within schools for that State.

It was recognized that the testing of a proportion of the Year 12 mathematics students may have been administratively inconvenient in many schools. The schools were therefore invited to test all these students. In these cases, ACER marked the Mathematics Tests for all the students, but retained for subsequent analysis only the data from the designated sample students. The results of all the students were calculated and returned to the schools shortly after the testing program and prior to the undertaking for any other analyses for the study. A summary of information about the populations and samples has been presented in Table 3.4.

Summary

In summary there were two studies: the First IEA Mathematics Study in 1964 and the Second IEA Mathematics Study in 1978. The First IEA Mathematics Study samples involved only government schools in five States. The Second IEA Mathematics Study samples involved both government and non-government schools in seven States. Thus a sub-set of the 1978 samples, termed the '1978 restricted' samples, was defined to match the 1964 samples for comparative purposes. Each study was conducted at two population levels: Population 1 (13-year-old students) and Population 3 (Year 12 mathematics students). Each study collected data from students, mathematics teachers, and school principals.

Results based on sample data are often generalized to the population from which the sample was drawn. For a given sample statistic an estimate can be made of the range of values within which the corresponding population parameter probably lies. The relationship between the sample statistic and the estimated population value is given by the sampling error, and is a function of the size and structure of the sample. On the basis of evidence collected over a range of similar studies, it was considered that the sampling errors associated with the complex samples employed in these IEA Mathematics Studies were approximately double those which would apply to simple random samples of the same size. This meant that the mean values of variables based on the Population 1 samples would have sampling errors of about six per cent of a standard deviation. The corresponding sampling errors for Population 3 would be about ten per cent of a standard deviation.

CHAPTER 4

TESTS AND QUESTIONNAIRES

For survey research on the scale of the IEA Mathematics Studies the most economical method for collecting data was by means of tests and questionnaires completed by the respondents rather than by interview procedures. This procedure has been feasible in Australia due to the willing co-operation of school staff who have accepted responsibility for administering the testing programs in their schools.

For each of the 1964 and 1978 studies, and at each of the Population 1 and Population 3 levels, data were collected from students, mathematics teachers and school Principals. This chapter describes the construction of the various measuring instruments (tests, questionnaires, etc.) used in the studies, recognizing that most of the 1978 instruments were modified versions of the 1964 instruments.

Copies of the instruments have been reproduced in various publications, as summarized in Table 4.1. This report itself includes only the 1978 Mathematics Tests (in Appendices 2 and 3), and the 1978 Opinion Questionnaire items (incorporated into this chapter). Relevant individual items from the background information questionnaires for the students, teachers and schools have been presented at appropriate stages of this report.

The report has adopted the convention of referring to Mathematics Test items and Opinion Questionnaire items in terms of the item numbers used in the 1978 study, with appropriate reference to the corresponding item numbers used in the 1964 Study.

Mathematics Tests

The 1964 Mathematics Tests were prepared co-operatively by the participating IEA countries. The first stage of this procedure was the completion of curriculum content analysis grids by each country, as summarized in Husén (1967, Vol. I: App. I). The IEA countries then submitted items which were considered to measure the various cells of the grid with respect to content and process categories. IEA decided that most of the items should be in a multiple-choice format with five alternative responses provided. This decision was itself determined by the prior decision to minimize costs by using answer sheets which could be processed by optical sensing equipment.

Table 4.1 Location of Copies of IEA Instruments

Sample	Instrument	Location
1964 Students	Mathematics Tests (Population 1: A,B,C; Population 3: 5,7-9)	Husén, 1967, Vol.II: App.II, and Keeves 1966
	Opinion Questionnaire	Husén, 1967, Vol.I: Ch.6
	Student Questionnaire(ST 2)[a]	Husén, 1967, Vol.I: App.II
1964 Teachers	Teacher Questionnaire(TCH 1)[a]	Husén, 1967, Vol.I: App.II
1964 Schools	School Questionnaire(SCH 1)[a]	Husén, 1967, Vol.I: App.II
1978 Students	Mathematics Tests (Population 1: A,B,C; Population 3: D,E,F)	Appendices 2 and 3 of this report, and Rosier, 1980a
	Word Knowledge Test (Population 1: C; Population 3: 4)	Rosier, 1980a
	Opinion Questionnaire(J)	Chapter 4 of this report, and Rosier, 1980a
	General Information Questionnaire (K)[a]	Rosier, 1980a
1978 Teachers	Teacher Questionnaire (Population 1 & Population 3)[a]	Rosier, 1980a
1978 Schools	School Questionnaire[a]	Rosier, 1980a

Note: [a] Relevant items have been presented at appropriate stages of this report.

It was also decided that about one-sixth of the items in the final versions of the tests should require the students to construct their own response, to be scored on a right-wrong basis.

The items were subjected to intensive trial-testing in IEA countries prior to the construction of the final versions of the tests. The items were originally prepared in English, so that countries where English was not the usual language of the students needed to undertake the additional task of translation. It was decided that the items in the 1978 Mathematics Tests should be the same as the 1964 items except where particular changes were appropriate to meet changing circumstances; for example, it was necessary to convert some units of measurement from Imperial to metric units although the numbers themselves were not altered.

The 1964 Mathematics Test for Population 1 contained 70 items in three sections (Tests A, B and C). The time allowed for each section was one hour, to give a total testing time of three hours. The 1978 Mathematics Test for Population 1 omitted five of the 1964 items dealing with Euclidean geometry and added seven new items. The items were arranged into three sections (Tests A, B and C) each of 24 items, and each given one hour of testing time. Since this report is concerned with comparisons between 1964 and 1978, discussion of the Mathematics Test have been limited to the version containing the 65 items that were common to the two testing programs.

The 1964 Mathematics Test for Population 3 contained 69 items in four sections (Tests 5, 7, 8 and 9), each given one hour of testing time for a total of four hours. In 1978 three items dealing with probability were added; there were three 24-item sections (Tests D, E and F), each given one hour of testing time for a total of three hours. It can be seen that the total testing time was reduced for 1978, since the experience of the 1964 testing program indicated that it was not necessary to allocate four hours for the completion of the tests by the majority of the students. There was no evidence from the results of the 1978 testing program that the scores of any students were affected by this reduction in testing time. Discussions of the Mathematics Test in this report have been limited to the version containing the 69 items that were common to the two testing programs.

Tables 4.2 and 4.3 present the classification of items by content and process for Population 1 and Population 3. Each entry indicates the 1978 item number followed by the 1964 item number as given in Husén (1967).

Two alternative groupings of the process categories have also been shown. Knowledge, Translation and Comprehension together may be regarded as a simple Verbal Processes category in contrast to Computational Processes category. Otherwise, Computation and Knowledge together constitute a Lower Mental Processes category while Translation and Comprehension constitute a Higher Mental Processes category. Tables 4.2 and 4.3 also indicate items classified as New Mathematics.

The assignment of items to mutually exclusive process categories proved to be difficult, and ultimately subjective judgments were made with respect to certain items. These tables also show that the items finally selected

Table 4.2 Classification of Items by Content and Process: Population 1

Content categories	Process categories (65)			
	Lower Mental Processes (37)		Higher Mental Processes (28)	
	Computational Processes (24)	Verbal Processes (41)		
(65)	Computation (24)	Knowledge (13)	Translation (11)	Comprehension (17)
Basic Arithmetic (20)	A1/A1 A3/A3 A6/A6 A8/AB A9/A9 A23/A23 B25/B1 B27/B3 B28/B4 B31/B7 C50/C2 C51/C3	A4/A4 A17/A17 B29/B5 C49/C1 C52/C4 C56/CB	A2/A2	B43/B19
Advanced Arithmetic (15)		B32/B8 B40/B16 B45/B21	A5/A5 B26/B2 B30/B6 B48/B24 C54/C6	A7/A7 A13/A13 A22/A22 B41/B17 C55/C7 C58/C10 C71/C23
Algebra (19)	A12/A12 A14/A14 A20/A20 B34/B10 B35/B11 B36/B12 B38/B14 B39/B15 C57/C9 C66/C18	C67/C19	A11/A11 A15/A15 B47/B23 C64/C16 C69/C21	A18/A18 B33/B9 C65/C17
Geometry (11)	A10/A10 B37/B13	C53/C5 C68/C20 C70/C22		A19/A19 A21/A21 C59/C11 C61/C13 C62/C14 C63/C15

Note: The cell entries are the numbers of the items used in 1978 that were also used in 1964. The 1978 item number is given first in each case. The items underlined constitute the New Mathematics subscale (12 items). The Arithmetic subscale (35 items) is the sum of the Basic Arithmetic and Advanced Arithmetic subscales.

Table 4.3 <u>Classification of Items by Content and Process: Population 3</u>

Content categories (69)	Process categories			
	Lower Mental Processes (43)		Higher Mental Processes (26)	
	Computational Processes (33)	Verbal Processes (36)		
	Computation (33)	Knowledge (10)	Translation (4)	Comprehension (22)
Arithmetic (3)	D15/5.15 D20/5.20 E29/7.29			
Algebra (20)	D1/5.1 D2/5.2 D3/5.3 D4/5.4 D5/5.5 D18/5.18 D23/7.2 <u>E30/7.9</u> E32/7.11 E36/7.15 E37/7.16 E38/7.17 E45/8.6	<u>D22/7.1</u>	E27/7.6	D14/5.14 E26/7.5 <u>E33/7.12</u> <u>E34/7.14</u> <u>F53/8.14</u>
Geometry (5)		D12/5.12 D13/5.13		D7/5.7 D8/5.8 D21/5.21
Co-ordinate Geometry (6)	D10/5.10 <u>F69/9.13</u>	F57/9.1	D11/5.11 F49/8.10	D19/5.19
Calculus (11)	F59/9.3 F60/9.4 F61/9.5 F65/9.9 F71/9.15	F66/9.10 F67/9.11		F58/9.2 F62/9.6 F64/9.8 F70/9.14
Relations & Functions (12)	D16/5.16 E39/8.1 F50/8.11 F51/8.12 F55/8.16 F63/9.7	D6/5.6	<u>E44/8.5</u>	<u>E28/7.7</u> <u>E31/7.10</u> E41/8.2 F68/9.12
Trigonometry (3)	E43/8.4 F54/8.15	D9/5.9		
Sets (2)	<u>E35/7.14</u> <u>F52/8.13</u>			
Logic (6)		D24/7.3		<u>D17/5.17</u> <u>E25/7.4</u> <u>E46/8.7</u> <u>E47/8.8</u> <u>E48/8.9</u>
Probability (1)		E42/8.3		

Note: The cell entries are the numbers of the items used in 1978 that were also used in 1964. The 1978 item number is given first in each case. The items underlined constitute the New Mathematics subscale (16 items).

Table 4.4 Mathematics Test and Sub-test Summary Statistics: Population 1

Test/sub-test	Number of items	Mean[a]	Standard deviation[a]	Reliability KR20[a]
Mathematics Total	65	26.2	11.1	0.91
Basic Arithmetic	20	9.7	4.4	0.82
Advanced Arithmetic	15	5.9	2.8	0.71
Algebra	19	6.6	3.4	0.70
Geometry	11	4.1	2.2	0.60
New Mathematics	12	4.4	2.2	0.55
Computation	24	10.3	4.7	0.80
Knowledge	13	6.3	2.9	0.71
Translation	11	4.9	2.3	0.65
Comprehension	17	4.8	2.8	0.65

Note: [a] Means of the ten values from the 1964 and 1978R State samples.

for the tests did not fall readily into the cells on an equal or proportional basis. Certain cells were not represented, or only weakly represented, in the tests.

The sets of items in the various content and process categories were regarded as constituting sub-tests, for which corresponding scores were also calculated. Table 4.4 presents summary test statistics for Population 1 for the test as a whole (Mathematics Total) and the various sub-tests. The mean value given for Mathematics Total and the sub-tests was the mean based on the ten comparable samples; that is, the mean of the mean values for the five States in the 1964 study together with the mean values for the students in government schools in the same five States in 1978 (the 1978 restricted sample).

Table 4.5 presents corresponding information for Population 3. Reliability coefficients have not been given for sub-tests with three or fewer items. Details of the statistics from which these summary values were calculated have been included in an associated technical document (Rosier, 1980b).

Table 4.5 Mathematics Test and Sub-test Summary Statistics: Population 3

Test/sub-test	Number of items	Mean[a]	Standard deviation[a]	Reliability KR20[a]
Mathematics Total	69	28.1	9.1	0.86
Arithmetic	3	1.2	0.9	--[b]
Algebra	20	8.2	2.9	0.65
Geometry	5	2.9	1.2	0.34
Co-ordinate Geometry	6	3.2	1.3	0.34
Calculus	11	3.1	2.1	0.60
Relations and Functions	12	4.6	2.0	0.50
Trigonometry	3	1.4	1.0	--[b]
Sets	2	0.6	0.6	--[b]
Logic	6	2.4	1.4	0.43
New Mathematics	16	5.7	2.5	0.55
Computation	33	13.6	4.8	0.77
Knowledge	10	5.1	1.9	0.47
Translation	4	1.5	1.1	0.26
Comprehension	22	7.9	3.3	0.65

Note: [a] Means of the ten values from the 1964 and 1978R State samples.

[b] Reliabilities not given for sub-tests with three or fewer items.

Opinion Questionnaire

The first part of the 1964 Opinion Questionnaire contained items that constituted two descriptive scales, one measuring students' views about the teaching methods adopted by their mathematics teachers, and the other measuring their perception of the climate of the school in terms of its authoritarian or open nature. Further details of these scales and the rationale behind them were given in Husén (1967, Vol. I: Ch. 6).

Prior to preparing the 1978 version of the Opinion Questionnaire, the 1964 data for Australia were re-analysed by factor analytic procedures, of which details have been given in Rosier (1980a). It was decided to include only the six items from the first descriptive scale that had adequate statistical properties for both the 1964 Australian Population 1 and Population 3 samples. Since the purpose of the scale was to enable comparisons to be made between 1964 and 1978, it was decided that no new items should be added. The modification procedure therefore involved eliminating unsatisfactory items, so that the 1978 version necessarily contained fewer items. Students were asked to respond to the items by indicating whether they agreed with the statement, disagreed with the statement, or could not decide whether they agreed or disagreed with the statement.

Once the 1978 data had been collected, further analyses were conducted to confirm that the 6-item version of the descriptive scale worked satisfactorily across both populations on both testing occasions. Scores on the scale were then calculated for each respondent who had no missing data on any of the items in the scale. A favourable response was assigned the value 3, a neutral response was assigned the value 2, and an unfavourable response was assigned the value 1.

The constituent items in the Descriptive Scale (Mathematics Teaching), have been set out in Table 4.6. This name for the scale was selected to avoid confusion with the original 1964 scale. The scale was designed to measure the perception of students concerning the approach to teaching adopted by their mathematics teachers. Students were located on a continuum ranging from a formalized approach which emphasized rote-learning to one which emphasized problem-solving processes. In order to reduce bias in response patterns, some items were worded so that disagreement with the statement indicated a favourable response.

The latter part of the 1964 Opinion Questionnaire contained 43 items from which a set of five scales measuring various attitudes was prepared. The 1964 data for Australia were re-analysed, and 30 items were retained for inclusion in the 1978 Opinion Questionnaire. After confirmatory analyses using the 1978 data, four scales were specified as set out in Tables 4.7 to 4.10.

Attitude Scale A1 (Importance of Mathematics) was designed to measure students' attitudes to the importance of mathematics for employment or understanding the environment. A high score on this scale was considered to indicate that the student regarded mathematics as important. Although 1978 item J9 (1964 item 19) was originally assigned to this scale, it was necessary to omit it for the comparisons between 1964 and 1978 since there was a very large amount of missing data on the 1964 files.

Table 4.6 Descriptive Scale (Mathematics Teaching)

Item number 1978	1964	Item [a]
J02	4	My mathematics teacher shows us different ways of solving the same problem.
J07	7	My mathematics teacher wants students to solve problems only by the procedures he or she teaches. (D)
J11	12	My mathematics teacher expects us to learn how to solve problems by ourselves, but helps when we have difficulties.
J18	16	My mathematics teacher encourages us to try to find several different methods for solving particular problems.
J23	18	My mathematics teacher wants us to discover mathematical principles and ideas for ourselves.
J31	19	My mathematics teacher explains the basic ideas; we are expected to develop the methods of solution for ourselves.

Note: [a] A favourable response was indicated by agreement with the statement, except for statements marked (D) where a favourable response was indicated by disagreement.

Attitude Scale A2 (Facility of Mathematics) contained the same items as one of the original scales. A high score indicated that the student thought that most persons could learn mathematics. A low score indicated that mathematics could only be learnt by a small elite group of persons.

Attitude Scale A3 (School Enjoyment) contained nine of the 11 items in one of the original scales. A student obtaining a high score displayed a strong enjoyment of schools and schoolwork. A low score reflected a lack of enjoyment of school and a desire to leave as soon as possible.

Attitude Scale A4 (Control of Environment) contained six of the nine items in one of the original scales. A high score reflected the attitude that man could control his physical and social environment. A low score indicated that the student did not agree with this attitude.

Table 4.7 Attitude Scale A1 (Importance of Mathematics)

Item number 1978	1964	Item
J10	35	Mathematics is of great importance to a country's development.
J13	39	Mathematics (algebra, geometry, etc.) is not useful for the problems of everyday life. (D)
J17	45	A thorough knowledge of advanced mathematics is the key to an understanding of our world in the 20th century.
J20	47	It is important to know mathematics (algebra, geometry, etc.) in order to get a good job.
J22	49	Mathematics is a very good field for creative people to enter.
J24	50	Unless one is planning to become a mathematician or scientist, the study of advanced mathematics is not very important. (D)
J28	54	In the near future most jobs will require a knowledge of advanced mathematics.

Table 4.8 Attitude Scale A2 (Facility of Mathematics)

Item number 1978	1974	Item
J04	29	Anyone can learn mathematics.
J12	37	Very few people can learn mathematics. (D)
J21	48	Almost anyone can learn mathematics if he or she is willing to study.
J25	51	Any person of average intelligence can learn to understand a good deal of mathematics.
J27	53	Even complex mathematics can be made understandable and useful to every high school student.
J32	57	Almost all students can learn complex mathematics if it is properly taught.
J35	61	Only people with a very special talent can learn mathematics. (D)

Table 4.9 Scale A3 (School Enjoyment)

Item number		Item
1978	1964	
J01	24	I generally like my school work.
J06	32	I dislike school and will leave just as soon as possible. (D)
J15	41	I am bored most of the time in school. (D)
J16	44	I enjoy everything about school.
J19	46	School is not very enjoyable, but I can see value in getting a good education.
J26	52	The most enjoyable part of my life is the time I spend in school.
J33	58	I like all school subjects.
J34	60	I enjoy most of my school work and want to get as much additional education as possible.
J36	65	I find school interesting and challenging.

Table 4.10 Scale A4 (Control of Environment)

Item number		Item
1978	1964	
J03	28	Some day most of the mysteries of the world will be revealed by science.
J05	31	By improving industrial and agricultural methods, poverty can be eliminated in the world.
J08	33	With increased medical knowledge, it should be possible to lengthen the average life span to 100 years or more.
J14	40	Some day the deserts will be converted into good farming land by the application of engineering and science.
J29	55	With hard work anyone can succeed.
J30	56	Almost every present human problem will be solved in the future.

Table 4.11 Descriptive and Attitude Scale Summary Statistics

Scale	Number of items	Mean[a]	Standard deviation[a]	Reliability alpha[a]
Descriptive Scale (Mathematics Teaching)	6	12.9	2.6	0.44
Attitude Scale A1 (Importance of Mathematics)	7	15.4	3.0	0.56
Attitude Scale A2 (Facility of Mathematics)	7	17.5	2.7	0.59
Attitude Scale A3 (School Enjoyment)	9	19.9	4.0	0.76
Attitude Scale A4 (Control of Environment)	6	13.0	2.5	0.44

Note: [a] Means of the twenty values from the 1964 and 1978R Population 1 and Population 3 State samples.

Table 4.11 presents statistics to summarize characteristics of the scales. The statistics were based on the mean of twenty values - for the five States in the 1964 and 1978R samples at both Population 1 and Population 3 levels.

Student Questionnaire

The purpose of the Student Questionnaire was to obtain background information about each student in order to construct explanatory variables that would assist in understanding differences between students with respect to their mathematics achievement. Table 4.12 presents a summary of the factors for which comparable information was collected in both 1964 and 1978. The wording used for various items has been included in subsequent sections of this report where the explanatory variables have been linked to achievement and attitude scores.

Table 4.12 Summary of Items in Student, Teacher and School Questionnaires

	1978	1964
Student Questionnaire	(Section K)	(ST 2)
Age	K1	5
Sex	K2	4
Father's occupation	K3/4	16/17
Father's education	K5	14
Mother's education	K6	15
Year level	K15	3
Name of mathematics teacher	K16	7
Number of students in mathematics class	K17	8
Number of periods of mathematics per week	K18	9
Number of hours of mathematics per week	K19	10
Number of hours of mathematics homework per week	K20	12(a)
Number of hours of all homework per week	K21	12(b)
Liking for mathematics	K24	28/29
Results in mathematics	K25	30/31
Teacher Questionnaire	(Teacher Questionnaire 1 & 3)	(TCH 1)
Age	1	2
Sex	2	3
Number of years of post-secondary education	3	4
Type of training institution: professional training	4	5
Type of training institution: mathematics training	5	6
Number of years of teaching experience	6	8
Attitude towards mathematics teaching	7	13
Opportunity-to-learn ratings	9	18
School Questionnaire	(School Questionnaire)	(SCH 1)
Number of students	1	1
Sex of school	1	6
Number of teachers	2(1)	2
Number of mathematics teachers	2(2)	3
Number of male mathematics teachers	2(3)	5

Teacher and School Questionnaires

The factors for which comparable background information was collected from teachers in 1964 and 1978 have also been set out in Table 4.12. Of particular importance were the opportunity-to-learn ratings. The mathematics teachers rated each item in the test in terms of the extent to which the students in their class had had the opportunity to learn that type of problem.

The school Principal or his delegate was asked to provide basic demographic information about the school on the School Questionnaire. Other relevant information was available from the ACER Sampling Frame from which the schools were selected; for example, the type of school (government, Catholic or independent) and location of school (metropolitan area, non-metropolitan city or non-metropolitan town).

Summary

This study was designed to investigate changes between 1964 and 1978 in the mathematics achievement of Australian secondary students, setting these changes in the context of corresponding changes in the structure of the education systems and the content of the mathematics curriculum. This meant that the tests and questionnaires administered in 1978 had to be comparable to those initially used in 1964, both for the measurement of student mathematics achievement and attitudes, and also for the range of background factors to be used in explaining changes over the period under review.

This chapter described the nature of the tests and questionnaires completed by the students in the samples, by the mathematics teachers of these students, and by the principals of the schools they attended. The collection of this comprehensive range of information meant that a very rich set of data was available for analysis in pursuit of the aims of the study. The following chapters describe these analyses.

CHAPTER 5

CHARACTERISTICS OF STUDENTS, TEACHERS AND SCHOOLS

The achievement of students is influenced by their home background, their teachers and the schools they attend. The purpose of this chapter is to describe some of these background factors for the samples which were involved in the two IEA Mathematics Studies. The documentation of these characteristics represents a further stage in setting the scene for the analysis of changes in mathematics achievement of Australian students between 1964 and 1978.

Associated with the data in this chapter were certain measurement and sampling problems. The measurement problems were concerned with data which were based on different questions in the 1964 and 1978 testing programs. Although data from the respective occasions were recoded for presentation in a comparable format, the data may not be strictly comparable. Where data involving this problem have been presented, further discussion of the comparability of the data has been included in the corresponding text. Details of the recoding procedures applied to student responses in order to produce data for 1964 and 1978 in a comparable format have been included in technical documents describing the sampling, administration and data preparation for the 1964 and 1978 studies (Rosier, 1980a).

The data presented in this chapter have been derived from information obtained from samples of respondents. These sample data have been used to estimate characteristics of the corresponding populations, but it is first necessary to clarify the nature of these populations. This requires a brief discussion of the weighting and disaggregating procedures used in obtaining the data for presentation.

The main samples for this study involved students at two levels (Population 1 and Population 3) on two occasions (1964 and 1978). Since these were probability samples, each student in the relevant population had a known non-zero probability of selection. This meant that each student in the sample for a given stratum was considered to represent a certain number of the students in the population for that stratum. This number, termed the 'raising factor', was the inverse of the probability of selecting a student from the population for that stratum, or sampling fraction for the stratum.

Some of the Population 1 State samples were composed of two subsamples, drawn with different sampling fractions from separate primary and secondary school strata. In order to present the results for a State, it was considered necessary to apply weighting procedures to compensate for the different sampling fractions. If the weighting were not carried out, the results may have been biased in favour of the strata with larger sampling fractions. In effect, the weighting procedure involved multiplying the data for each case by the raising factor for the stratum to which the case belonged, and combining these weighted data across the relevant strata. This procedure was adopted in obtaining the results from the 1964 Population 1 samples for New South Wales, Queensland and Western Australia.

The weighting procedure for the 1978 Population 1 sample involved two stages. Firstly, data were weighted to compensate for different sampling fractions for primary and secondary level students in the three States that had these pairs of strata. Secondly, data within each State were weighted to compensate for differential school non-response rates. The probability sampling approach assumed that the students selected from each school (the expected sample) all attended the testing program and provided data that could be used. In practice the number of students from whom useful data were obtained (the achieved sample) was sometimes lower than the expected sample. The extent of non-response varied across schools. This could result in bias in favour of schools with higher response rates when data from students in different schools in a stratum were combined to produce results for the stratum. The weighting procedure to compensate for differential non-response across schools involved multiplying the data for each case by the ratio:

$$\frac{\text{number of students in the expected sample for the school}}{\text{number of students in the achieved sample for the school}} .$$

This procedure assumed that there were no differences between the respondents and non-respondents within a school with respect to the variables being measured by the study.

For this study, the simplest sampling design used for the selection of students was for the 1964 Population 3 sample. The five strata were the students in government schools in the five States in the study. In calculating the data for each State no weighting adjustments were needed to compensate for different sampling fractions, and no data were available for weighting to compensate for differential non-response across schools.

For each State in the 1978 Population 3 sample the same sampling fraction was applied across the three strata (government, Catholic and independent) so that no weighting was needed in order to combine data from these strata. However, weighting was used in this sample to compensate for differential non-response across schools.

The studies included samples of mathematics teachers, but there were problems in identifying the population represented by these samples. They were not random probability samples of teachers, but rather the teachers of probability samples of students. This method of sampling teachers was intentional, since the focus of the study was not on teacher attributes but on student outcomes, and teachers were included in the studies only in order to examine the effects of their attributes on the student outcomes.

The strategy adopted to solve this problem was to 'disaggregate' the teacher data; that is, the data for each teacher in a study were linked to the data for the one or more members of the sample of students for whom he or she was the teacher. For smaller schools, an individual teacher was usually linked to a relatively large number of sample students. For larger schools, an individual teacher was usually linked to fewer students. In effect, the data did not describe characteristics of a sample of teachers, but instead described the teacher characteristics experienced by the sample students in the stratum under consideration. This meant that the data presented in this report to describe teacher characteristics were based on the samples of students, not on the samples of teachers. Since weighted data were generally used to describe the student samples, this meant that the teacher data presented in this chapter were both disaggregated and weighted.

A similar problem was involved in the interpretation and presentation of data derived from school questionnaires. The sampling designs for these studies involved two-stage selection procedures. The schools, selected at the first stage, were random probability samples of schools, so that schools could readily be used as the unit of analysis in between-schools analyses. However, since the focus of this report was on students as the unit of analysis, it was decided to disaggregate the school data. The data for each school were linked to the data for each of the students in the sample who attended that school.

It follows that the school data presented in this report did not describe characteristics of a sample of schools, but described the school characteristics experienced by the students in the sample. These data were both disaggregated and weighted with respect to the student samples.

Student Home Background Characteristics

The first set of characteristics to be considered describe the home background of the students in terms of the occupation of the father of each student, and the education of his father and mother. Although these factors have often been used in educational and sociological research as indicators of the socio-economic status of a respondent, their measurement has posed problems. Firstly, there has always been an element of uncertainty where a respondent has supplied information about another person, as when a student has supplied information about his parents. Secondly, it has proved difficult to develop suitable systems for the classification of occupational status and educational attainment, especially where the classification systems must retain their validity for use across time.

Similar questions were used in 1964 and 1978 to obtain information about the occupation of the student's father. The 1978 version stated:

> What is your father's occupation? If your father is no longer alive, give your guardian's occupation. If you do not have a guardian, give your father's occupation before he died.

On both testing occasions there was an additional part to the question, which asked the student to provide a clear description of the duties involved in the occupation. This additional detail was used to assist in the coding of the information.

The 1964 responses were coded according to a classification system specified by IEA (Husén, 1967, Vol. I:272). The 1978 responses were coded according to the Australian National University (ANU) 16-point scale (Broom, Jones and Zubrzycki, 1965) which was in turn derived from the occupational classification system used for the Australian population census. In order to form the variable Father's Occupation for use in this report, the responses from 1964 and 1978 were recoded to a common 8-point scale. Table 5.1 sets out the relationship between this scale and the ANU classification system.

In order to summarize the data on Father's Occupation, it was decided to present the data for the percentage of students in the three highest categories: executive managerial, lower professional and higher professional. It was assumed that the assignment of occupational titles to these categories would have remained fairly consistent over the period under review. These percentages for Populations 1 and 3 have been presented in Tables 5.2 and 5.3.

Table 5.1 Relationship Between 8-Point Occupational Classification System and ANU Classification System

Occupational categories	ANU categories (Broom, Jones and Zubrzycki, 1965)
1 Unskilled	Personal, domestic and other service workers (13), Miners (14), Farm and rural workers (15), Labourers (16)
2 Skilled, semi-skilled	Craftsmen and foremen (9), Shop assistants (10), Operatives and process workers (11), Drivers (12)
3 Clerical, sales	Clerical and related workers (7), Members of armed services and police force (8)
4 Owner-farmer	Other farmers (6)
5 Working proprietor	Self-employed shop proprietor (5)
6 Executive managerial	Managerial (4)
7 Lower professional	Lower professional (3)
8 Upper professional	Upper professional (1), Graziers, and wheat and sheep farmers (2)

Care should be taken in comparing the 1964 and 1978 data, since the assignment of occupational titles to code categories was not necessarily consistent across the two testing programs. Further, the percentage of cases with unclassifiable or missing responses was higher in 1978, and there was no evidence to justify the allocation of these missing data to other categories on a random or proportional basis.

At the Population 1 level the percentages of students whose fathers were rated at the higher occupational levels tended to be lower for the 1978 restricted samples than for the 1964 samples. However the differences were not large and may have been a function of the different classification procedures employed on the two occasions. The percentages for the 1978 samples were all higher than the corresponding values for the 1978 restricted samples, indicating that the mean ratings of the occupational levels were higher for the fathers of students in non-government schools in all States in 1978.

The pattern of results for Population 3 was similar to that for Population 1. For each of the five States with comparable data the

Table 5.2 Student Home Background Characteristics: Population 1

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Father's Occupation: % in higher level occupations							
1964		21%	17%	14%		21%	18%
1978R		17%	14%	14%		18%	13%
1978	33%	21%	18%	19%	15%	22%	19%
Father's Education in years							
1964		a	9.3	a		9.2	9.1
1978R		10.6	10.3	9.7		9.7	9.4
1978	12.4	10.2	10.5	9.9	10.1	10.0	9.8
Mother's Education in years							
1964		a	9.2	a		9.1	9.1
1978R		9.8	10.2	9.7		9.6	9.4
1978	11.6	10.0	10.3	10.0	10.2	9.8	9.7

Note: [a] This information was not collected in New South Wales or Queensland.

Table 5.3 Student Home Background Characteristics: Population 3

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Father's Occupation: % in higher level occupations							
1964		39%	40%	37%		47%	49%
1978R		34%	36%	36%		27%	42%
1978	45%	39%	44%	44%	36%	38%	46%
Father's Education in years							
1964		a	10.0	a		9.3	9.9
1978R		10.2	10.2	10.5		9.9	11.1
1978	12.3	10.8	11.1	11.1	10.8	10.8	11.3
Mother's Education in years							
1964		a	9.7	a		9.2	9.8
1978R		9.2	9.4	9.8		9.8	10.4
1978	[illegible].8	9.8	10.3	10.1	10.3	10.4	10.5

Note: [a] This information was not collected in New South Wales or Queensland.

percentage of students with higher values for Father's Occupation was lower for the 1978 restricted samples than for the 1964 samples. From a comparison of the values for the 1978 restricted and total samples, it could be seen that the percentages of students with higher values for Father's Occupation were higher in non-government schools.

From the percentages of students with higher values for Father's Occupation it was possible to examine changes in the relative selectivity at the two populations. For each pair of corresponding percentages for Population 1 and Population 3 the following selectivity index was calculated:

$$\frac{\text{value for Population 3 (from Table 5.3)}}{\text{corresponding value for Population 1 (from Table 5.2)}}$$

The values of the indices in Table 5.4 showed that the degree of selectivity of students at Population 3 level relative to those at Population 1 level was similar for the 1964 samples and the 1978 restricted samples in New South Wales, Victoria and Queensland, with a decrease in Western Australia and an increase in Tasmania.

In 1964 each student was asked the following question about the education of his or her father:

Did your father:	
Leave school before the age of fifteen	(8 years)
Attend school only up to the age of fifteen	(9 years)
Attend school to Intermediate or Junior level (or equivalent)	(10 years)
Attend school to Leaving or Matriculation level (or equivalent)	(12 years)
Have other full-time further education after leaving school	(11 years)

In order to prepare the variable Father's Education, each response category was coded in terms of the number of years of education to which it generally corresponded; the number of years has been indicated in brackets next to each category. Each student was also asked a similar question about the education of his or her mother from which data were obtained for the variable Mother's Education. Students in New South Wales and Queensland did not answer these two questions.

The questions on father's and mother's education in the 1978 study were the same as the ones used in the 1970 IEA Science Study (Comber and Keeves, 1973). The following wording was used:

How many years of full-time education (including school, university, etc.) did your father receive?

1 none at all	(0 years)

Table 5.4 Selectivity Indices for Father's Occupation from Population 3 to Population 1[a]

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Father's Occupation							
1964		1.9	2.4	2.6		2.2	2.7
1978R		2.0	2.6	2.6		1.5	3.2
1978	1.4	1.9	2.4	2.3	2.4	1.7	2.4

Note: [a] Calculated as:

$$\frac{\text{value for Population 3 (from Table 5.3)}}{\text{corresponding value for Population 1 (from Table 5.2)}}$$

B up to 5 years (5 years)
C more than 5 years - up to 10 years (8 years)
D more than 10 years - up to 15 years (13 years)
E more than 15 years (18 years)

In order to form the variable Father's Education for the purposes of this report, the response categories were equated to the number of years indicated in brackets. Each student was also asked a similar question about the education of his or her mother for the variable Mother's Education. The mean number of years of father's and mother's education has been included in Tables 5.2 and 5.3 although care should be taken in compa ng 1964 and 1978 data.

The clear picture that emerged from the results for Father's Education and Mother's Education was that the mean educational level of the parents of the 13-year-old Australian students increased during the period under review. In general the educational level of the father was higher than that of the mother for the corresponding entry in the table. The mean level of education of the parents was markedly higher in the Australian Capital Territory than in the other States in 1978, which was consistent with the results for Father's Occupation. At the Population 3 level, the values for Father's Education and Mother's Education also tended to be higher in 1978 than in 1964.

Most of the Population 3 values for these two variables were higher than the corresponding ones for Population 1. There were a few cases where the Population 3 values were lower, although these negative values may have been a function of the different measurement procedures on the two occasions.

Student School Characteristics

This section presents weighted data describing various characteristics of the sample students, given in Table 5.5 for Population 1 and in Table 5.6 for Population 3. The mean age for the students in the Population 1 State samples was 13:5 years or 13:6 years, near the centre of the defined target population range of 13:0 to 13:11 years. For Population 3 the mean age of students in the New South Wales sample increased by almost one year, reflecting the addition of a further year to the system of secondary schooling. In the States with a five-year secondary system (New South Wales in 1964, and Queensland, Western Australia and South Australia in 1964 and 1978) the mean age was about six months lower than in the other States.

At the Population 1 level the percentage of male students in the 1964 and 1978 samples was about 50 per cent. For Population 3 the percentage of male students decreased from 1964 to 1978. The increased participation of female students in mathematics courses at the Year 12 level probably reflected both changing societial attitudes about the suitability of mathematics as a topic to be studies by female students, and also the wider range of available mathematics courses.

In 1964 students provided information on the number of students in their mathematics class by indicating which of the following ranges best represented their class:

Under 10 students	(7 students)
10-14 students	(12 students)
(further intervale of 5 students)	...
40 or more students	(42 students)

In order to form the variable Class Size for use in this report the student responses to these categories were recoded to give the values indicated in brackets.

In 1978 the students were asked the direct question:

How many students are in your present
mathematics class?

The number given as a response was used to form the variable Class Size.

For both Population 1 and Population 3 the mean number of students in mathematics classes in 1978 was markedly lower than in 1964, except for Western Australia at the Population 3 level where the 1964 value was already relatively low. By 1978 the median value was about 29 students per class at the Population 1 level and 20 students per class at the Population 3 level.

Table 5.5 Student School Characteristics: Population 1

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Age: mean age in years and months							
1964		13:5	13:6	13:5		13:5	13:6
1978R		13:5	13:6	13:5		13:5	13:6
1978	13:5	13:5	13:5	13:5	13:5	13:5	13:6
Sex of Student: male students %							
1964		50%	54%	53%		54%	51%
1978R		56%	54%	49%		53%	56%
1978	41%	58%	53%	49%	51%	53%	52%
Class Size: mean number of students in mathematics class							
1964		36.0	36.5	37.7		37.5	32.7
1978R		29.5	25.2	28.3		29.6	25.3
1978	29.3	30.2	26.4	28.7	28.0	29.7	26.1
Class Mathematics: mean number of hours per week							
1964		4.3	4.8	4.9		4.8	3.7
1978R		3.7	4.1	3.8		4.1	3.6
1978	3.7	3.7	4.0	3.8	4.0	4.1	3.6
Mathematics Homework: mean number of hours per week							
1964		2.5	1.9	2.6		2.8	1.9
1978R		2.2	2.1	2.4		2.3	1.7
1978	2.2	2.2	2.2	2.5	2.2	2.3	1.9
All Homework: mean number of hours per week							
1964		6.4	4.8	7.1		7.3	6.6
1978R		5.2	4.7	6.1		5.3	4.6
1978	5.3	5.6	5.3	6.7	6.1	5.9	5.2

Table 5.6 Student School Characteristics: Population 3

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Age: mean age in years and months							
1964		17:0	17:9	17:4		17:2	17:6
1978R		17:10	17:10	17:2		17:2	17:7
1978	17:8	17:9	17:8	17:2	17:2	17:2	17:6
Sex of Student: male students %							
1964		71%	75%	62%		61%	81%
1978R		60%	55%	61%		54%	63%
1978	57%	58%	57%	59%	70%	59%	65%
Class Size: mean number of students in mathematics class							
1964		20.6	24.2	27.9		19.7	26.8
1978R		16.6	15.6	21.0		18.0	22.6
1978	22.2	19.7	17.7	21.1	18.3	20.5	20.8
Class Mathematics: mean number of hours per week							
1964		6.5	6.7	6.8		4.7	5.0
1978R		4.9	5.9	5.7		5.7	5.4
1978	5.1	4.7	5.4	5.5	6.3	5.1	5.3
Mathematics Homework: mean number of hours per week							
1964		5.7	8.5	5.0		5.2	4.2
1978R		5.4	7.5	4.0		4.8	3.8
1978	3.0	5.8	6.8	4.4	5.9	4.6	3.9
All Homework: mean number of hours per week							
1964		19.9	20.9	16.6		20.3	17.1
1978R		19.7	21.6	13.2		17.1	14.2
1978	12.2	20.5	22.2	14.2	18.9	17.2	14.5

In general the values for the 1978 total sample were higher than those for the 1978 restricted sample, indicating that the mean class sizes were lower in the government sector than in the non-government sector.

Information about the amount of time spent in class on the teaching of mathematics was obtained in both 1964 and 1978 by means of the following question:

Please indicate the number of hours (60 minutes) you have mathematics each week.	
less than 1 hour	(0.5 hours)
between 1 hour and 1 hour 59 minutes	(1.5 hours)
(further intervals of 1 hour)	...
8 hours or more	(8.5 hours)

The variable Class Mathematics was formed from student responses to these categories, according to the coding indicated in brackets.

The amount of time spent in class on the teaching of mathematics at the Population 1 level clearly decreased from 1964 to 1978. The extent of the decrease varied across the States, but the net result was that the median amount of time spent on mathematics in 1978 was about 4 hours in all the States.

At the Population 3 level the amount of time spent in class on mathematics decreased from 1964 to 1978 in New South Wales, Victoria and Queensland, and increased in Western Australia and Tasmania. These mean values reflected changes in the pattern of mathematics curriculum and participation at the Year 12 level. The significance of the changes can only be properly assessed by taking account of these associated factors, as described later in this report.

The last two sets of characteristics in this section were concerned with the amount of time spent by the students on homework. For both the 1964 and 1978 studies the information was gained by asking the direct questions:

How many hours a week do you usually devote to mathematics homework?

How many hours a week do you usually devote to all homework (including mathematics)?

The student responses were used directly to form the variables Mathematics Homework and All Homework. There must always be some concern about the validity of data derived from student responses to a direct question of this type. The student may not be able to make an accurate estimate, or may deliberately exaggerate the time spent. In the absence of separate validating evidence, the student data on these variables have been accepted at face value for this study, although confidence in this position was gained from the meaningfulness of the responses across States and across the two testing programs.

There was generally a small decrease at the Population 1 level on the amount of time spent on both mathematics homework and homework for all subjects. By 1978 the mean time spent each week on mathematics homework was a little more than 2 hours in each State. There was also an overall decrease between 1964 and 1978 in the mean amount of mathematics homework done by the Population 3 students, although these changes may also have been influenced by the changing patterns mentioned above. There was considerable variation across States for both Mathematics Homework and All Homework.

Teacher Background Characteristics

The IEA Mathematics studies described in this report did not focus on the activities of mathematics teachers in their classrooms, so that the data can not be used to evaluate the influence of teaching behaviour on the mathematics achievement of students. However, information was collected on background characteristics of the teachers in order to provide some insight into the context for the teaching of mathematics in Australia. The data in this section were derived from the samples of teachers and disaggregated on to the corresponding samples of students. They were also subjected to the weighting procedures described earlier in this chapter. Thus the data no longer described the samples of teachers, but set out the characteristics of the teachers as experienced by the students in the samples. The data for Population 1 and Population 3 are presented in Tables 5.7 and 5.8.

In 1964 the majority of students at both population levels were taught by male mathematics teachers, and there was no clear departure from changes in this pattern by 1978, except in the Australian Capital Territory at the Population 1 level.

Information about the age of the teacher was collected in both studies by asking the teacher to indicate one of the following ranges:

18 to 23 years	(20.5 years)
24 to 29 years	(26.5 years)
(further intervals of 10 years)	...
60 years or older	(64.5 years)

D

Table 5.7 Teacher Background Characteristics: Population 1

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Teacher Sex: male mathematics teachers %							
1964		70%	67%	72%		57%	78%
1978R		64%	73%	74%		63%	72%
1978	42%	66%	73%	68%	69%	61%	65%
Teacher Age: mean age in years							
1964		33	32	35		26	33
1978R		30	29	34		30	32
1978	32	32	31	34	31	31	35
Post-secondary Education: mean number of years							
1964		3.3	2.8	2.2		3.0	2.9
1978R		4.2	4.5	3.8		4.4	4.5
1978	4.4	4.2	4.4	3.8	4.4	4.3	4.6
Teaching Experience: mean number of years							
1964		9.6	9.4	13.7		4.6	10.4
1978R		8.4	6.4	11.8		7.9	8.4
1978	8.9	9.0	8.5	12.1	8.1	8.2	10.4
Professional Training							
1964							
University %		0%	8%	4%		6%	36%
College %		44%	56%	66%		28%	33%
Both %		55%	12%	25%		66%	23%
1978R							
University %		34%	32%	24%		16%	55%
College %		37%	33%	43%		35%	36%
Both %		28%	34%	33%		47%	9%
1978							
University %	30%	32%	26%	21%	29%	17%	55%
College %	37%	39%	38%	43%	32%	33%	32%
Both %	32%	29%	34%	36%	36%	46%	9%

... contd

Table 5.7 Teacher Background Characteristics: Population 1 (contd)

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Mathematics Training							
1964							
University %		17%	11%	12%		27%	24%
College %		34%	29%	54%		34%	32%
Both %		37%	5%	6%		23%	11%
1978R							
University %		53%	56%	30%		45%	46%
College %		23%	23%	35%		27%	33%
Both %		21%	19%	21%		21%	4%
1978							
University %	55%	50%	52%	29%	54%	47%	46%
College %	27%	26%	27%	37%	20%	27%	30%
Both %	13%	19%	17%	23%	18%	20%	4%

The values indicated in brackets were used to form the variable Teacher Age.

In general the students in Population 1 in 1978 were taught by slightly younger teachers than were the students in 1964. However, in Western Australia there was an increase in the mean age of teachers from the low value of 26 in 1964. In 1978 the Population 3 students in government schools were taught by teachers of lower mean age in New South Wales, Queensland and Western Australia. At both population levels in 1978 there was relatively little variation across the States in the mean values for Teacher Age. For both 1964 and 1978 students in all States in Population 1 were generally taught by younger teachers than were the Population 3 students.

In both of the studies the teachers were asked about the amount of training they had received. The following question was used in 1964:

> Please indicate the total number of years of training you have received. Include both professional (e.g. teaching methods, educational psychology) and subject (i.e. mathematics).

The following question, derived from the 1970 IEA Science Project, was used in 1978:

> Please indicate the total number of years of full-time education you have received after your secondary schooling. Include part-time education by reducing it to its full-time equivalent.

The teachers' responses were used directly to form the variable Post-secondary Education.

Table 5.8 Teacher Background Characteristics: Population 3

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Teacher Sex: male mathematics teachers %							
1964		75%	77%	73%		76%	100%
1978R		70%	74%	70%		71%	86%
1978	64%	68%	69%	65%	84%	65%	87%
Teacher Age: mean age in years							
1964		37	33	41		34	29
1978R		35	36	33		33	37
1978	33	38	38	35	38	36	40
Post-secondary Education: mean number of years							
1964		4.0	4.2	3.3		3.6	4.2
1978R		5.1	5.4	4.5		4.5	4.8
1978	4.5	5.1	5.5	4.5	5.3	4.8	4.8
Teaching Experience: mean number of years							
1964		14.6	13.1	16.7		12.3	7.7
1978R		12.2	12.7	11.7		12.3	11.6
1978	9.6	14.8	16.0	13.6	15.2	13.4	14.3
Professional Training							
1964							
University %		0%	44%	35%		9%	73%
College %		2%	7%	27%		6%	6%
Both %		96%	49%	25%		85%	21%
1978R							
University %		18%	40%	25%		6%	75%
College %		15%	31%	26%		9%	0%
Both %		67%	30%	46%		85%	22%
1978							
University	23%	31%	42%	39%	43%	19%	66%
College %	39%	25%	37%	22%	26%	13%	7%
Both %	38%	45%	22%	29%	27%	63%	19%

... contd

Table 5.8 Teacher Background Characteristics: Population 3 (contd)

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Mathematics Training							
1964							
University %		42%	97%	79%		73%	100%
College %		1%	0%	2%		0%	0%
Both %		55%	3%	4%		18%	0%
1978R							
University %		48%	87%	33%		73%	91%
College %		8%	13%	29%		5%	5%
Both %		44%	0%	33%		21%	4%
1978							
University %	70%	64%	84%	58%	89%	59%	94%
College %	20%	11%	10%	18%	1%	14%	4%
Both %	9%	26%	6%	21%	10%	20%	3%

In each State and at each population level the students in 1978 were taught mathematics by teachers with a higher mean number of years of post-secondary education than in 1964. This reflected the policy of increasing the amount of basic preservice training of teachers as well as the increased opportunities for teachers to extend their qualifications beyond the level of their initial training. In both 1964 and 1978 the Population 3 students in each State were in the hands of teachers with higher mean amounts of post-secondary education than the corresponding Population 1 students.

The amount of teaching experience that teachers could gain was obviously linked both to their age and their post-secondary education. In order to measure the amount of teaching experience the following question was asked in 1964:

How many years teaching experience have you had?

Less than 1 year	(1 year)
1-2 years	(2 years)
3-5 years	(4 years)
6-10 years	(8 years)
11-15 years	(13 years)
16-20 years	(18 years)
21-25 years	(23 years)
26+ years	(28 years)

The categories were recoded according to the values indicated in brackets to form the variable Teaching Experience.

In 1978 the following question was asked:

Including this year, how many years teaching experience have you had?

The number of years given as a response was used directly to form the variable Teaching Experience.

With the exception of Western Australia (Populations 1 and 3) and Tasmania (Population 3), the students in 1978 were taught by teachers with lower mean levels of teaching experience. For Population 1 on both occasions there was wide variation across the States in the mean values of Teacher Experience. By 1978 there was little variation in these values at the Population 3 level.

A distinction was made between professional training and training in mathematics itself. In order to obtain information about these two aspects, two separate questions were asked on each testing occasion. The same questions were asked in 1964 and 1978:

In what type of higher educational institution did you receive your professional training?

In what type of higher educational institution did you receive your mathematics training?

The wording used in 1964 for the response categories for these questions was modified for use in 1978 to reflect changes in terminology and organization among institutions at the tertiary level:

<u>1964</u>

University	(1)
Teacher training college	(2)
University <u>and</u> teacher training college	(3)
Other	(4)
None	(5)

<u>1978</u>

University	(1)
College of Advanced Education or teacher training college	(2)
University and College of Advanced Education (or teacher training college)	(3)
Other	(4)
None	(5)

The values indicated in brackets were used to form the variables Professional Training and Mathematics Training. The data for the first three categories of these variables were included in Tables 5.7 and 5.8.

The results display considerable variation across States, reflecting differences in patterns of teacher education. At the Population 1 level between 1964 and 1978 there was a major increase in the percentage of students whose mathematics teachers received their professional and mathematics training solely at universities, particularly. The changes were less marked at the Population 3 level, which was partly due to the greater age and experience of the teachers of these students. The major differences between the Population 1 and Population 3 students were in terms of the percentages of their teachers who had received training in Mathematics at a university.

School Characteristics

This final section describes various characteristics of the schools attended by the sample students. The data presented have been disaggregated and weighted, as described above. The data do not describe the sample of schools, but indicate the characteristics of the schools attended by the random probability sample of students. Tables 5.9 and 5.10 present the data for Population 1 and Population 3.

In 1964 the Principal (or other person completing the School Questionnaire) was asked the following question about the school enrolment:

> What is the total enrolment of your school?
> Give the exact number here.

The number given as a response was used to form the variable School Size. In order to improve the comparability of data between 1964 and 1978, the data presented here on student enrolments (and also numbers of teachers) were limited to the strata from which the samples of secondary students were drawn.

Equivalent information was gathered in 1978 by adopting an alternative strategy. The principal was asked to indicate the number of male students and the number of female students at each of Years 7 to 12. The variable School Size (secondary level only) was prepared by summing the total number of students across Years 7 to 12 in the Australian Capital Territory, New South Wales, Victoria and Tasmania, and across Years 8 to 12 in Queensland, South Australia and Western Australia.

At the Population 1 level there were no apparent patterns to mark differences between the data for the 1964 samples and the 1978 restricted samples, although on both occasions the students in Victoria and Tasmania

Table 5.9 School Characteristics: Population 1

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
School Size: mean number of students (secondary)							
1964		738	600	774		1011	591
1978R		876	663	1004		899	599
1978	746	808	635	862	779	819	559
Sex of School							
1964							
male students only %		18%	23%	0%		0%	0%
female students only %		21%	0%	1%		0%	0%
mixed %		60%	77%	99%		100%	100%
1978R							
male students only %		21%	15%	0%		0%	4%
female students only %		11%	0%	0%		0%	0%
mixed %		68%	85%	100%		100%	96%
1978							
male students only %	0%	32%	25%	9%	7%	8%	9%
female students only %	12%	13%	14%	9%	8%	5%	13%
mixed %	88%	55%	62%	83%	85%	87%	78%
Type of School							
1978							
Government %	69%	76%	73%	76%	85%	82%	81%
Catholic %	25%	18%	19%	18%	10%	10%	13%
Independent %	6%	5%	8%	6%	5%	8%	6%
Teachers: mean number of teachers (secondary)							
1964		37	28	32		47	31
1978R		60	55	62		58	42
1978	56	54	48	53	57	53	39
Mathematics Teachers: mean number of mathematics teachers (secondary)							
1964		7	7	8		8	8
1978R		9	11	13		8	9
1978	8	9	10	12	12	7	8

... contd

Table 5.9 School Characteristics: Population 1 (contd)

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Mathematics Teachers %: (secondary)							
1964		19%	25%	24%		18%	24%
1978R		15%	20%	22%		13%	21%
1978	15%	16%	21%	22%	21%	14%	22%
Male Mathematics Teachers: (secondary) %							
1964 %		65%	76%	67%		56%	84%
1978R %		70%	74%	68%		68%	76%
1978	51%	71%	72%	64%	74%	68%	72%

were studying mathematics in schools with lower mean enrolments than in the other States. However, at the Population 3 level students in the 1978 restricted sample were in schools with lower mean enrolments than the 1964 students. For both Population 1 and Population 3 the mean values for School Size were lower for the 1978 total sample than for the 1978 restricted sample, which indicated that students in the non-government sector typically attended schools with lower secondary school enrolments.

The variable Sex of School was formed in 1964 from responses to a direct question. In 1978 the equivalent variable was formed from the question about student enrolments, which obtained separate information about the number of male and female students. The variable Sex of School had three categories: male students only, female students only, and mixed (both male and female students).

From the data for the 1964 samples and the 1978 restricted samples (which represented only students in government schools) it can be seen that most of the students were in mixed schools. Virtually the only students in government single-sex schools were in New South Wales and Victoria.

The variable Type of School had three categories: government, Catholic and independent (non-government non-Catholic). In 1978 the percentage of mathematics students in government schools was markedly lower for Population 3 than for Population 1, except in the Australian Capital Territory and Tasmania. The differences in percentages were a function of the differential

Table 5.10 School Characteristics: Population 3

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
School Size: mean number of students (secondary)							
1964		916	884	1299		1220	792
1978R		903	856	926		818	557
1978	755	757	761	771	698	651	514
Sex of School							
1964							
male students only %		25%	25%	0%		0%	0%
female students only %		15%	11%	0%		0%	0%
mixed %		60%	64%	100%		100%	100%
1978R							
male students only %		34%	0%	0%		0%	0%
female students only %		12%	0%	0%		0%	0%
mixed %		55%	100%	100%		100%	100%
1978							
male students only %	6%	32%	20%	20%	17%	32%	8%
female students only %	10%	29%	18%	15%	0%	16%	3%
mixed %	84%	39%	62%	65%	83%	52%	89%
Type of School							
1978							
Government %	70%	48%	53%	61%	51%	47%	75%
Catholic %	26%	43%	37%	23%	29%	24%	9%
Independent %	4%	9%	11%	16%	20%	29%	16%
Teachers: mean number of teachers (secondary)							
1964		48	39	52		58	61
1978R		62	62	59		63	45
1978	66	49	51	49	51	47	40
Mathematics Teachers: mean number of mathematics teachers (secondary)							
1964		8	8	9		9	9
1978R		9	12	14		7	6
1978	11	8	11	12	13	7	6

... contd

Table 5.10 School Characteristics: Population 3 (contd)

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Mathematics Teachers % (secondary)							
1964		16%	21%	17%		16%	15%
1978R		15%	20%	24%		12%	12%
1978	17%	17%	21%	24%	25%	16%	16%
Male Mathematics Teachers: (secondary) %							
1964 %		73%	69%	77%		66%	79%
1978R %		69%	69%	72%		76%	74%
1978 %	57%	63%	61%	67%	83%	70%	77%

retentivity of the three types of schools.

The number of teachers in the school was measured by the following question in 1964:

What is the total full-time (2 part-time are equal to 1 full-time) members of the teaching staff in your school?
Less than 10 (5 teachers)
11-20 (15 teachers)
(further intervals of 10) ...
81 or more (85 teachers)

The number in brackets indicates the code value of each category used in forming the variable Teachers. The equivalent variable for 1978 was derived from responses to a direct question about the number of teachers at the school, including part-time teachers reduced to their full-time equivalent. There was a general increase over the period 1964 to 1978 in the mean number of teachers in the schools attended by the sample students.

In 1964 the following question was asked about the number of mathematics teachers:

How many members of your staff teach mathematics?

The variable Mathematics Teachers was formed directly from the coded responses. In 1978 the variable Mathematics Teachers was derived from responses to a direct question about the number of teachers who were teaching mathematics. The data for the variable Mathematics Teachers were then linked to the data for the variable Teachers to give the percentage of mathematics teachers:

$$\text{Mathematics Teachers \%} = \frac{\text{value for Mathematics Teachers}}{\text{corresponding value for Teachers}}$$

At the Population 1 level these results show that, relative to 1964, the students in 1978 were in schools where a smaller percentage of the teaching staff was assigned to the teaching of mathematics. This did not necessarily mean that fewer staff resources were applied to the teaching of mathematics, since the observed results could have been due to greater specialization by teachers on the teaching of mathematics.

Schools were also asked to indicate the percentage of the mathematics teachers who were male. In 1964 the following question was asked:

What percentage of all those who teach mathematics are men?

0%	(0%)
1-25%	(13%)
26-50%	(38%)
51-75%	(63%)
76-99%	(88%)
100%	(98%)

The values in brackets indicate the code values used in forming the variable Male Mathematics Teachers. (The recoded value of 98 per cent was chosen to avoid problems with missing data cases coded 99). In 1978 the schools were asked to state the number of male mathematics teachers. As part of the file-building process the variable Male Mathematics Teachers was derived, giving the percentage of male mathematics teachers relative to the total number of mathematics teachers for each school.

The data for the variable Male Mathematics Teachers showed little systematic variation between 1964 and 1978 for either population. On both occasions students in Population 1 and Population 3 tended to be in schools where relatively high percentages of the mathematics teachers were male.

Summary

In order to explain differences between students in terms of their performance in mathematics it was necessary to assemble information on a variety of potentially significant background characteristics concerning the students, their mathematics teachers, and the schools they attended. Comparisons of results for 1964 and 1978 were possible since comparable data were collected in both testing programs. The teachers and schools were not themselves units of analysis in this study. They were of importance only to the extent that they influenced the students' experiences.

Teacher and school data were therefore disaggregated and linked to the data for the relevant students in the sample.

The mean percentages of students whose fathers had professional or managerial occupations were higher for Population 3 than for Population 1 in both 1964 and 1978 in the five States with comparable data. This indicated the greater level of socio-economic selectivity of the mathematics students at Year 12 relative to the lower secondary school students, although the degree of selectivity tended to be the same on both occasions. The mean educational level of the parents of the students also tended to increase from 1964 to 1978, with the level of father's education being generally higher than that of the mother, and the Population 3 values higher than the corresponding Population 1 values. For both of the indicators of socio-economic status - father's occupation and parents' education - the mean values were higher for students in non-government schools than in government schools in 1978.

The mean age of Population 3 students was similar in both 1964 and 1978, except for New South Wales where the age increased as a consequence of the addition of a further year of schooling under the Wyndham scheme. The mean number of students in mathematics classes decreased from 1964 to 1978 at both population levels. The mean amount of time spent on mathematics, including both time in class and time on mathematics homework, decreased in all five States at the Population 1 level, and in New South Wales, Victoria and Queensland at the Population 3 level.

In most States in 1978 students were taught by teachers of lower mean age than in 1964, although the teachers had received more post-secondary education. The net effect was that the students in 1978 were taught by teachers with less teaching experience except in Western Australia (both populations) and Tasmania (Population 3).

This chapter summarized background characteristics of mathematics students at the lower and upper levels of Australian secondary schools in 1964 and 1978, and of their teachers and the schools they attended. It was not the intention of the studies from which these data were taken to conduct a detailed investigation into the wide range of characteristics of students, teachers and schools. In particular the studies did not explore the vital processes of interaction between students and their teachers in the mathematics classrooms, nevertheless, the data presented do describe basic characteristics of the mathematics students and major influences on these students, thus setting the context for an examination of mathematics education in Australia.

CHAPTER 6

MATHEMATICS ACHIEVEMENT OF 13-YEAR-OLD STUDENTS

The key purpose of this report was to document the mathematics achievement of secondary school students in Australia using the data collected in the First IEA Mathematics Study in 1964 and the Second IEA Mathematics Study in 1978. This chapter focuses on the mathematics achievement of the 13-year-old (Population 1) students. The initial section of the chapter examines the scores of the students on the IEA Mathematics Test administered in 1964 and 1978, and identifies changes in achievement across this period. The rest of the chapter is devoted to explaining the observed achievement in terms of the mathematics curriculum and various background factors.

The first set of analyses deals with differences between States, where the criterion is the State mean score on the mathematics test. The appropriate explanatory factors to include in the analyses were those associated with the State education systems. The most important of these factors was the curriculum in the schools in the State. In addition other background factors were considered, including the amount of time spent in class on mathematics and the distribution of the 13-year-old students across the three year levels (Years 7 to 9) that were included in the definition of the target population. For the examination of relationships where the State was the unit of analysis, only fairly simple procedures could be used. For the 1964 samples, the set of data for each variable contained only five values - one for each State. For the 1978 restricted samples there were five data-points for each variable, and seven data-points for the total samples.

The second set of analyses examines differences between individual students, where data were available on a wide range of explanatory factors. In order to rationalize the examination of relationships, the analyses were constrained by a causal model. It was considered that this approach would provide a more succinct summary of the data than a series of cross-tabulations, and would also enable a comparison of changes in relationships between 1964 and 1978.

Mathematics Test and Sub-test Scores

Table 6.1 sets out the mean values for the 1964 State samples, the 1978 restricted samples and the 1978 total samples for the variable Mathematics

Table 6.1 Mathematics Test and Sub-test Mean Scores for Population 1[a]

Test/sub-test	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Mathematics Total (65)							
1964		27.4	27.9	30.7		25.7	23.7
1978R		25.1	23.1	29.0		26.2	23.4
1978	29.6	25.9	24.6	29.9	26.7	26.9	24.2
Basic Arithmetic (20)							
1964		9.5	10.3	12.1		9.2	8.5
1978R		9.2	8.6	11.1		9.7	8.6
1978	11.0	9.5	9.2	11.4	10.0	10.0	9.0
Advanced Arithmetic (15)							
1964		6.3	6.2	7.0		5.8	5.5
1978R		5.5	5.3	6.3		5.7	5.2
1978	6.5	5.7	5.6	6.6	6.0	5.9	5.3
Algebra (19)							
1964		7.0	6.7	7.1		6.4	6.1
1978R		6.6	5.7	7.4		6.6	6.0
1978	7.8	6.8	6.2	7.6	6.5	6.9	6.2
Geometry (11)							
1964		4.6	4.7	4.6		4.3	3.7
1978R		3.8	3.5	4.2		4.2	3.5
1978	4.5	3.9	3.6	4.3	4.1	4.2	3.6
New Mathematics (12)							
1964		4.8	4.2	4.7		4.2	4.0
1978R		4.4	4.0	5.3		4.6	4.0
1978	5.0	4.5	4.3	5.5	4.7	4.7	4.2
Computation (24)							
1964		10.4	11.1	12.1		10.1	9.2
1978R		9.8	9.0	11.3		10.4	9.3
1978	11.8	10.2	9.7	11.6	10.5	10.7	9.6
Knowledge (13)							
1964		6.7	6.7	7.1		6.1	5.7
1978R		6.2	5.6	7.1		6.6	5.7
1978	6.9	6.3	5.9	7.2	6.5	6.8	5.8
Translation (11)							
1964		5.1	5.1	6.0		5.0	4.6
1978R		4.5	4.2	5.2		4.6	4.3
1978	5.4	4.7	4.5	5.4	4.7	4.7	4.4
Comprehension (17)							
1964		5.3	5.1	5.9		4.5	4.2
1978R		4.6	4.4	5.5		4.7	4.2
1978	5.6	4.7	4.6	5.7	5.0	4.8	4.3

Note: [a] The number of items in the test and sub-tests is indicated in brackets.

Total, measuring the total score on the Mathematics Test of 65 items which were common to the two testing programs. The table also includes the mean values for the variables measuring the scores on the various sub-tests measuring curriculum content and teaching process areas.

At this stage the results have been presented without discussion of possible reasons for differences, leaving explanatory analyses to subsequent sections of the chapter. The scores presented in the first section of this chapter are raw scores, which have not been corrected for guessing, and apply to the unweighted sample data for each State.

In order to facilitate comparisons between these variables and across the three sets of samples, the scores were also expressed in a standardized format. Since only the 1964 samples and the 1978 restricted samples were strictly comparable, the standardization procedure was based on the results for these ten samples. The following formula was used:

$$\text{mean standard score} = \frac{\text{State mean score} - \text{grand mean score}}{\text{grand standard deviation}}$$

where

State mean score = mean value for a given test or sub-test score for that State,

grand mean score = mean of the ten mean values for that test or sub-test score for the five 1964 State samples and the five 1978 State restricted samples, and

grand standard deviation = mean of the ten student standard deviation values of that test or sub-test score for the same ten samples.

The mean standard scores for the 1978 State total samples for a given variable were then calculated using the same grand mean and grand standard deviation. Table 6.2 sets out these standard scores, including the change from the 1964 samples to the 1978 restricted samples. The standard deviations and reliability coefficients (KR20) for each variable for each sample have been included in an associated technical document (Rosier, 1980b).

This report makes little use of the procedures of significance testing for the establishment of its generalized results. Such procedures are usually inappropriate for large studies where complex samples have been used for the collection of data. Instead the report has relied on the principle of replication across States for the establishment of generalizations; that is, a general result was considered to exist where there

Table 6.2 Mathematics Test and Sub-test Mean Standard Scores for Population 1

Test/sub-test	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Mathematics Total							
1964		0.11	0.15	0.41		-0.05	-0.23
1978R		-0.10	-0.28	0.25		0.00	-0.26
1978	0.31	-0.03	-0.14	0.33	0.04	0.06	-0.19
Change 1978R-1964		-0.21	-0.43	-0.16		0.05	-0.03
Basic Arithmetic							
1964		-0.04	0.14	0.54		-0.10	-0.26
1978R		-0.11	-0.24	0.31		0.00	-0.23
1978	0.29	-0.04	-0.10	0.38	0.07	0.07	-0.16
Change 1978R-1964		-0.07	-0.38	-0.23		0.10	0.03
Advanced Arithmetic							
1964		0.16	0.11	0.39		-0.03	-0.15
1978R		-0.13	-0.20	0.16		-0.06	-0.24
1978	0.21	-0.08	-0.11	0.23	0.04	0.01	-0.20
Change 1978R-1964		-0.29	-0.31	-0.23		-0.03	-0.09
Algebra							
1964		0.12	0.05	0.17		-0.05	-0.14
1978R		0.01	-0.26	0.24		0.03	-0.16
1978	0.36	0.07	-0.10	0.32	-0.00	0.09	-0.10
Change 1978R-1964		-0.11	-0.31	0.07		0.08	-0.02
Geometry							
1964		0.23	0.28	0.20		0.10	-0.21
1978R		-0.12	-0.29	0.05		0.02	-0.26
1978	0.15	-0.08	-0.23	0.10	-0.01	0.04	-0.22
Change 1978R-1964		-0.35	-0.57	-0.15		-0.08	-0.05
New Mathematics							
1964		0.16	-0.09	0.13		-0.11	-0.18
1978R		0.00	-0.18	0.40		0.06	-0.18
1978	0.28	0.05	-0.05	0.47	0.10	0.13	-0.11
Change 1978R-1964		-0.16	-0.09	0.27		0.17	0.00
Computation							
1964		0.03	0.17	0.39		-0.04	-0.23
1978R		-0.09	-0.27	0.22		0.03	-0.22
1978	0.32	-0.02	-0.13	0.29	0.04	0.09	-0.13
Change 1978R-1964		-0.12	-0.44	-0.17		0.07	-0.01
Knowledge							
1964		0.12	0.12	0.28		-0.07	-0.23
1978R		-0.06	-0.27	0.25		0.09	-0.23
1978	0.20	-0.01	-0.15	0.31	0.06	0.16	-0.18
Change 1978R-1964		-0.18	-0.39	-0.03		0.16	0.00

... contd

Table 6.2 Mathematics Test and Sub-test Mean Standard Scores for Population 1 (contd)

Test/sub-test	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Translation							
1964		0.10	0.11	0.48		0.06	-0.10
1978R		-0.14	-0.29	0.14		-0.11	-0.24
1978	0.23	-0.08	-0.17	0.23	-0.06	-0.07	-0.20
Change 1978R-1964		-0.24	-0.40	-0.34		-0.17	-0.14
Comprehension							
1964		0.16	0.10	0.38		-0.11	-0.21
1978R		-0.08	-0.16	0.23		-0.06	-0.24
1978	0.28	-0.03	0.08	0.03	0.05	-0.01	-0.19
Change 1978R-1964		-0.24	-0.26	-0.15		-0.05	-0.03

were consistent patterns of results which applied across the State samples. However, some indication of the significance of the State differences in Table 6.1 and 6.2 may be obtained by reference to the sampling designs which were considered to have standard errors of the mean of about six per cent of a student standard deviation. If confidence limits corresponding to two standard errors were placed around the mean value of a variable derived from the data from a State sample, it would be possible to state, at the 95 per cent probability level, that the mean value of that variable for the population from which the sample was drawn lay within those confidence limits. That is, for a given mean standard score of S, the confidence limits at the 95 per cent probability level would be about $S \pm 0.12$.

The standard error of the difference between statistics from two samples is given by $\sqrt{2}$ times the standard error associated with one of the samples. This means that a difference of at least 0.17 between the mean standard scores on a given test or sub-test derived from the data from two samples would be needed to establish that there were significant differences at the 95 per cent probability level between the corresponding populations on that test or sub-test.

In New South Wales, Victoria, Queensland and Tasmania the Mathematics Total scores were lower for the 1978 restricted samples, relative to the 1964 samples. These results provide some evidence for asserting that there has been a slight decline in the mathematics performance of 13-year-old

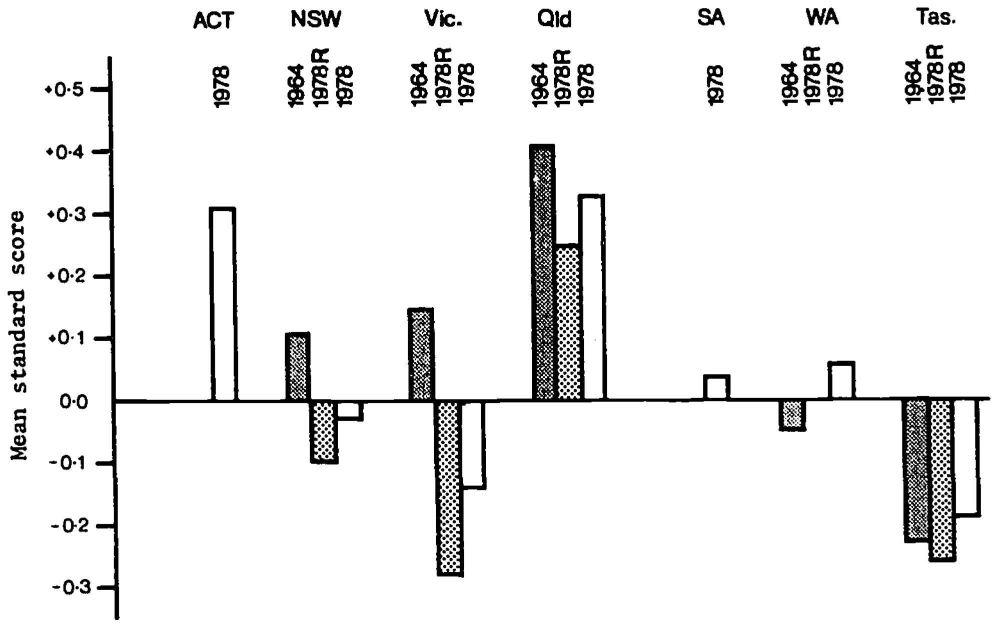


Figure 6.1 Mathematics Total Mean Standard Scores: Population 1

students from 1964 to 1978. To assist in the examination of these results, the Mathematics Total mean standard scores have also been presented graphically in Figure 6.1.

The relative performance of students in government and non-government schools in 1978 in New South Wales, Victoria, Queensland, Western Australia and Tasmania may be investigated by comparing scores for the restricted and total samples. The restricted samples contained only students from government schools (representing about 77 per cent of the target population) while the total samples also contained the students from non-government schools. In each of these States the scores were higher for the total samples than for the restricted samples, which implied that the achievement of students in non-government schools was higher than those in government schools.

For Mathematics Total and the four constituent content sub-tests (Basic Arithmetic, Advanced Arithmetic, Algebra and Geometry), the mean scores for Queensland were generally higher than in the other States in both 1964 and 1978. In terms of changes from 1964 to 1978, Western Australia and Tasmania tended to have small increases or decreases, while Victoria had the largest decrease for each sub-test.

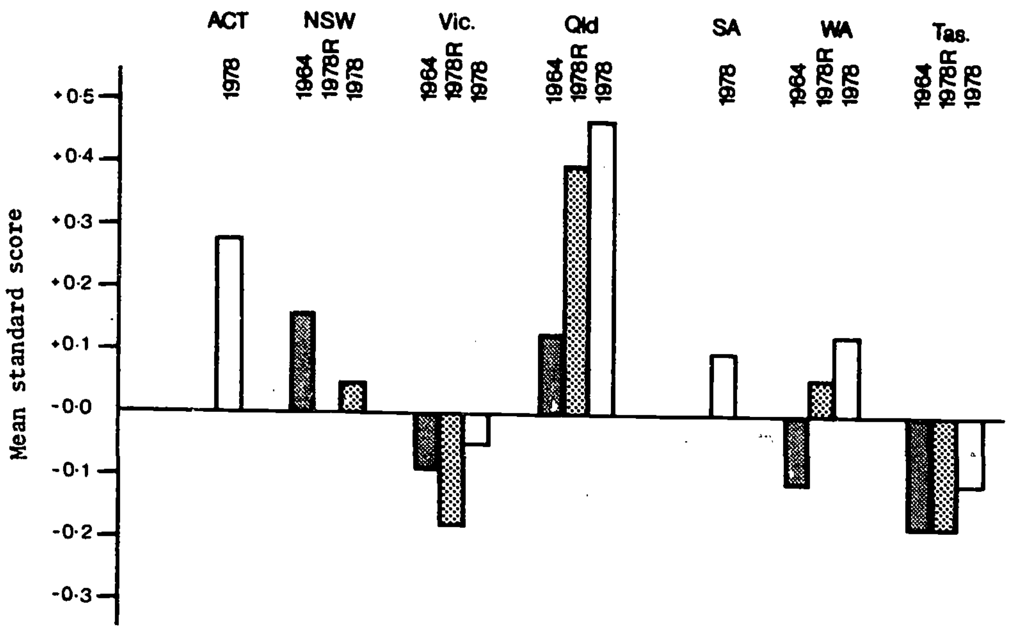


Figure 6.2 New Mathematics Mean Standard Scores: Population 1

The pattern of change for the New Mathematics sub-test scores was different, since in 1964 the five States were at different stages in the implementation of new mathematics into the curriculum. As well as having the highest score on this sub-test in 1964, Queensland registered the largest increase to 1978. In order to illustrate this different pattern, the mean standard scores for New Mathematics have also been presented graphically in Figure 6.2.

The items in the Mathematics Test could also be arranged to form four process sub-tests. The patterns of scores in 1964 and 1978 as well as the patterns of changes were similar to those for the content sub-tests. These four process areas were considered to form a hierarchy of cognitive skills, but the results show no systematic change in performance in these areas. In particular, these data provided no evidence to suggest that the introduction of new mathematics resulted in increased performance in the higher cognitive skill areas of translation and comprehension. At the same time, the data lend no support to any marked decrease in students' computational skills.

Mathematics Total Score Percentage Frequency Distributions

Further insight into the Mathematics Total scores may be obtained from an examination of Table 6.3, giving the percentage frequency distribution of the scores arranged in 5-item bands. The symbol •• indicates a score less than 0.5 per cent.

. In all States except Western Australia there was an increase from 1964 to 1978 in the percentage of students with low scores. Indeed, in Victoria the percentage of students scoring 20 or less jumped from 27 per cent in 1964 to 47 per cent for the 1978 restricted sample or 40 per cent for the 1978 total sample. The large difference between the 1978 restricted and total samples indicated that the percentage of low scoring students was much higher in government schools than in non-government schools.

At the other end of the distribution there was a small decrease in New South Wales, Victoria and Queensland in the percentage of students obtaining scores higher than 40. These results indicate that the moderate decrease in mean scores in these three States from 1964 to 1978 was primarily due to an increase in the percentage of students with rather low scores. This evidence would appear to suggest that the differences recorded between 1964 and 1978 are associated with a failure in more recent times to meet the needs of low performing students in the learning of mathematics.

Test Validity

Before concluding the presentation of the test scores, it is important to discuss the validity of the test for use in measuring mathematics achievement in Australia in 1964 and 1978. The test used for the two testing programs was originally developed in the early 1960s by IEA as a co-operative exercise involving the participating countries. Underlying the development was the IEA curriculum content analysis grid, described in Chapter 2 of this report. The items for the test were selected to measure the cells of this grid which were regarded as important by the majority of the countries.

Under these circumstances the test inevitably represented a compromise for most countries in that the set of items could not readily reflect the unique curriculum of a particular country. However, the test was not merely designed to measure a 'core' curriculum, or set of curriculum content areas that was common to all the participating countries. Rather, it was designed to contain items reflecting a wide range of content areas. This provided scope within which an individual country could demonstrate its level of mathematical competence. In effect it was left to the individual students

Table 6.3 Mathematics Total Score Percentage Distributions for Population 1

	1-5 %	6-10 %	11-15 %	16-20 %	21-25 %	26-30 %	31-35 %	36-40 %	41-45 %	46-50 %	51-55 %	56-60 %	61-65 %
ACT													
1978	0	5	6	14	16	14	15	12	9	6	3	2	0
NSW													
1964	1	5	11	15	16	13	12	11	9	4	2	1	..
1978R	2	7	14	16	17	14	11	9	4	4	2	1	0
1978	1	6	14	16	17	14	11	9	5	4	2	1	0
Vic.													
1964	..	3	10	13	18	15	16	11	7	5	2	0	..
1978R	2	9	17	19	16	13	9	7	6	2	1	..	..
1978	1	8	14	17	16	14	10	8	6	2	1	1	..
Qld													
1964	1	4	9	11	14	13	14	13	12	7	3	2	..
1978	..	5	11	13	15	12	14	13	9	6	3	1	0
1978	..	4	9	12	14	12	16	12	10	6	3	1	0
SA													
1978	..	6	10	16	16	16	14	10	6	4	1	1	0
WA													
1964	2	3	11	16	19	19	13	8	6	2	1	..	0
1978R	..	5	13	14	19	15	15	8	6	4	1	1	0
1978	..	4	12	13	18	16	14	10	7	3	1	1	0
Tas.													
1964	1	5	17	20	19	13	10	7	3	3	1	..	..
1978R	1	7	18	19	17	12	11	7	4	2	1	0	..
1978	1	7	16	18	17	13	12	8	5	2	1	..	..

completing the test to define the scope of the curriculum for their country in terms of the items they chose to answer and their performance on those items.

The construction of an 'international' test based on an 'international' curriculum grid raises questions about the validity of the test for measuring mathematics achievement in a particular country. An associated issue concerns the validity of using the 1964 test for measuring mathematics achievement in 1978.

In order to provide evidence to justify the validity of the test, a 'reduced' form of the test was prepared. This 50-item reduced Mathematics Test was developed by deleting 15 items from the original 65-item test. The size of the reduced test was chosen to allow sufficient scope for the deletion of items while retaining an adequate number to maintain the reliability level of the test.

Various criteria were used to identify items for deletion, including ratings of the suitability of items in meeting curriculum objectives and the percentage of students obtaining correct responses to the items. All the information used in the deletion process was taken from the 1978 testing program, in order to maximize the validity of the reduced test for the 1978 samples of students. The following list indicates the 1978 item numbers of the deleted items: A07, A15, A19, A20, A21, B45, C57, C58, C61, C62, C63, C64, C65, C66 and C70. The results for each of the samples for the variable Reduced Mathematics Total have been set out in Table 6.4

The correlation coefficient across the States between the mean Reduced Mathematics Total scores and the mean Mathematics Total scores was 1.00 for the 1964 samples, for the 1978 restricted samples, and for the 1978 total samples, although it was recognized that this value might be inflated through correlating the scores for part of the test with the scores for the whole test. From these results it was inferred that the mean State scores for the original mathematics test and the reduced test were virtually interchangeable, in the sense that either set could have been used to measure mathematics achievement.

In other words, the original IEA test based on a wider mathematics curriculum was as adequate for the measurement of mathematics achievement in Australia as the reduced test which was biased to the Australian curriculum by the selection of items which best reflected this curriculum. This comparison of the original test with the reduced test gives added confidence in the adequacy of the original test for the measurement of general mathematics achievement in Australia. Further, the relationship between the original test and the reduced test applied as strongly in 1964 as in 1978, even though the development of the reduced test was undertaken in terms of its relevance to the 1978 situation. This result gives further confidence in the adequacy of the original test for the measurement of mathematics achievement on both testing occasions.

Table 6.4 Reduced Mathematics Test Scores for Population 1[a]

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
1964		23.3	24.0	26.4		22.1	20.4
1978R		21.4	19.7	24.7		22.4	20.0
1978	25.5	22.1	21.0	25.5	22.8	23.1	20.7

Note: [a] The reduced Mathematics Test was a 50-item test derived from the 65-item Mathematics Test by the deletion of the 15 items which were considered to be least relevant to the mathematics curriculum in Australia in 1978.

Relationships Between Curriculum and Achievement

One important proposition guiding this study was that student achievement must be evaluated in the context of the curriculum which determines the learning experiences of the students. The curriculum was seen to contain three stages in sequence: the intended curriculum as specified by the education system, the translated curriculum as interpreted by the teachers, and student performance which indicates the extent to which the intended curriculum has been achieved by the students.

In order to examine the relationship between the three sequential curriculum stages, it was decided to apply simple quantitative procedures to the information collected as part of the 1964 and 1978 studies. Although the IEA Science Project (Comber and Keeves, 1973; Keeves, 1974) pioneered this type of analysis, it has not subsequently been widely used. The intended curriculum was measured by means of Curriculum Content scores. The translated curriculum was measured by means of Opportunity-to-Learn (OTL) scores. The student performance was measured with the Mathematics Total scores. The following sections described the measurement procedures and the relationship between the three sets of scores.

The intended curriculum was measured by means of Curriculum Content scores, indicating the extent to which the set of items in the mathematics test and sub-tests reflected topics in the mathematics curriculum studied by the students. These scores were based on the information in Chapter 2, where each topic in the Population 1 curriculum content analysis grid was rated for 'universality'. Each topic in each State was rated as U (universal - taught or assumed in all schools, R (restricted - taught or assumed in some schools) or N (nil - not taught or assumed in any shcools). The Curriculum Content scores per item were calculated in five steps:

1 Numbers, designated Curriculum Content ratings, were assigned to the letter ratings: U = 1.0, R = 0.5, N = 0.0.

2 Each of the 65 Mathematics Test items that were common to the 1964 and 1978 testing programs was assigned to one of the topic categories in the curriculum content analysis grid.

3 By using this relationship between topic categories and test items, the numerical Curriculum Content rating for the topic category was assigned to each of the items associated with that category.

4 For the total test and the various sub-tests, a Curriculum Content score was calculated as the sum of the Curriculum Content ratings for the relevant items.

5 For the total test and the various sub-tests, a Curriculum Content score per item was calculated by dividing the Curriculum Content score by the relevant number of items in the test or sub-test.

The Curriculum Content scores per item presented in Table 6.5 range from a low value of 0 to a high value of 1. A score of 0 indicated that none of the items in the test or sub-test measured topics in the mathematics curriculum studied by students in any schools. A score of 1 indicated that all of the items measured topics in the curriculum studied by all students. A score between 0 and 1 indicated that only some items measured topics studied by all students, while the remaining items measured topics studied by a restricted group of students or measured topics that were not in the curriculum. That is, the Curriculum Content score per item for the test or sub-test measured the extent to which the set of items in the test or sub-test reflected the curriculum studied by the students. Further details about the first four steps in the calculation of the Curriculum Content scores have been included in Rosier (1980b).

Several comments about the Curriculum Content scores should be noted. Firstly, the ability of the scores to reflect the curriculum depends on the accuracy of the original responses to the curriculum content analysis grid. Although carefully prepared by curriculum officers in the various States, the responses inevitably involved a subjective assessment. Secondly, the scores reflect only the degree of universality of the topics in the curriculum, and not the degree of emphasis placed on the topics. Although ratings of emphasis were obtained for each State in 1978, they were available

Table 6.5 Curriculum Content Score per Item for Population 1 Mathematics Test and Sub-tests

Test/sub-test	ACT	NSW	Vic.	Qld	SA	WA	Tas.
1964							
Mathematics Total		0.58	0.75	0.55	0.55	0.57	0.78
Basic Arithmetic		0.75	0.93	0.78	0.78	0.78	0.93
Advanced Arithmetic		0.70	0.77	0.70	0.70	0.70	0.80
Algebra		0.45	0.71	0.34	0.37	0.45	0.79
Geometry		0.32	0.50	0.32	0.27	0.23	0.45
New Mathematics		0.38	0.46	0.21	0.21	0.38	0.58
1978							
Mathematics Total	0.95	0.87	0.85	0.85	0.86	0.89	0.78
Basic Arithmetic	1.00	0.90	0.90	1.00	0.83	0.98	0.85
Advanced Arithmetic	0.97	0.97	0.87	1.00	0.87	0.93	0.80
Algebra	0.89	0.84	0.95	0.74	0.89	0.82	0.89
Geometry	0.91	0.73	0.59	0.55	0.86	0.82	0.45
New Mathematics	0.96	0.83	0.75	0.75	0.83	0.92	0.71

only for Australia overall in 1964. This meant that these ratings could not be incorporated into scores comparing the intended curriculum by States across both occasions. Thirdly, the Curriculum Content scores are a function of the structure of the test itself. The resulting score depends on the number of items associated with each topic, where the assignment of items to topics itself involves an element of subjective judgment. It follows from these three comments that care must be exercised in using the Curriculum Content scores. Nevertheless, it is maintained that the quatification procedure is valid, and that the Curriculum Content scores facilitate the analysis of the relationship between the intended curriculum and the succeeding stages of the curriculum sequence.

For 1964 the Curriculum Content scores for the total test and the sub-tests were higher in Victoria and Tasmania than in the other States. This reflected the structure of the Population 1 target population, since these were the only States in the 1964 sample where all three year levels in the target population were at the secondary school level. A wider range of curriculum topics has traditionally been introduced at the secondary level, so that in Victoria and Tasmania an extra year level was available for widening the curriculum, relative to the other three States. In 1978 the Curriculum Content scores across the States were generally similar for the test and each of the sub-tests. For Tasmania the 1978 scores were similar to the corresponding 1964 scores. In the other States the 1978 scores were higher than the corresponding 1964 scores in almost every case. These results suggested that, during the period from 1964 to 1978, each of the States extended its curriculum until it tended to reach the pattern that had already been established by 1964 in Tasmania. In any case, as far as the IEA study was concerned, the Curriculum Content scores indicated that the test was more strongly associated with the mathematics curriculum in 1978 than in the first testing program in 1964.

The Curriculum Content scores were calculated in order to measure the intended curriculum. The next stage in quantifying the stages in the curriculum sequence involved the preparation of Opportunity-to-Learn (OTL) scores to measure the translated curriculum - the extent to which the mathematics teachers translated the intended curriculum into a range of learning activities for their students.

The teachers who taught mathematics to the students in the samples were asked to rate each item in the Mathematics Test in terms of the opportunity of the students to learn the type of problem. The rating information for 1978 was collected by means of the following question in the Teacher Questionnaire:

> In order that information is available concerning the appropriateness of each test item for *your* students, you are now asked to rate the items as to whether or not the topic with which any particular item deals has been convered by the students *to whom you teach mathematics and who are taking this set of tests*. Even if you are not sure, please make an estimate according to the scale given below.
>
> Please examine in turn each item in the Mathematics Test (Sections A, B and C of Student Booklet 1). For each item, circle one of the responses, *A*, *B* or *C* to indicate that, in your opinion:
>
> *A* all or most (at least 75 per cent) of this group of students have had an opportunity to learn this type of problem, or
>
> *B* some (25 per cent to 75 per cent) of this group of students have had an opportunity to learn this type of problem, or
>
> *C* few or none (fewer than 25 per cent) of this group of students have had an opportunity to learn this type of problem.
>
> If you teach mathematics to more than one class-group from which students were selected for this study, you will need to answer this question in terms of one particular class-group. Please choose the class-group with the greatest number of students in the sample.

The wording for the corresponding question in the 1964 Teacher Questionnaire was virtually identical. However, although these data were collected in Australia, they were subsequently lost at some stage of the international processing outside the control of ACER.

The preparation of an Opportunity-to-Learn score for the Mathematics Test and the sub-tests was carried out in the following stages:

1 The responses of the teachers to the items were recoded, based on the mid-point of the percentage range for the category:

   1 = 0.875, 2 = 0.500, 3 = 0.125

2 For the total test and the various content sub-tests, an Opportunity-to-Learn score was calculated as the sum of the Opportunity-to-Learn ratings for the relevant items.

3 For the total test and the various content sub-tests, an Opportunity-to-Learn score per item was calculated by dividing the Opportunity-to-Learn score by the relevant number of items in the test or sub-test.

The Opportunity-to-Learn scores per item for the Mathematics Test and the sub-tests in 1978 have been set out in Table 6.6 These scores may be interpreted as measuring the teachers' estimates of the proportion of students who had the opportunity to learn the types of problems in the test or sub-test. The scores were based on data for the 1978 State total samples, which had been disaggregated and weighted according to the procedures described in Chapter 5.

A feature of this table was the general consistency across States in the Opportunity-to-Learn scores for Mathematics Total and the sub-tests. In terms of the teachers' Opportunity-to-Learn ratings, students in each of the States had received about the same level of exposure to the types of problems in the tests. The Opportunity-to-Learn scores for Basic Arithmetic were all higher than for the other sub-tests, among which there was little variation in Opportunity-to-Learn scores. In the unfortunate absence of 1964 data, it was not possible to compare the relevance of the 1964 and 1978 tests in terms of Opportunity-to-Learn ratings.

The final stage in the curriculum sequence was student performance. In order to obtain a measure of student achievement that could be compared with the Curriculum Content scores per item and the Opportunity-to-Learn scores per item, the Mean scores per item for each State were calculated for Mathematics Total and the content area sub-tests. These values are set out in Table 6.7; the 1978 scores were based on the State total samples.

This mode of presenting the test score data also enabled the comparison of student mathematics achievement across the content areas covered by the sub-tests. It can be seen that the achievement of students for Basic

Table 6.6 Mean Opportunity-to-Learn Score per Item for Population 1 Mathematics Test and Sub-tests

Test/Sub-test	ACT	NSW	Vic.	Qld	SA	WA	Tas.
1978							
Mathematics Total	0.65	0.61	0.59	0.64	0.58	0.58	0.58
Basic Arithmetic	0.75	0.67	0.68	0.71	0.68	0.69	0.69
Advanced Arithmetic	0.47	0.46	0.43	0.49	0.38	0.38	0.44
Algebra	0.48	0.48	0.43	0.54	0.44	0.43	0.44
Geometry	0.44	0.41	0.40	0.34	0.41	0.41	0.37
New Mathematics	0.51	0.50	0.45	0.52	0.44	0.46	0.42

Arithmetic was higher than for the other four sub-tests in each State and on each testing occasion. Among these remaining sub-tests there was little variation in the mean score per item. These results showed that there were no marked differences in achievement between the major sections of the Mathematics Test as represented by the sub-tests.

At this point in the discussion of the relationships between the intended curriculum, the translated curriculum and student performance for the mathematics test and sub-tests can be examined in terms of the quantified curriculum indices described above: the Curriculum Content scores for each State, the mean Opportunity-to-Learn scores for each State, and the mean value of the mathematics scores for each State. In order to facilitate meaningful comparisons, each of these indices has been calculated as a score per item for the relevant test or sub-test. Each score was expressed in the same way, as a proportion between 0 and 1, which permitted a meaningful direct interpretation of the scores in terms of the proportion (or percentage) of respondents possessing the property measured by the rating scale or test.

For each State, the Curriculum Content score per item measured the extent to which State Education Department curriculum officers considered that the set of items in the test or sub-test reflected the official curriculum studied by the students. The State mean Opportunity-to-Learn score per item measured the mean value of the teacher's estimates of the proportion of the students in their mathematics classes who had had the opportunity to learn the types of problems in the test or sub-test. The State mean test score per item measured the proportion of students obtaining correct answers to the set of items in the test or sub-test.

Table 6.7 Mean Test Score per Item for Population 1 Mathematics Test and Sub-tests

Test/Sub-test	ACT	NSW	Vic.	Qld	SA	WA	Tas.
1964							
Mathematics Total		0.42	0.43	0.47		0.40	0.36
Basic Arithmetic		0.48	0.51	0.60		0.46	0.43
Advanced Arithmetic		0.42	0.41	0.47		0.39	0.36
Algebra		0.37	0.35	0.37		0.34	0.32
Geometry		0.42	0.43	0.41		0.39	0.33
New Mathematics		0.40	0.35	0.39		0.35	0.33
1978							
Mathematics Total	0.46	0.40	0.38	0.46	0.41	0.41	0.37
Basic Arithmetic	0.55	0.47	0.46	0.57	0.50	0.50	0.45
Advanced Arithmetic	0.43	0.38	0.37	0.44	0.40	0.39	0.36
Algebra	0.41	0.36	0.33	0.40	0.34	0.36	0.33
Geometry	0.40	0.36	0.33	0.39	0.37	0.38	0.33
New Mathematics	0.42	0.38	0.36	0.46	0.39	0.39	0.35

The above discussion has been based on the assumption that there was a relationship between the three stages of the curriculum sequence. The description of procedures for preparing indices of these stages was the necessary first step in testing the assumption. The existence of the proposed relationship was examined initially by calculating correlation coefficients between the two indices (for 1964) and three indices (for 1978) for the test and sub-tests.

The correlation coefficients in Table 6.8 between the Curriculum Content scores and the test scores for 1964 were all negative, indicating clearly that student achievement was not dependent on the intended curriculum in these five States in 1964. A closer examination of the data shows that the negative correlations were largely due to the scores for Queensland and Tasmania. Queensland had low Curriculum Content scores but high test scores, while the reverse pattern applied to Tasmania. A possible explanation for these results was that the new curriculum introduced into the Tasmanian system had not been thoroughly implemented by the schools, while the Curriculum Content score for Queensland did not adequately reflect the range of mathematics topics actually studied in the schools in that State. The general conclusion drawn for Australia from these 1964 results was that the expected relationship did not apply during a period

Table 6.8 Correlation Coefficients Between State Curriculum Content Scores, Mean Opportunity-to-Learn Scores and Mean Test Scores for Population 1

	1964[a]	1978[b]		
	Curriculum Content - Test	Curriculum Content - Test	Opportunity-to-Learn - Test	Curriculum Content - Opportunity-to-Learn
Mathematics Total	-0.53	0.61	0.85	0.57
Basic Arithmetic	-0.30	0.75	0.73	0.68
Advanced Arithmetic	-0.59	0.78	0.43	0.50
Algebra	-0.71	-0.58	0.78	-0.74
Geometry	-0.15	0.66	0.21	0.82
New Mathematics	-0.77	0.27	0.81	0.37

Note: [a] Calculation based on five States

[b] Calculation based on seven States

when changes in curriculum were being proposed and implemented.

The 1978 correlation coefficients were generally positive, indicating that the States with higher curriculum Content scores also tended to have higher mean Opportunity-to-Learn scores and mean test scores. These results confirmed the expected relationship between the three stages in the curriculum sequence. However, for the Algebra sub-test there were negative correlation coefficients between the Curriculum Content score and the other two indices. The data showed that, although Victoria, South Australia and Tasmania had higher Curriculum Content scores for this area, they had lower Opportunity-to-Learn scores and test scores.

In many ways, the findings arising from this section were disappointing. In the first place, the absence of Opportunity-to-Learn scores for 1964 meant that the relationship between the three stages in the curriculum sequence could not be investigated. Further, the expected relationship between the Curriculum Content scores and test scores was not observed for 1964. This meant that the 1964 results provided an inadequate basis for attempting to explain changes in mathematics achievement from 1964 to 1978 in terms of changes in the intended curriculum or the translated curriculum.

Individual Mathematics Test Items

Further understanding of changes in mathematics achievement between 1964 and 1978 may be obtained by examining student performance on the individual items that constituted the mathematics test. The percentages of students obtaining the correct response for each item for each of the three sets of samples (1964 samples, 1978 restricted samples and 1978 total samples) have been presented in Appendix A. More detailed item statistics including the percentages of students selecting each of the alternative responses for the multiple-choice items have been included in an associated technical document (Rosier, 1980b). It should be noted that the test contained both multiple-choice and corrected-response items. For the multiple-choice items, 20 per cent of the students could select one of the five alternative responses by chance. For equally hard constructed-response items, the percentage of students obtaining the correct answer would be lower, since the correct answer could not be obtained by fortuitous guessing among available alternatives.

It was not the purpose of this report to undertake a detailed discussion of all of the items. However, in order to draw attention to the items on which student performance altered most noticeably between 1964 and 1978, Table 6.9 was prepared, indicating where the change in the percentage of correct responses from the 1964 samples to the 1978 restricted samples was equal to or greater than 15 per cent. The wording of these items will not be repeated here, since they have been included in Appendix 2. The levels of student performance on the items can also be related to the ratings given in Chapter 2 of the degree of emphasis and universality of the curriculum content areas.

The three items for which positive changes were registered (A14, A17 and C67) probably reflected changes in teaching emphasis, although there was no marked change in the curriculum emphasis placed on these topics between 1964 and 1978. This suggests that the changes in achievement were not associated with the changes in curriculum. Students probably achieved better on item A14 due to an improved understanding of the meaning of 'zero'. The higher achievement on items A17 and C67 was probably due to an increased understanding of the nature and language of set theory.

There were negative changes for four Basic Arithmetic items (A09, B25, B28 and C51). Item A09 involved the calculation of a square root. The performance was lower in Victoria although the importance of the topic was given a higher rating in 1978. It should be noted that the percentage

Table 6.9 Mathematics Items Involving Major Change from 1964 to 1978: Population 1[a]

Item	Content Area	NSW %	Vic. %	Qld %	WA %	Tas. %
A09	Basic Arithmetic		-21			
A10	Geometry		-16			
A14	Algebra		+16	+18	+19	+15
A15	Algebra		-15			
A17	Basic Arithmetic			+20		
A18	Algebra[b]			-15		
B25	Basic Arithmetic		-20	-18	-19	
B28	Basic Arithmetic		-28			-16
B30	Advanced Arithmetic[b]			-24	-16	
B34	Algebra			-20		-15
B35	Algebra		-28		-30	-15
C51	Basic Arithmetic			-24	-24	
C53	Geometry[b]		-34			
C54	Advanced Arithmetic		-19	-17	-20	
C55	Advanced Arithmetic	-17		-30		
C67	Algebra	+15			+16	
C70	Geometry		-16			

Note [a] This table presents the difference from the 1964 to the 1978R samples in the percentage of students obtaining the correct response on items in the Mathematics Test. Only differences equal to or greater than 15 per cent have been included.

[b] Indicates a constructed-response item.

differences for this item were positive in New South Wales, Western Australia and Tasmania in 1978 relative to 1964, although they did not reach the arbitrary 15 per cent difference adopted for this section. Items B25 and C51 involved fractions. Although there was no major shift in curriculum emphasis in the relevant states, the topic may have been given less attention following the introduction of decimal currency and metric measures. Item B28 involved the calculation of the arithmetic mean of three decimal numbers so that the difficulty of the item may be due both to the manipulation of decimals as well as to the notion of a mean. The lower performance in Tasmania probably reflected the lower emphasis on the notion of a mean in the curriculum.

The lower performance on the Advanced Arithmetic items (B30, C54 and C58) may not be explained by simple reference to curriculum emphasis ratings. These items involved more than one stage of calculation for their solution. The lower performance probably reflected changing emphases on the types of topics selected by teachers for teaching such multi-stage calculations.

There were four Algebra items (A15, A18, B34 and B35) for which the percentage of correct responses was markedly lower in 1978. There was no clear explanation in terms of curriculum emphasis, so that the lower performance probably reflected changes in teaching emphasis.

Finally, in Victoria there were three lower performance Geometry items (A10, C53 and C70). All these items involved knowledge of the number of degrees in a triangle or circle. The curriculum emphasis ratings indicated that these topics were considered to have only a low importance. The higher performance in 1964 may have been due to the teaching of topics that had been included in earlier curriculum statements but were no longer current in 1964.

Relationships Between Background Factors and Achievement

The previous section examined the relationship between the mathematics curriculum for a State and the mathematics achievement of the students. The next issue to discuss concerns the link at the State level between selected other factors and achievement.

Year Level

The first factor to consider is the distribution of 13-year-old students across the three year levels in the target population: Year 7, Year 8 and Year 9. As described in Chapter 2, in both 1964 and 1978 there was a wide variation across the States in the percentage of students in the three year levels. There was also a greater tendency in 1978 for the 13-year-old students to be concentrated in Year 8. As a result, by 1978 there was only a small percentage of 13-year-old students in Year 7 in the States where this was at the primary level. The purpose of this section is to examine the extent to which changes in mathematics achievement during this period were associated with these changes in the distribution of students across

Table 6.10 Mean Mathematics Total by Year Level for Population 1

		ACT	NSW	Vic.	Qld	SA	WA	Tas.
1964								
Year 7	Score		12.6	19.2	16.4		12.4	17.9
	(n%)		7%	25%	21%		10%	37%
Year 8	Score		22.9	29.9	31.5		24.8	26.1
	(n%)		47%	67%	55%		62%	58%
Year 9	Score		34.2	38.3	41.6		32.4	38.3
	(n%)		46%	8%	24%		28%	5%
1978R								
Year 7	Score		19.5	18.6	17.2		12.2	16.3
	(n%)		40%	17%	6%		2%	19%
Year 8	Score		28.8	23.8	27.1		25.1	25.8
	(n%)		59%	81%	61%		72%	79%
Year 9	Score		38.5	35.7	35.0		29.7	23.8
	(n%)		1%	2%	32%		26%	2%
1978								
Year 7	Score	23.4	19.4	19.2	18.1	14.5	12.1	17.8
	(n%)	30%	37%	15%	6%	1%	3%	20%
Year 8	Score	32.4	29.6	25.3	27.6	23.4	26.0	26.4
	(n%)	69%	62%	83%	61%	54%	71%	78%
Year 9	Score	30.0	42.4	35.0	36.0	30.9	30.9	27.3
	(n%)	1%	1%	2%	34%	45%	26%	2%

year levels. Table 6.10 presents the mean Mathematics Total scores by year levels, together with the percentage of students in the sample in each year level.

In most cases the mean score increased with year level. For the two exceptions the mean scores were based on a very small number of cases: Tasmania Year 9 for the 1978 restricted sample and the Australian Capital Territory Year 9 for the 1978 total sample. In interpreting the New South Wales data it is important to refer to the year level equivalents set out in Table 2.1. In 1964 Year 7 was Grade 6, the last primary year level before the five-year secondary system. In 1978 Year 7 was the first secondary year level in the six-year secondary system. However, in both 1964 and 1978 Year 8 was the modal year level for 13-year-old students; that is, the year level in which most of the 13-year-old students were located. Further, on both occasions the majority of the 13-year-old students were studying mathematics at the first two secondary school levels: 93 per cent in Year 8 and Year 9 in 1964, and 99 per cent in Year 7 and Year 8 in 1978. For New South Wales the mean score for Year 8 in 1964 was higher than the mean score for Year 7 in 1978, and the mean score for Year 9 in 1964 was higher than the mean score for Year 8 in 1978. In Victoria and Tasmania the mean scores for each year level were lower in 1978 than in 1964, but the pattern was less consistent in Queensland and Western Australia.

The State mean score for the mathematics test can be regarded as the weighted sum of the mean scores for the three year levels, where the weighting factor is the percentage of students at each year level. From an examination of the weighted values at each year level (the mean score multiplied by the percentage of students) the relative contribution of students at each year level to the State mean score can be determined. This analysis showed that the major contribution to the New South Wales mean score was made by the Year 9 students in 1964 and the Year 8 students in 1978. For Victoria, Western Australia and Tasmania, the contribution of both Year 7 students and Year 9 students to the State mean score was less in 1978 than in 1964. For Queensland the contribution of the Year 7 students was less in 1978, but there was a greater contribution from the students at the Year 9 level, where the percentage of students was higher in 1978 relative to 1964. Overall, the contribution of the Year 8 students to the State mean scores was greater in 1978 than in 1964.

Finally, the change in distribution of 13-year-old students across year levels probably meant that these students were exposed to different amounts of the mathematics curriculum in 1964 and 1978. In particular, by 1978 there was a reduction in the percentage of students exposed to the more limited range of curriculum topics at the primary school level, and a consequent increase in the percentage exposed to the wider secondary school curriculum. The general increase in Curriculum Content scores from 1964 to 1978 supports this position.

Class Time on Mathematics

The second factor to be considered was the mean amount of time spent in class on the teaching of mathematics in each State. As documented in Chapter 2, there was a substantial reduction in time in Years 7 to 9 from 1964 to 1978. Most of the information provided in Chapter 2 represented estimated by State Education Department officers of the time spent in class

Table 6.11 Mean Class Time in Hours per Week by Year Level for Population 1[a]

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
1964							
Year 7		4.5	4.9	5.2		4.8	3.6
Year 8		4.8	4.8	4.8		4.9	3.7
Year 9		3.9	4.4	5.1		4.4	4.6
Total sample		4.4	4.8	5.0		4.8	3.7
1978R							
Year 7		3.8	3.9	4.0		2.1	3.3
Year 8		3.6	4.1	3.5		4.2	3.6
Year 9		4.0	4.0	3.8		4.1	5.1
Total sample		3.7	4.1	3.6		4.1	3.6
1978							
Year 7	3.5	3.8	3.9	4.6	4.2	2.4	3.5
Year 8	3.8	3.6	4.0	3.6	3.8	4.2	3.7
Year 9	3.5	3.9	4.0	3.9	4.1	4.1	4.0
Total sample	3.7	3.8	4.0	3.8	3.9	4.1	3.7

Note: [a] The transition point between primary and secondary year levels is indicated with a horizontal line.

on mathematics in government schools. In the 1964 and 1978 studies, the students themselves provided information on the amount of time they spent in class on learning mathematics. Their responses were used to form the variable Class Time, for which the State mean values for Years 7 to 9 have been set out in Table 6.11. The table also presents the mean value of the amount of time spent in class on mathematics by all the 13-year-old students in the samples. The stability of the mean values of Class Time for the individual year levels depended on the number of cases in the subsamples on which the values were based. In particular, the low values for Year 7 in Western Australia were based on only 2 to 3 per cent of the State samples.

The values for the 1978 samples were generally lower than for the corresponding 1964 ones. This suggested that the observed slight decreases in mathematics achievement were due, at least to some extent, to the reduction in the amount of time spent on the teaching of mathematics. The results for Tasmania, where there was essentially no change in time

Table 6.12 Correlation Coefficients Between State Mean Class Time and State Mean Mathematics Total for Population 1

	Year 7	Year 8	Year 9	Total sample
1964	-0.15	0.11	0.77	0.80
1978R	0.93	-0.75	-0.87	-0.30
1978	0.35	-0.34	-0.01	-0.22

allocation and no change in performance, tended to confirm this general relationship.

The extent to which differences in mathematics achievement across the States were associated with Class Time at the various year levels may be examined by reference to the correlation coefficients in Table 6.12. The association was strong for the total sample in 1964, but this association was not sustained for the total sample in 1978, or when individual year levels were examined. In effect, in 1978 there was little variation between the States in the amount of time spent in class on mathematics, whether for the total sample of 13-year-old students or for those in the modal Year 8. However, it was also recognized that the mean value of Class Time, measured at one point in time, failed to take account of the cumulated amount of time over the primary school year levels. Undoubtably the high mean level of mathematics achievement in Queensland in 1964 and 1978 was associated with the strong emphasis on mathematics in the primary school, as indicated by the time spent in class on the subject.

Calculators

Between 1964 and 1978, one of the major changes with a potentially large impact on student mathematics achievement was the introduction of relatively inexpensive electronic hand-calculators. Since they were not available in the 1960s, no questions were asked about calculators in the 1964 testing program. In 1978 two questions were included in the General Information Questionnaire in the Student Booklet:

> Do you own a calculator?
>
> Did you use a calculator for the mathematics tests in this booklet?

The response alternatives were 'yes' or 'no'. Before the testing program, the sample students in each school were advised that they should bring a

Table 6.13 Percentage of Population 1 Students Owning and Using Calculators: 1978

	ACT %	NSW %	Vic. %	Qld %	SA %	WA %	Tas. %
Own Calculator	41	50	39	43	47	45	39
Use of Calculator	29	16	6	9	29	18	1

hand-calculator to the testing sessions if they normally used one during mathematics lessons. The purpose of this instruction was to enable students to answer the tests under the same conditions that would normally apply in their mathematics classes. This also meant that their responses to the question about the use of a calculator could be generalized to the normal learning situation for their classes. The percentage of students owning and using calculators is given in Table 6.13.

The mean percentage of students owning calculators was approaching 50 per cent in most of the States, although the mean percentage of students using them during the IEA testing program was much lower. These results suggest that there was little support at the State level for the use of calculators by lower secondary level students. The correlation coefficient between the State mean values for Use of Calculator and Mathematics Total was 0.51.

Differences Between Students

The previous sections have dealt with data at a highly aggregated level, where the criteria were the mean scores for each State on the mathematics test and sub-tests. The number of data-points examined was limited to the number of States in the 1964 and 1978 samples. Although there were differences between the States on these criteria, they were very much less than the differences between individual students within the States. The purpose of this final section of the chapter is to take the student as the unit of analysis, to examine the extent to which differences between students with respect to their mathematics achievement can be explained in terms of a set of background characteristics, and to examine changes in the pattern of explanation between 1964 and 1978.

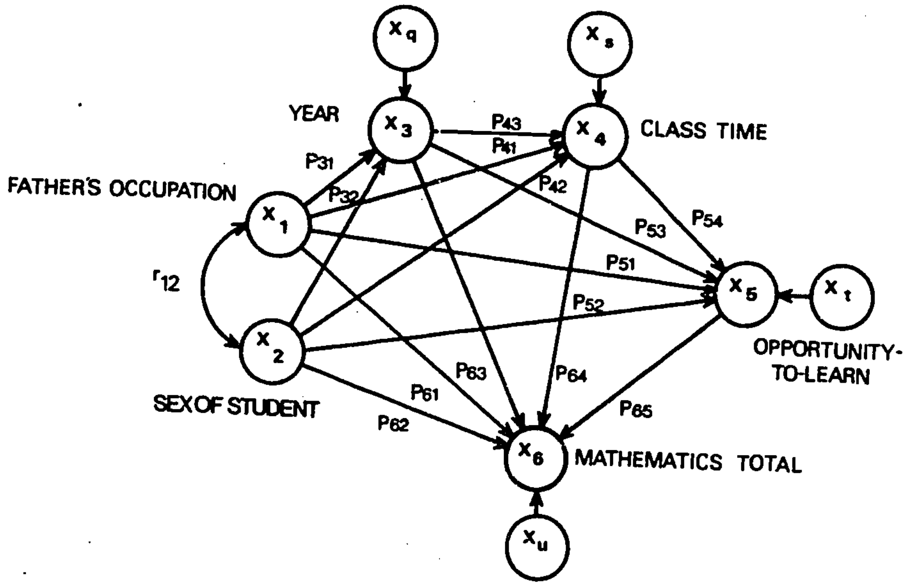


Figure 6.3 Path Diagram for Causal Model of Mathematics Total for Population 1

It was considered inappropriate to undertake this examination by means of a series of cross-tabulations, since the complex relationships could not be adequately examined by taking variables two at a time. Rather, regression analysis was used to enable the simultaneous effects of the inter-related explanatory factors on the criterion to be examined.

Underlying the regression analysis was a simple conceptual framework in which the explanatory factors were arranged in a causal sequence. Each factor was assumed to have both a direct effect on the criterion as well as an indirect effect operating through its influence on subsequent factors in the causal sequence. The variables used to measure these factors have been discussed earlier in this report. Figure 6.3 presents the variables in the causal model that was designed to reflect the conceptual framework, together with the network of causal paths acting on the criterion variable Mathematics Total.

The causal model was specified by a set of structural equations:

$$X_3 = p_{32}X_2 + p_{31}X_1 + p_{3q}X_q$$

$$X_4 = p_{43}X_3 + p_{42}X_2 + p_{41}X_1 + p_{4s}X_s$$

$$X_5 = p_{54}X_4 + p_{53}X_3 + p_{52}X_2 + p_{51}X_1 + p_{5t}X_t$$

$$X_6 = p_{65}X_5 + p_{64}X_4 + p_{63}X_3 + p_{62}X_2 + p_{61}X_1 + p_{6u}X_u$$

where

X_1 = Father's Occupation (8-point scale)

X_2 = Sex of Student (coded male = 1, female = 2)

X_3 = Year (Year 7, Year 8 or Year 9)

X_4 = Class Time (in hours)

X_5 = Opportunity-to-Learn (mean score per item in the range 0 to 1)

X_6 = Mathematics Total (test score corrected for guessing)

X_q = disturbance term for Year (X_3)

X_s = disturbance term for Class Time (X_4)

X_t = disturbance term for Opportunity-to-Learn (X_5)

X_u = disturbance term for Mathematics Total (X_6)

The variables Father's Occupation (X_1) and Sex of Student (X_2) were exogenous, not being determined by any other variables in the model. The curved bi-directional arrow linking these two variables in the diagram of the causal model indicated the non-causal relationship between the variables. The other variables Year (X_3), Class Time (X_4), Opportunity-to-Learn (X_5) and Mathematics Total (X_6) were endogenous, being influenced by the causally prior variables, and also by factors external to the model, represented by the disturbance variables. The causal relationships have been indicated on the causal model by straight uni-directional arrows.

Father's Occupation was included as a measure of the home background of the student, regarded as a simple surrogate measure of the educational climate of the home, including the range of activities and attitudes in the home that encouraged and assisted the cognitive development of the student. Indices of socio-economic level often include measures of the education of the parents of the students. It was not possible to develop such a composite index for the comparative purposes of this study since there was a large amount of missing data for the variables Father's Education and Mother's Education in the 1964 samples.

As noted earlier in this chapter, mathematics achievement was monotonically related to the year level of the 13-year-old students. The variable Year was included in the model to control for these effects in explaining variation in mathematics. This variable may also be regarded as a surrogate measure of the ability of the student, as rated by the student's progress through the education system.

The association between the time spent by students studying a subject and their achievement in the subject is an important topic for investigation since the amount of time allocated to a subject is a key malleable factor in a school system. The variable Class Time was included in the causal model in order to examine its relationship with achievement at the analysis level of the individual student to complement the earlier analysis at the level of the State system. The variable Class Time measures the number of hours per week spent in class on mathematics.

The earlier variables in the model were considered to influence the student's opportunity to learn the processes covered by the test items, which was itself considered to have a major effect on the criterion. This factor was included in the model as the variable Opportunity-to-Learn. It was measured as the mean Opportunity-to-Learn score per item, derived according to the procedures described earlier in this chapter. Unfortunately, data on the variable Opportunity-to-Learn were not available for 1964, so that the 1964 and 1978 results can only be compared by estimating causal models which omitted this variable. The full causal model was estimated only for 1978.

Finally, the criterion used in the causal model to measure student achievement was the variable Mathematics Total. For the earlier analyses reported in this chapter, the variable Mathematics Total was based on the student's raw score; that is, the total number of correct test items. For the regression procedures a different version of the criterion variable was used, in which the student's score had been corrected for guessing. The variance associated with scores corrected for guessing was greater than the variance associated with raw scores, so that this decision had the desirable statistical effect of increasing the amount of criterion variance to be explained by the independent variables in the model.

The previous results in this report have been presented by States, recognizing that the curriculum and structures have traditionally been developed on a State basis. This procedure was also followed in the estimation of the causal models. In effect, the separate State analyses represented a set of replications of the same basic study in several similar education system environments. This approach facilitates the drawing of generalized conclusions across the replications. The computational procedures for estimating the causal model were based on linear multiple regression techniques applied to the correlation coefficients derived from the sample data (Duncan, 1975).

Table 6.14 Sample Correlation Coefficients for Causal Model of Mathematics Total for Population 1: 1964[ab]

	NSW	Vic.	Qld	WA	Tas.	Median
r_{12}	-0.03	0.02	0.05	0.02	0.02	0.02
r_{13}	<u>0.13</u>	<u>0.15</u>	0.08	<u>0.19</u>	<u>0.12</u>	0.13*
r_{23}	0.09	0.02	0.01	0.07	0.09	0.07
r_{14}	-0.01	0.04	0.03	-0.03	0.07	0.03
r_{24}	-0.01	<u>-0.11</u>	<u>-0.14</u>	-0.04	0.03	-0.04
r_{34}	<u>-0.59</u>	<u>-0.15</u>	-0.06	<u>-0.19</u>	<u>0.26</u>	-0.15*
r_{16}	<u>0.26</u>	<u>0.23</u>	<u>0.19</u>	<u>0.20</u>	<u>0.22</u>	0.22*
r_{26}	-0.01	-0.05	0.00	-0.07	-0.02	-0.02
r_{36}	<u>0.56</u>	<u>0.49</u>	<u>0.66</u>	<u>0.49</u>	<u>0.48</u>	0.49*
r_{46}	<u>-0.38</u>	0.08	-0.02	-0.05	<u>0.26</u>	-0.02
Sample size	(607)	(649)	(703)	(465)	(397)	

Note: [a] Coefficients significant at the 95 per cent level have been underlined. An asterisk indicates a median value for a coefficient that was significant in a majority of States.

[b] Key to variable numbers: 1 = Father's Occupation, 2 = Sex of Student, 3 = Year, 4 = Class Time, 6 = Mathematics Total.

The correlation coefficients between the variables in the model for each of the State samples have been presented in Tables 6.14 and 6.15. The calculation of correlation coefficients was based on case-wise deletion; that is, a case was eliminated from the analysis if it had missing data on any of the variables in the model. Most of the missing data values for the 1978 samples were associated with the variable Opportunity-to-Learn, since these teacher data were not available for every student in the study. Alternatively it would have been possible to use pair-wise deletion for these calculations, basing each correlation coefficient on the cases for which data were available on the two variables being correlated. However the use of this option would have involved the assumption that the Opportunity-to-Learn ratings supplied would also have been applicable to the students without Opportunity-to-Learn ratings, and this assumption could not be justified.

The values of the correlation coefficients that were significantly different from zero at the 95 per cent confidence level have been underlined.

Table 6.15 Sample Correlation Coefficients for Causal Model of Mathematics Total for Population 1: 1978[ab]

	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median
r_{12}	0.07	-0.05	-0.03	-0.07	-0.03	-0.01	0.05	-0.03
r_{13}	0.14	0.14	0.02	0.07	0.03	0.09	0.12	0.09
r_{23}	0.18	0.14	0.00	0.02	-0.06	0.01	0.03	0.02
r_{14}	0.15	0.08	0.05	0.02	0.08	0.01	0.02	0.05
r_{24}	0.05	-0.11	-0.19	0.01	-0.04	-0.07	-0.02	-0.04
r_{34}	0.07	-0.08	-0.01	-0.04	0.09	0.05	0.19	0.05
r_{15}	0.15	0.27	0.21	0.11	0.28	0.31	0.24	0.24*
r_{25}	0.12	0.05	-0.09	-0.04	-0.05	-0.02	0.01	-0.02
r_{35}	0.46	0.52	0.29	0.28	0.40	0.27	0.28	0.29*
r_{45}	0.05	-0.01	0.09	0.08	0.14	0.02	0.04	0.05
r_{16}	0.34	0.33	0.26	0.26	0.15	0.16	0.17	0.26*
r_{26}	0.15	0.01	-0.13	0.00	-0.02	0.05	0.05	0.05
r_{36}	0.33	0.42	0.16	0.38	0.58	0.43	0.37	0.38*
r_{46}	0.14	0.12	0.13	0.10	0.11	0.12	0.02	0.12*
r_{56}	0.43	0.58	0.51	0.22	0.45	0.39	0.49	0.45*
Sample size	(266)	(702)	(717)	(686)	(650)	(605)	(550)	

Note: [a] Coefficients significant at the 95 per cent level have been underlined. An asterisk indicates a median value for a coefficient that was significant in a majority of States.

[b] Key to variable numbers: 1 = Father's Occupation, 2 = Sex of Student, 3 = Year, 4 = Class Time, 5 = Opportunity-to-Learn, 6 = Mathematics Total.

If simple random sampling of students had been used, the confidence limits would have been equal to about two standard errors, where the standard error for a correlation coefficient is the inverse of the square root of the sample size (Guilford and Fruchter, 1973:145). For the complex samples drawn for this study, the standard errors would have been greater than those calculated on the basis of the size of a simple random sample.

Ross (1976) investigated the relationship between the standard errors of various statistics for complex samples and simple random samples of the same size. For two-stage samples where schools were chosen with probability proportional to size and a random cluster of 25 students was chosen from the selected schools, Ross found that the mean value of the ratio between the standard error of the correlation coefficient for a complex sample and the standard error for a simple random sample of the same size (the square root of the 'design effect') was 1.15. On the basis of this empirical evidence, a correlation coefficient in this present study was defined to be significantly different from zero at the 95 per cent confidence level of its value was greater than 2.3 times the standard error associated with a simple random sample of the same size as the complex sample; that is, two simple random sample standard errors multiplied by the factor 1.15.

For each pair of variables, the median value of correlation coefficients across the States has also been presented. The median was used in preference to the mean as a summary statistic, since it was less susceptible to the influence of high extreme values. The median values have been marked with an asterisk where there were singificant correlation coefficients in a majority of the State replications.

Tables 6.15 to 6.17 present the results of the estimation of the causal model from the sample data. The path coefficients are the standardized regression coefficients derived from the multiple regression analyses. The value of the path coefficient for the disturbance term associated with any endogenous variable was calculated as $\sqrt{(1-R^2)}$ where R^2 was the proportion of variance in that variable explained by the variables included at the stage of the model. The tables also show the proportion of criterion variance explained by the model. Table 6.16 for 1964 and Table 6.17 for 1978 omit paths associated with the variable Opportunity-to-Learn, while Table 6.18 for 1978 presents results for the full causal model described above.

In the previously-cited study by Ross (1976) the mean value of the ratio between the standard error of the standardized regression coefficient for a complex sample and the standard error for a simple random sample of the same size was 1.16. Hence a path coefficient presented in this study was defined to be significantly different from zero at the 95 per cent confidence level if its value was greater than 2.3 times the standard error associated with a simple random sample of the same size as the complex sample. It should be noted that the value of the simple random sample standard error (given by the formula in Guilford and Fruchter, 1973:368) varies with the stage of the analysis as well as with the sample size. This means that a path coefficient of a given value may be significant for one path in the analysis but not for another. In order to summarize the

Table 6.16 Estimated Path Coefficients for Causal Model of Mathematics Total for Population 1: 1964 (excluding Opportunity-to-Learn)[ab]

	NSW	Vic.	Qld	WA	Tas.	Median
Sample correlation						
r_{12}	-0.03	0.02	0.05	0.02	0.02	0.02
Path coefficients						
p_{31}	0.13	0.15	0.08	0.19	0.12	0.13*
p_{32}	0.09	0.02	0.00	0.07	0.09	0.07
p_{41}	0.07	0.06	0.04	0.01	0.04	0.04
p_{42}	0.05	-0.11	-0.14	-0.02	0.01	-0.02
p_{43}	-0.60	-0.16	-0.06	-0.19	0.25	-0.16*
p_{61}	0.19	0.15	0.14	0.11	0.16	0.15*
p_{62}	-0.05	-0.05	-0.01	-0.11	-0.06	-0.05
p_{63}	0.49	0.49	0.65	0.49	0.43	0.49*
p_{64}	-0.09	0.14	0.02	0.04	0.14	0.04
Disturbance term						
X_q	0.99	0.99	1.00	0.98	0.99	0.99
X_s	0.80	0.98	0.99	0.98	0.97	0.98
X_u	0.80	0.85	0.74	0.85	0.85	0.85
Explained variance	0.355	0.293	0.456	0.269	0.276	0.293

Note: [a] Coefficients significant at the 95 per cent level have been underlined. An asterisk indicates a median value for a coefficient that was significant in a majority of States.

[b] Key to variable numbers: 1 = Father's Occupation, 2 = Sex of Student, 3 = Year, 4 = Class Time, 6 = Mathematics Total.

results for the causal models across the States, median values have been included in Tables 6.16 to 6.18. Figures 6.4 to 6.6 present path diagrams based on these median values. Paths have been included in these figures only where the path coefficients were significant in a majority of the State replications.

The corresponding general causal structure for 1978 was similar to that in 1964. Father's Occupation and Year had direct paths leading to

Table 6.17 Estimated Path Coefficients for Causal Model of Mathematics Total for Population 1: 1978 (excluding Opportunity-to-Learn)[ab]

	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median
Sample correlation								
r_{12}	0.07	-0.05	-0.03	-0.07	-0.03	-0.01	0.05	-0.02
Path coefficients								
p_{31}	0.13	0.14	0.02	0.07	0.03	0.09	0.12	0.09
p_{32}	0.18	0.15	0.00	0.03	-0.06	0.01	0.03	0.03
p_{41}	0.14	0.08	0.04	0.02	0.08	0.00	-0.01	0.04
p_{42}	0.03	-0.10	-0.19	0.01	-0.03	-0.07	-0.03	-0.03
p_{43}	0.04	-0.08	-0.01	-0.04	0.08	0.05	0.19	0.04
p_{61}	0.29	0.26	0.25	0.23	0.26	0.29	0.21	0.26*
p_{62}	0.07	-0.02	-0.11	0.01	-0.01	-0.01	0.00	-0.01
p_{63}	0.27	0.39	0.16	0.37	0.39	0.24	0.25	0.27*
p_{64}	0.08	0.13	0.10	0.11	0.08	0.01	-0.01	0.08*
Disturbance terms								
X_q	0.97	0.89	1.00	1.00	1.00	1.00	0.99	1.00
X_s	0.99	0.99	0.98	0.98	0.99	1.00	0.98	0.98
X_u	0.89	0.86	0.94	0.89	0.87	0.92	0.94	0.89
Explained variance	0.209	0.266	0.116	0.214	0.241	0.156	0.120	0.214

Note: [a] Coefficients significant at the 95 per cent level have been underlined. An asterisk indicates a median value for a coefficient that was significant in a majority of States.

[b] Key to variable numbers: 1 = Father's Occupation, 2 = Sex of Student, 3 = Year, 4 = Class Time, 6 = Mathematics Total.

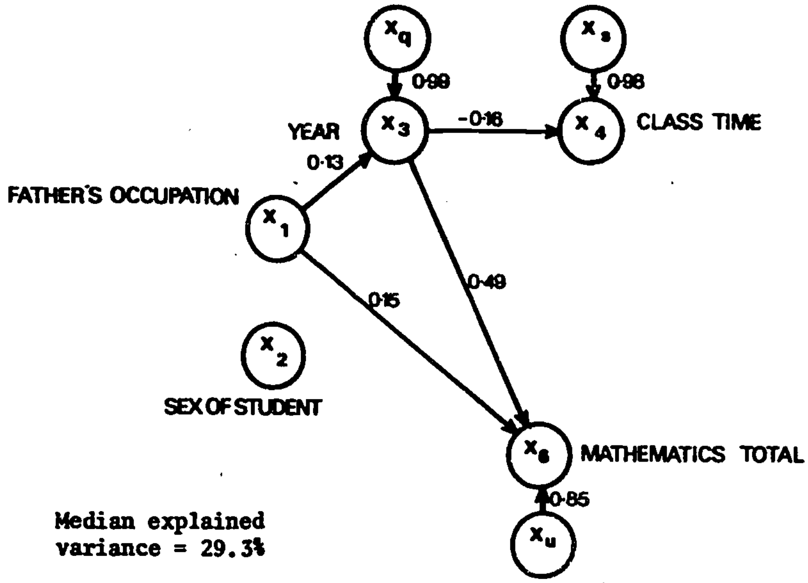
Mathematics Total, and there was also a path from Class Time to the criterion. However, the path from Father's Occupation to Year was less important, being significant only in New South Wales and Tasmania. In addition, the path from Year to Class Time was significant only in Tasmania. The causal model for 1978 accounted for a median value of 21.4 per cent of the criterion variance, compared to the 1964 value of 29.3 per cent.

Table 6.18 Estimated Path Coefficients for Causal Model of Mathematics Total for Population 1: 1978[ab]

	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median
Sample correlation								
r_{12}	0.07	-0.05	-0.03	-0.07	-0.03	-0.01	0.05	-0.02
Path coefficients								
p_{31}	0.13	0.14	0.02	0.07	0.03	0.09	0.12	0.09
p_{32}	0.18	0.14	0.00	0.03	-0.06	0.01	0.03	0.03
p_{41}	0.14	0.08	0.04	0.02	0.08	0.00	-0.01	0.04
p_{42}	0.03	-0.10	-0.19	0.01	-0.03	-0.07	-0.03	-0.03
p_{43}	0.04	-0.08	-0.01	-0.04	0.08	0.05	0.19	0.04
p_{51}	0.09	0.20	0.20	0.08	0.13	0.12	0.12	0.12*
p_{52}	0.03	-0.01	-0.07	-0.04	0.02	0.05	0.04	0.02
p_{53}	0.44	0.50	0.29	0.28	0.58	0.41	0.37	0.41*
p_{54}	0.00	0.01	0.07	0.09	0.04	0.11	-0.06	0.04
p_{61}	0.26	0.17	0.16	0.22	0.23	0.25	0.16	0.22*
p_{62}	0.06	-0.01	-0.07	0.01	-0.02	-0.03	-0.02	-0.02
p_{63}	0.12	0.17	0.02	0.35	0.23	0.12	0.10	0.12*
p_{64}	0.08	0.12	0.07	0.10	0.07	-0.02	0.01	0.08
p_{65}	0.33	0.44	0.46	0.09	0.27	0.30	0.43	0.33*
Disturbance terms								
X_q	0.97	0.89	1.00	1.00	1.00	1.00	0.99	1.00
X_s	0.99	0.99	0.98	0.98	0.99	1.00	0.98	0.98
X_t	0.88	0.83	0.93	0.95	0.80	0.89	0.92	0.89
X_u	0.84	0.77	0.84	0.88	0.84	0.88	0.85	0.84
Explained variance	0.292	0.401	0.299	0.221	0.286	0.266	0.273	0.286
Additional variance due X_5 OTL	0.083	0.135	0.183	0.007	0.045	0.110	0.153	0.072

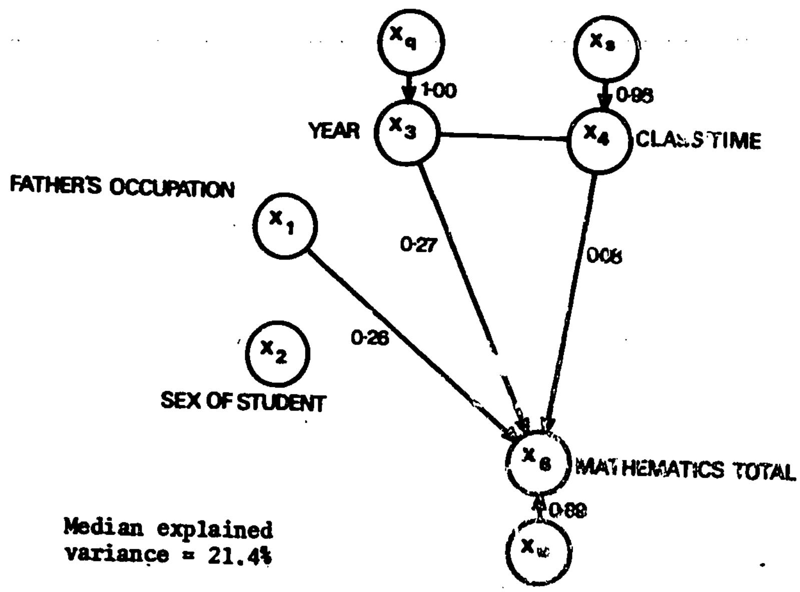
Note: [a] Coefficients significant at the 95 per cent level have been underlined. An asterisk indicates a median value for a coefficient which was significant in a majority of States.

[b] Key to variable numbers: 1 = Father's Occupation, 2 = Sex of Student, 3 = Year, 4 = Class Time, 5 = Opportunity-to-Learn, 6 = Mathematics Total.



Median explained
variance = 29.3%

Figure 6.4 Path Diagram for Causal Model of Mathematics Total with Median Values of Estimated Path Coefficients for Five States for Population 1: 1964 (excluding Opportunity-to-Learn)



Median explained
variance = 21.4%

Figure 6.5 Path Diagram for Causal Model of Mathematics Total with Median Values of Estimated Path Coefficients for Seven States for Population 1: 1978 (excluding Opportunity-to-Learn)

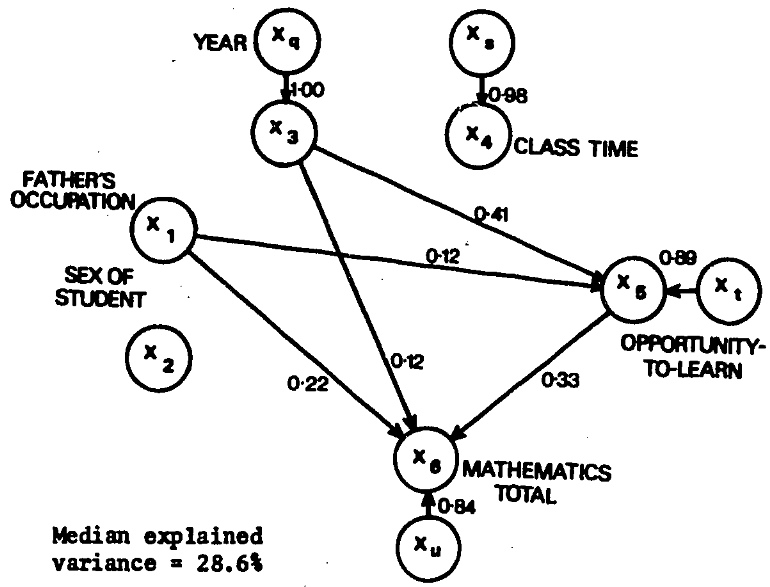


Figure 6.6 Path Diagram for Causal Model of Mathematics Total with Median Values of Estimated Path Coefficients for Seven States for Population 1: 1978

The overall causal picture for 1964, given by the median values of the path coefficients, showed that Year had the main direct influence on Mathematics Total. Father's Occupation had a direct influence on the criterion, but also exerted an indirect influence via Year. The negative path from Year to Class Time indicated that less time was spent in class on mathematics at higher year levels, as noted earlier in this chapter.

For the general picture, Sex of Student was not linked directly or indirectly to the criterion. For the individual States there were some significant paths. In New South Wales there was a weak path from Sex of Student to Year, indicating a tendency for female students to be at higher year levels than male students. The negative path from Sex of Student to Class Time in Victoria and Queensland indicated that female students spent less time in class on mathematics. Only in Western Australia was there a direct link from Sex of Student to Mathematics Total, indicating significantly higher achievement by male students. After controlling for the earlier variables in the causal sequence, Class Time was linked to Mathematics Total only in Victoria and Tasmania.

The inclusion of the variable Opportunity-to-Learn in the model being estimated clarified the mode of influence of the earlier variables in the causal sequence. Opportunity-to-Learn had the strongest direct influence on Mathematics Total. The paths from Father's Occupation and Year to the criterion were weakened, and instead were seen to exert their influence indirectly by means of significant effects on Opportunity-to-Learn. In the process, the path from Class Time to Mathematics Total was weakened, so that it was no longer significant. With the inclusion of Opportunity-to-Learn, the causal model explained a median value of 28.5 per cent of the criterion variance.

Summary

An IEA Mathematics Test was administered to 13-year-old students in Australia in 1964 and 1978. In Western Australia there was a slight increase in the mean test score, with a decrease in the other four States for which comparable data were available. Overall the evidence pointed to a slight decline in mathematics performance over the period.

There was no clear evidence of a relationship between the changes in the mathematics curriculum from 1964 to 1978, and the observed changes in the mathematics achievement of students. However, it was probable that the slight decrease in performance was associated with the reduction in the mean amount of time spent in class on mathematics from 1964 to 1978.

Population 1 was defined to include only 13-year-old students. Although they were spread over Years 7 to 9, there was an increased tendency for Year 8 to become the modal year level for these students. Differences in achievement between the students at this common age level were mainly due to the year level to which they were allocated. However, students from a higher home background level, as measured by the occupation of their fathers, also tended to have significantly higher mathematics achievement. Evidence from the 1978 study suggested that the influence of both father's occupation and the year level operated by means of increased opportunity to learn the curriculum material associated with the test items. An important negative finding was that the sex of the student was not significantly associated with the other explanatory factors in the causal model or with the criterion of mathematics achievement.

CHAPTER 7

MATHEMATICS ACHIEVEMENT OF YEAR 12 STUDENTS

Most Year 12 students are taking courses which provide skills, and consequent certification, leading to entry to the workforce or further education. The proportion of these students studying mathematics has varied across time and across the Australian States. There has also been an increasing tendency for students entering the secondary school to remain until Year 12. In examining the achievement of Year 12 mathematics students, using data from the 1964 and 1978 IEA studies, it was important to take account of these changes in the patterns of participation of young persons in mathematics studies at this level.

The pattern of this chapter is similar to that of Chapter 6. Initially, the mean scores of the mathematics test and sub-tests are presented by States for the 1964 and 1978 testing programs. The middle part of the chapter relates the State mean scores to characteristics of the mathematics curriculum and other characteristics of the State education systems. Finally, differences between students are related to various explanatory characteristics.

Mathematics Test and Sub-test Scores

Table 7.1 sets out the State mean values for the various samples of the variable Mathematics Total, measuring the total score on the Mathematics Test of 69 items which were common to the two testing programs. The table also contains the mean values for the various sub-tests, some of which contained a very small number of items. The mean standard scores have also been presented, in Table 7.2, calculated according to the procedure described in Chapter 6. Overall, the changes in mean standard scores on the mathematics tests and sub-tests between 1964 and 1978 were much larger for Population 3 than for Population 1. For each of the five States that were in both testing programs there was an increase in the mean standard scores for Mathematics Total. These results may be interpreted as indicating a general improvement in mathematics achievement from 1964 to 1978 at this level. The mean standard scores for Mathematics Total have been presented graphically in Figure 7.1.

The sampling errors for mean scores for the Population 3 State samples were estimated to be about ten per cent of a student standard deviation.

Table 7.1 Mathematics Test and Sub-test Mean Scores for Population 3[a]

Test/sub-test	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Mathematics Total (69)							
1964		27.2	30.7	26.7		20.7	31.4
1978R		27.3	31.8	28.7		23.3	33.1
1978	23.8	26.8	30.9	28.9	28.5	22.6	33.6
Arithmetic (3)							
1964		1.2	1.1	0.8		1.0	1.2
1978R		1.0	1.7	1.5		0.5	1.6
1978	1.0	1.0	1.5	1.5	2.2	0.6	1.6
Algebra (20)							
1964		7.3	8.2	7.6		5.8	9.1
1978R		7.9	9.6	9.2		7.0	10.0
1978	7.3	7.7	9.4	9.2	9.0	6.8	10.1
Geometry (5)							
1964		3.1	3.2	3.3		3.0	3.3
1978R		2.4	2.6	2.6		2.4	2.9
1978	2.4	2.3	2.6	2.6	2.1	2.4	2.9
Co-ordinate Geometry (6)							
1964		3.1	3.8	2.9		2.4	3.8
1978R		3.1	3.7	3.0		2.6	3.7
1978	2.8	3.1	3.6	3.0	3.3	2.6	3.8
Calculus (11)							
1964		3.7	4.1	3.5		1.8	2.9
1978R		3.6	3.8	2.9		2.1	2.8
1978	2.4	3.6	3.4	2.9	2.9	1.8	3.0
Relations and Functions (12)							
1964		4.7	5.3	4.1		3.3	5.0
1978R		4.5	4.9	4.1		4.2	5.5
1978	3.5	4.5	4.8	4.2	4.2	4.1	5.7
Trigonometry (3)							
1964		1.5	2.0	1.6		1.3	1.5
1978R		1.0	1.7	1.2		0.8	1.7
1978	0.8	0.9	1.5	1.2	1.0	0.8	1.7
Sets (2)							
1964		0.1	0.1	0.2		0.1	0.6
1978R		1.1	1.0	0.9		1.2	1.0
1978	0.9	1.1	1.0	1.0	0.8	1.1	1.1

... contd

Table 7.1 Mathematics Test and Sub-test Mean Scores for Population 3 (contd)

Test/sub-test	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Logic (6)							
1964		1.9	2.3	2.3		1.6	3.4
1978R		2.2	2.2	2.7		1.9	3.2
1978	2.1	2.1	2.4	2.8	2.4	1.9	3.2
Probability (1)							
1964		0.5	0.6	0.5		0.5	0.6
1978R		0.6	0.7	0.7		0.6	0.6
1978	0.6	0.6	0.7	0.7	0.5	0.6	0.6
New Mathematics (16)							
1964		3.6	4.4	4.3		2.7	6.7
1978R		6.8	7.2	7.2		5.9	8.2
1978	6.1	6.7	7.4	7.5	6.9	5.6	8.3
Computation (33)							
1964		13.6	15.1	12.7		10.0	14.8
1978R		12.8	16.4	13.7		10.6	16.0
1978	10.7	12.5	15.3	13.7	15.2	10.3	16.4
Knowledge (10)							
1964		5.2	5.4	5.2		4.1	5.4
1978R		5.1	5.2	5.1		4.7	5.6
1978	4.8	5.0	5.3	5.2	4.4	4.5	5.7
Translation (4)							
1964		1.3	1.9	1.4		1.0	1.8
1978R		1.6	1.8	1.5		1.4	1.5
1978	1.5	1.5	1.8	1.5	1.5	1.4	1.6
Comprehension (22)							
1964		7.0	8.3	7.3		5.6	9.4
1978R		8.0	8.4	8.4		6.7	9.9
1978	7.2	7.8	8.6	8.5	7.4	6.4	10.0

Note: [a] The number of items in the tests and sub-tests is indicated in brackets.

This meant that, for a given mean standard score of S, the confidence limits at the 95 per cent level would be about S ± 0.20. A difference of at least 0.28 between the mean standard scores for a given variable from two samples would be required to establish at this confidence level that there were significant differences between the populations from which the samples were drawn.

Table 7.2 Mathematics Test and Sub-test Mean Standard Scores for Population 3

Test/sub-test	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Mathematics Total							
1964		-0.10	0.29	-0.16		-0.81	0.36
1978R		-0.08	0.41	0.06		-0.52	0.55
1978	-0.47	-0.14	0.31	0.09	0.04	-0.60	0.60
Change 1978R-1964		0.02	0.12	0.22		0.29	0.19
Arithmetic							
1964		0.05	-0.05	-0.42		-0.16	0.08
1978R		-0.14	0.63	0.33		-0.73	0.44
1978	-0.16	-0.24	0.38	0.34	1.23	-0.67	0.51
Change 1978R-1964		-0.19	0.68	0.75		-0.57	0.36
Algebra							
1964		-0.31	0.02	-0.20		-0.82	0.30
1978R		-0.09	0.47	0.36		-0.38	0.66
1978	-0.31	-0.15	0.41	0.35	0.27	-0.45	0.68
Change 1978R-1964		0.22	0.45	0.56		0.44	0.36
Geometry							
1964		-0.19	0.28	0.34		0.08	0.35
1978R		-0.40	-0.25	-0.23		-0.38	0.05
1978	-0.41	-0.44	-0.23	-0.22	-0.61	-0.37	0.02
Change 1978R-1964		-0.21	-0.53	-0.57		-0.46	-0.30
Co-ordinate Geometry							
1964		-0.08	0.45	-0.22		-0.65	0.46
1978R		-0.08	0.39	-0.21		-0.47	0.39
1978	-0.33	-0.13	0.27	-0.17	0.08	-0.47	0.40
Change 1978R-1964		0.00	-0.06	0.01		0.18	-0.07
Calculus							
1964		0.28	0.47	0.17		-0.63	-0.11
1978R		0.25	0.33	-0.10		-0.52	-0.15
1978	-0.34	0.23	0.16	-0.09	-0.12	-0.62	-0.07
Change 1978R-1964		-0.03	-0.14	-0.27		0.11	-0.04
Relations and Functions							
1964		0.07	0.39	-0.24		-0.64	0.21
1978R		-0.04	0.19	-0.23		-0.18	0.48
1978	-0.53	-0.04	0.14	-0.17	-0.20	-0.24	0.56
Change 1978R-1964		-0.11	-0.20	0.01		0.46	0.27

... contd

Table 7.2 Mathematics Test and Sub-test Mean Standard Scores for Population 3 (contd)

Test-sub-test	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Trigonometry							
1964		0.11	0.55	0.16		-0.14	0.09
1978R		-0.54	0.27	-0.26		-0.64	0.32
1978	-0.63	-0.54	0.07	-0.28	-0.42	-0.68	0.31
Change 1978R-1964		-0.65	-0.28	-0.42		-0.50	0.23
Sets							
1964		-0.93	-0.96	-0.76		-0.91	-0.09
1978R		0.82	0.66	0.53		0.95	0.73
1978	0.51	0.78	0.71	0.58	0.29	0.87	0.76
Change 1978R-1964		1.75	1.62	1.29		1.86	0.82
Logic							
1964		-0.31	-0.04	-0.08		-0.57	0.75
1978R		-0.13	-0.12	0.24		-0.31	0.57
1978	-0.16	-0.16	0.03	0.31	0.06	-0.36	0.58
Change 1978R-1964		0.18	-0.08	0.32		0.26	-0.18
New Mathematics							
1964		-0.84	-0.51	-0.55		-1.18	0.39
1978R		0.43	0.60	0.59		0.07	0.98
1978	0.17	0.40	0.66	0.69	0.49	-0.03	1.03
Change 1978R-1964		1.27	1.11	1.14		1.25	0.59
Computation							
1964		0.01	0.31	-0.19		-0.76	0.24
1978R		-0.17	0.57	0.02		-0.63	0.51
1978	-0.61	-0.23	0.34	0.01	0.34	-0.68	0.57
Change 1978R-1964		-0.18	0.26	0.21		0.13	0.27
Knowledge							
1964		0.07	0.17	0.05		-0.53	0.17
1978R		-0.03	0.06	0.01		-0.24	0.26
1978	-0.14	-0.04	0.09	0.06	-0.40	-0.34	0.29
Change 1978R-1964		-0.10	-0.11	-0.04		-0.29	0.09
Translation							
1964		-0.20	0.36	-0.11		-0.49	0.26
1978R		0.10	0.26	-0.02		-0.11	0.00
1978	-0.06	-0.03	0.23	-0.02	-0.03	-0.11	0.07
Change 1978R-1964		0.30	-0.10	0.09		0.38	-0.26
Comprehension							
1964		-0.28	0.12	-0.17		-0.69	0.46
1978R		0.02	0.16	0.14		-0.37	0.61
1978	-0.22	-0.04	0.20	0.20	-0.16	-0.45	0.63
Change 1978R-1964		0.30	0.04	0.31		0.32	0.15

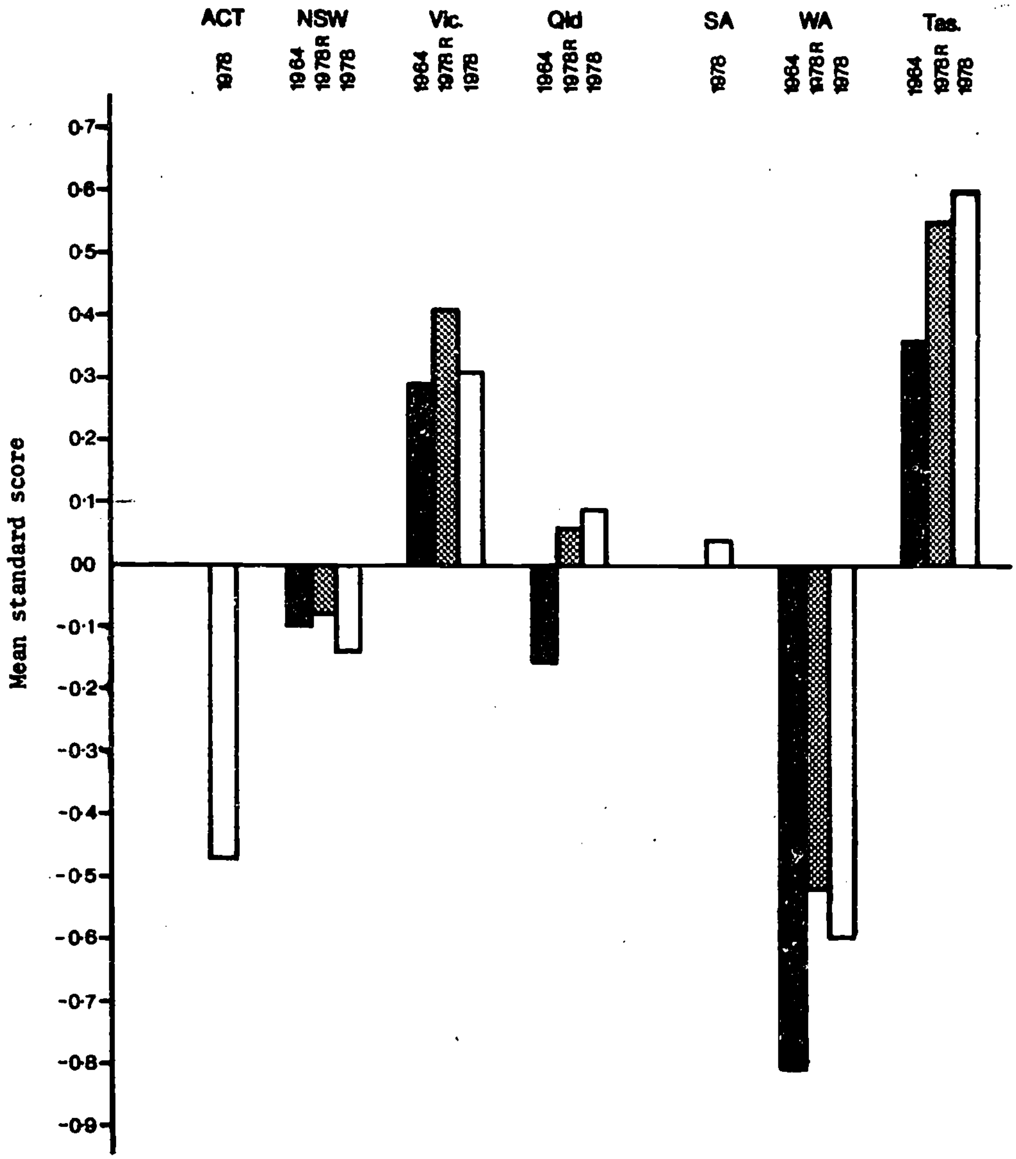


Figure 7.1 Mathematics Total Mean Standard Scores: Population 3

151

In New South Wales, Victoria and Western Australia the values for the 1978 total sample were lower than for the 1978 restricted sample, indicating that the achievement of students in government schools in these States was at a higher mean level than in the non-government schools.

The scores for the content areas Arithmetic, Trigonometry, Sets and Probability were based on sub-tests with three or fewer items, and will generally not be included in further discussion. In each State there was a large increase from 1964 to 1978 in the standard scores on the Algebra sub-test, whereas there was a large decrease for Geometry. There was little change across the States for Co-ordinate Geometry.

The pattern of standard scores for Calculus was rather different, with a significant decrease taking place in Queensland. For Relations and Functions, there were large increases in Western Australia and Tasmania. Finally, there were very large increases in all States for New Mathematics. In general, there was no consistent overall pattern across States in the observed changes in mean standard scores for the various content sub-tests, and consequently it is necessary to relate these changes to curricular changes from 1964 to 1978.

Similarly, there was no consistent pattern across the States in the changes in mean standard scores for the process sub-tests. However, a majority of the States registered increases in both Computation and Comprehension, indicating at least that improvement in higher cognitive skills did not occur at the expense of basic computational skills.

Mathematics Total Score Percentage Frequency Distributions

Table 7.3 presents the percentage frequency distributions for the Mathematics Total scores, arranged in 5-item bands. There were only minor differences between the results for the 1978 restricted and total samples, thus indicating the similarity between students in government and non-government schools with respect to the score distributions.

At the lower end of the distribution there were no marked changes between 1964 and 1978 in the percentages of students across the 5-item bands. On the other hand, the percentage of students obtaining scores in bands at the higher end of the distribution increased from 1964 to 1978 in each of the five States for which comparative data were available. The data presented in the frequency distributions complement the data given by the mean test scores in demonstrating that mathematics achievement at the Year 12 level has generally increased between 1964 and 1978.

Table 7.3 Mathematics Total Score Percentage Distributions for Population 3

	1-5 %	6-10 %	11-15 %	16-20 %	21-25 %	26-30 %	31-35 %	36-40 %	41-45 %	46-50 %	51-55 %	56-60 %	61-65 %
ACT													
1978	1	7	15	19	21	10	12	9	3	0	2	1	U
NSW													
1964	0	1	9	18	18	18	19	9	4	3	1	0	0
1978R	••	1	6	18	23	21	12	7	7	2	1	1	1
1978	••	••	6	18	25	21	13	7	5	2	1	••	••
Vic.													
1964	0	0	1	9	16	25	22	14	9	3	1	0	0
1978R	0	0	1	8	18	23	18	16	7	6	3	0	••
1978	0	••	3	8	19	25	18	12	8	5	3	••	••
Qld													
1964	0	2	5	21	15	20	23	9	3	••	1	0	0
1978R	0	2	6	14	19	18	17	10	7	5	1	••	0
1978	0	1	5	13	19	22	17	10	8	4	1	••	••
SA													
1978	••	1	7	16	17	22	14	11	7	3	1	1	1
WA													
1964	0	6	16	32	24	15	6	2	0	0	0	0	0
1978R	0	4	20	23	16	12	11	7	5	1	0	••	0
1978	••	6	18	26	17	11	9	5	4	2	0	1	0
Tas.													
1964	0	0	1	7	24	20	20	13	8	3	4	2	0
1978R	0	0	3	8	16	19	14	14	13	8	4	1	1
1978	0	0	2	8	14	18	18	12	14	8	4	1	1

Effects of Holding Power

The examination of changes in achievement from 1964 to 1978 across the Australian States is confounded by differences in holding power, in terms of the percentage of mathematics students in each State in the Year 12 population cohort. It was anticipated that the mean value of Mathematics Total would be higher in States with lower retentivity. This was confirmed by the strong negative correlation coefficients between the percentage of mathematics students in the population cohort (documented in Chapter 2) and the State mean Mathematics Total: -0.82 across five States in 1964 and -0.77 across seven States in 1978. These results suggest that it would be meaningful to examine the mathematics achievement after making allowances for the holding power.

At this stage it is convenient to introduce the concept of 'yield' performance of the education system relative to the corresponding year cohort. The yield may be examined most readily by means of a graph which shows the percentage of young persons in the year cohort reaching various levels of mathematics achievement as measured by the Mathematics Total scores.

Two steps were involved in the preparation of the yield graph for each State. Firstly, each of the entries in Table 7.3 was multiplied by the percentage of mathematics students in the relevant Year 12 cohort. This gave an estimate of the percentage of persons in the year cohort who would have obtained scores in each 5-item band had the tests been administered to the whole population cohort. Secondly, these population estimates were cumulated to obtain values that have been presented as yield graphs in Figure 7.2. The reading on the vertical axis of each graph indicates the percentage of persons in the year cohort exceeding the Mathematics Total score given on the horizontal axis. The maximum percentage indicated on the vertical axis is the holding power of mathematics students in the given cohort.

The calculation of the holding power percentages was based on the total number of mathematics students in each State, including those in both government and non-government schools. The Mathematics Total scores in the yield graphs for 1978 were therefore based on data from the 1978 total sample. For the 1964 yield graphs the Mathematics Total scores were available only for students in government schools. However, since there were only minor differences in 1978 between the score distributions for the restricted and total samples, it was assumed by extrapolation that the 1964 score distribution data were adequate to represent students in both government and non-government schools for the purpose of discussing the yield of the systems.

In interpreting the yield graphs it is important to recognize that the method adopted underestimates the percentage of persons in the cohort who achieved given performance levels. Testing was restricted to defined

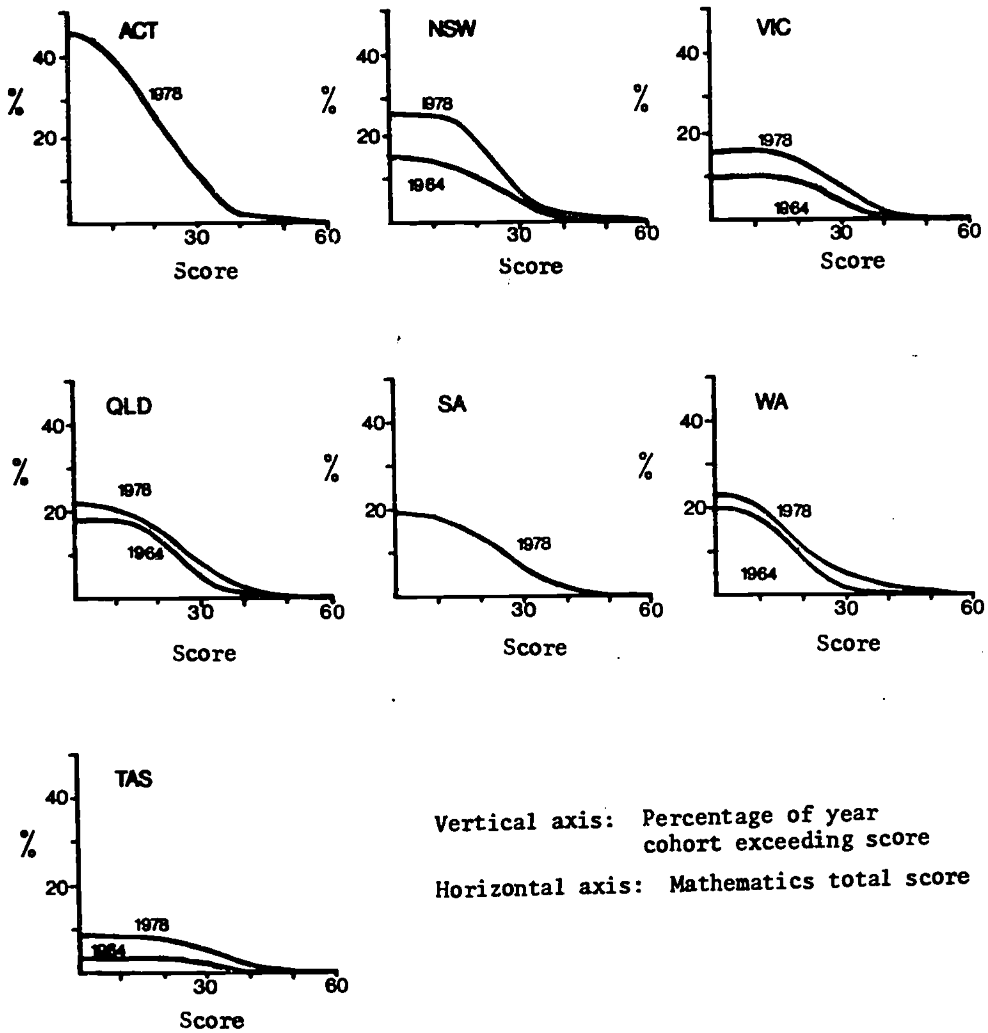


Figure 7.2 Cumulative Distribution (Smoothed) of Percentage of Students in Year Cohort by Mathematics Total Scores

target populations of students in schools, and did not include students who were not in these target populations or young persons who were no longer at school. The underestimation was probably greater at the low end of the score distribution than at the higher end. In effect, the yield is measured by the area under the curved line of the graph, recognizing that students at the higher end of the distribution had a greater knowledge of mathematics than those at the lower end.

The graphs show clearly that the yield increased from 1964 to 1978 in the five States with comparable data. The increase was particularly high in Tasmania, largely due to the low holding power in 1964. The increase in Queensland and Western Australia was lower than in the other States, due to the reduction in the percentage of Year 12 students taking mathematics, which was in turn due to changes in the prerequisite requirements imposed by tertiary institutions on the pattern of courses undertaken by the Year 12 students.

Due to the relatively low percentage values involved at the right-hand end of the curves, the yield graphs do not always give a clear picture of the performance of the most able mathematics students. Table 7.4 presents the percentage of the mathematics students who obtained high scores, defined as Mathematics Total values greater than 35 and greater than 40. On the basis of the grand mean of 28.1 and the grand standard deviation of 9.1, these scores represent percentile ratings of 78 per cent and 90 per cent respectively. That is, in terms of the standardization procedures adopted earlier in this chapter, a score greater than 35 locates a student in the top 22 per cent of the 1964 and 1978 groups of mathematics students, and a score greater than 40 locates a student in the top 10 per cent.

In order to show the effects of compensating for holding power, Table 7.4 also includes the estimated percentage of persons in the year cohort who obtained high scores. For 1964 these percentages were similar in New South Wales, Victoria and Queensland, and lower in the other two States. For 1978 there was a general level of similarity in the percentages for the seven States. The table also shows that the percentage of persons in the year cohort who obtained high scores increased from 1964 to 1978 in each of the five States with data available on both occasions. In summary, these results demonstrate very convincingly that the increase in holding power of the educational systems has not taken place at the expense of the more able mathematics students, and that the overall yield of mathematics has also increased.

Table 7.4 Students Obtaining High Mathematics Total Scores as Percentage of All Mathematics Students and of Year Cohort

	All Mathematics Students		Year Cohort		
	Score > 35 %	Score > 40 %	Holding power %	Score > 35 %	Score > 40 %
ACT					
1978	15	6	45	7	3
NSW					
1964	18	8	15	3	1
1978	16	9	26	4	2
Vic.					
1964	27	14	10	3	1
1978	28	16	16	4	3
Qld					
1964	13	4	19	3	1
1978	23	13	21	5	3
SA					
1978	23	12	19	4	2
WA					
1964	2	0	19	..	0
1978	12	6	22	3	1
Tas.					
1964	29	16	3	1	..
1978	40	28	8	3	2

Relationships Between Curriculum and Achievement

Detailed information about mathematics courses at Year 12 in 1964 and 1978 was included in the curriculum content analysis grids set out in Chapter 2. In order to relate this information to the translated curriculum and student achievement, Curriculum Content scores were calculated. The steps adopted for the calculation were the same as those followed for Population 1 (as described in the previous chapter) with one important modification. For each State there were two or more mathematics courses at the Year 12 level; the percentage of mathematics students in each course in each State was

Table 7.5 Curriculum Content Score per Item for Population 3 Mathematics Test and Sub-tests

Test/sub-test	ACT	NSW	Vic.	Qld	SA	WA	Tas.
1964							
Mathematics Total		0.68	0.58	0.54	0.68	0.51	0.78
Arithmetic		0.57	0.33	0.33	0.33	0.33	1.00
Algebra		0.84	0.75	0.75	0.70	0.70	1.00
Geometry		1.00	1.00	1.00	1.00	1.00	1.00
Co-ordinate Geometry		0.83	0.83	1.00	0.83	0.83	1.00
Calculus		0.67	0.60	0.55	0.91	0.55	0.73
Relations and Functions		0.59	0.35	0.08	0.75	0.08	0.50
Trigonometry		1.00	1.00	1.00	1.00	1.00	1.00
Sets		0.00	0.00	0.00	0.00	0.00	1.00
Logic		0.00	0.00	0.00	0.00	0.00	0.00
Probability		1.00	0.36	0.00	0.00	0.00	1.00
New Mathematics		0.32	0.21	0.19	0.25	0.13	0.63
1978							
Mathematics Total	0.61	0.73	0.73	0.76	0.71	0.62	0.85
Arithmetic	0.49	0.35	0.57	0.70	1.00	0.33	1.00
Algebra	0.73	0.76	1.00	0.89	0.85	0.75	0.82
Geometry	1.00	0.00	0.00	0.00	0.23	1.00	1.00
Co-ordinate Geometry	0.53	0.83	0.89	1.00	0.92	0.83	0.88
Calculus	0.43	1.00	0.81	0.73	0.70	0.19	1.00
Relations and Functions	0.62	1.00	0.73	1.00	0.86	0.71	1.00
Trigonometry	1.00	1.00	0.97	1.00	0.73	1.00	1.00
Sets	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Logic	0.05	0.00	0.00	0.02	0.00	0.00	0.09
Probability	0.62	1.00	1.00	0.28	0.28	1.00	0.73
New Mathematics	0.40	0.44	0.57	0.67	0.62	0.35	0.52

given in Chapter 2. These percentages were used as weighting factors in order to prepare a single Curriculum Content rating for each topic for each State. This meant that the Curriculum Content scores that were calculated for the test and sub-tests were able to take into account the curriculum covered in the range of courses studied by the Population 3 students.

The Curriculum Content scores per item in Table 7.5 showed less consistency across the sub-tests for each State than was the case for Population 1. For each State the Curriculum Content scores for Mathematics Total for 1978 were higher than for 1964, indicating that the test was more relevant to the curriculum in 1978. The same pattern tended to apply for the Curriculum Content scores for the sub-tests, although the scores were lower in 1978 than in 1964 for Geometry in several States.

Table 7.6 Mean Opportunity-to-Learn Score per Item for Population 3 Mathematics Test and Sub-tests

Test/sub-test	ACT	NSW	Vic.	Qld	SA	WA	Tas.
1964							
Mathematics Total		0.56	0.61	0.57		0.48	0.59
Arithmetic		0.41	0.40	0.36		0.40	0.41
Algebra		0.56	0.62	0.62		0.52	0.62
Geometry		0.80	0.87	0.83		0.67	0.84
Co-ordinate Geometry		0.71	0.77	0.71		0.63	0.77
Calculus		0.56	0.60	0.52		0.39	0.37
Relations and Functions		0.56	0.68	0.55		0.48	0.67
Trigonometry		0.67	0.83	0.79		0.68	0.77
Sets		0.13	0.13	0.13		0.13	0.30
Logic		0.32	0.26	0.34		0.26	0.44
Probability		0.62	0.57	0.37		0.19	0.18
New Mathematics		0.23	0.25	0.24		0.16	0.36
1978							
Mathematics Total	0.60	0.59	0.70	0.62	0.67	0.52	0.66
Arithmetic	0.47	0.40	0.53	0.53	0.88	0.27	0.52
Algebra	0.59	0.56	0.70	0.67	0.68	0.49	0.69
Geometry	0.69	0.68	0.74	0.47	0.69	0.72	0.72
Co-ordinate Geometry	0.69	0.68	0.79	0.76	0.86	0.77	0.75
Calculus	0.63	0.65	0.77	0.67	0.60	0.34	0.53
Relations and Functions	0.69	0.64	0.69	0.65	0.67	0.58	0.74
Trigonometry	0.66	0.64	0.73	0.66	0.73	0.48	0.78
Sets	0.55	0.66	0.72	0.63	0.54	0.75	0.70
Logic	0.34	0.32	0.46	0.31	0.63	0.38	0.50
Probability	0.57	0.85	0.81	0.60	0.81	0.80	0.67
New Mathematics	0.41	0.41	0.56	0.38	0.52	0.39	0.52

The State mean Opportunity-to-Learn scores per item in Table 7.6 were calculated, as described in the previous chapter, from the mathematics teachers' ratings of the students' opportunity to learn the processes embodied in the test items. These scores also tended to be higher for 1978 than for 1964, so that the teachers' ratings also indicated that the test was more relevant to the curriculum at the time of the second testing program.

Finally, the mean scores per item for Mathematics Total and the sub-tests were calculated, and presented in Table 7.7.

The purpose of the above quantification procedures was to facilitate the comparison of the intended curriculum and the translated curriculum with student performance in mathematics. One way to examine the relation-

Table 7.7 Mean Test Score Item for Population 3 Mathematics Test and Sub-tests

Test/sub-test	ACT	NSW	Vic.	Qld	SA	WA	Tas.
1964							
Mathematics Total		0.39	0.44	0.39		0.30	0.46
Arithmetic		0.40	0.37	0.26		0.34	0.41
Algebra		0.36	0.41	0.38		0.29	0.45
Geometry		0.62	0.64	0.66		0.59	0.66
Co-ordinate Geometry		0.52	0.64	0.49		0.39	0.64
Calculus		0.33	0.37	0.31		0.17	0.26
Relations and Functions		0.39	0.44	0.34		0.28	0.41
Trigonometry		0.51	0.65	0.53		0.43	0.51
Sets		0.06	0.05	0.11		0.07	0.29
Logic		0.32	0.39	0.38		0.26	0.57
Probability		0.53	0.55	0.48		0.49	0.63
New Mathematics		0.22	0.28	0.27		0.17	0.42
1978							
Mathematics Total	0.35	0.39	0.45	0.42	0.41	0.33	0.49
Arithmetic	0.34	0.32	0.50	0.49	0.75	0.19	0.54
Algebra	0.36	0.39	0.47	0.46	0.45	0.34	0.51
Geometry	0.47	0.47	0.52	0.52	0.42	0.48	0.58
Co-ordinate Geometry	0.47	0.51	0.60	0.50	0.56	0.43	0.63
Calculus	0.22	0.33	0.31	0.27	0.26	0.17	0.27
Relations and Functions	0.29	0.37	0.40	0.35	0.35	0.34	0.47
Trigonometry	0.27	0.30	0.50	0.39	0.34	0.26	0.58
Sets	0.46	0.53	0.51	0.48	0.40	0.56	0.53
Logic	0.36	0.36	0.40	0.47	0.41	0.31	0.53
Probability	0.62	0.57	0.67	0.66	0.54	0.57	0.62
New Mathematics	0.38	0.42	0.46	0.47	0.43	0.35	0.52

ship involved calculating the correlation coefficients between the Curriculum Content scores, the mean Opportunity-to-Learn scores and the mean test scores across the five 1964 State samples and the seven 1978 State samples. These values, set out in Table 7.8, include some of 0.00 where the Curriculum Content score was the same for each State. A consistent relationship was considered to be present where there were positive correlation coefficients for the three pairs of variables. This was the case for Mathematics Total and the following sub-tests: Arithmetic, Algebra, Co-ordinate Geometry, Calculus (1978 only), Relations and Functions, and New Mathematics. Sets also had a consistent set of indices for 1964, but these were due to the high scores for Tasmania linked with very low scores for the other States.

An alternative aspect of the analysis involved relating changes from 1964 to 1978 in the test scores to changes in the other two indices. The

Table 7.8 Correlations Between State Curriculum Content Scores, Mean Opportunity-to-Learn Scores and Mean Test Scores

	1964[a]			1978[b]		
	Curriculum Content - Test	Opportunity-to-Learn - Test	Curriculum Content - Opportunity-to-Learn	Curriculum Content - Test	Opportunity-to-Learn - Test	Curriculum Content - Opportunity-to-Learn
Mathematics Total	0.69	0.95	0.50	0.93	0.82	0.57
Arithmetic	0.65	0.97	0.52	0.90	0.96	0.79
Algebra	0.76	0.90	0.41	0.70	0.92	0.76
Geometry	0.00	0.86	0.00	0.19	-0.07	0.41
Co-ordinate Geometry	0.23	0.99	0.35	0.39	0.34	0.58
Calculus	0.21	0.88	-0.19	0.91	0.79	0.58
Relations and Functions	0.74	0.93	0.56	0.57	0.54	0.18
Trigonometry	0.00	0.80	0.00	0.09	0.75	-0.31
Sets	0.79	0.97	1.00	0.00	0.91	0.00
Logic	0.00	0.85	0.00	0.65	0.30	0.04
Probability	0.38	-0.17	0.23	0.02	-0.51	0.51
New Mathematics	0.88	0.99	0.91	0.69	0.54	0.39

Note: [a] Calculation based on five States

[b] Calculation based on seven States

pattern of changes for Mathematics Total has been presented graphically as Figure 7.3. The diagram showed clearly that there was a consistent pattern of increased scores from 1964 to 1978 for the three indices, except that the mean test score in New South Wales was the same on both occasions.

The changes across the three indices for most of the other sub-tests were also consistent, although the direction of the changes was not necessarily the same for all States. For example, for Arithmetic the three indices showed positive changes for Victoria, Queensland and Tasmania but consistent negative changes in New South Wales and Western Australia. For Algebra there was an increase in the scores in each State, but this was consistently associated with the other two indices only in Victoria and Queensland. The test scores for Calculus in 1978 were also close to the 1964 values, although the Curriculum Content scores and Opportunity-to-Learn scores were generally much higher, suggesting that performance in this area did not match the increased expectations. Similarly, the Curriculum Content

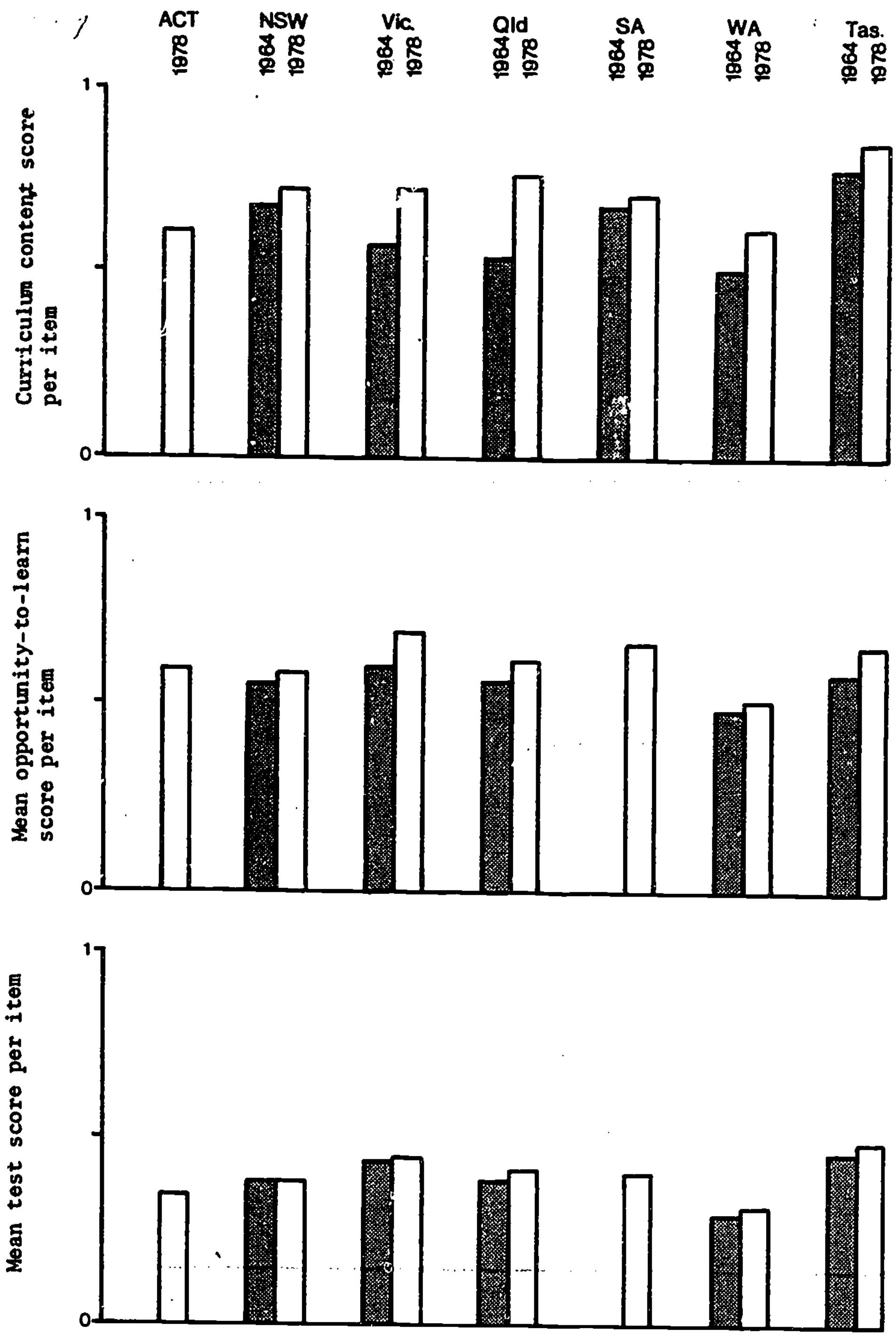


Figure 7.3 Relationship Between Three Indices of Curriculum for Mathematics Total from 1964 to 1978: Population 3

scores and Opportunity-to-Learn scores for Relations and Functions were generally higher in 1978, whereas the test scores increased in Queensland, Western Australia and Tasmania, and decreased in New South Wales and Victoria. Overall, most of the changes from 1964 to 1978 were consistent across the three indices, providing a basis for examining changes in test scores, and explaining them in terms of changes in achievement.

Individual Mathematics Test Items

The percentages of students obtaining the correct response for each item in each of the three sets of samples (1964 State samples, 1978 restricted samples and 1978 total samples) have been included in Appendix 4. More detailed item statistics have been included in an associated technical report (Rosier, 1980b).

Table 7.9 lists the items for which there was the greatest change in student performance between 1964 and 1978. Only items with a change in the percentage of correct responses which was equal to or greater than 15 per cent in three or more States have been included. This criterion was more strict than for Population 1 due to the greater variability in the percentages of correct responses at the Population 3 level.

For about half of these items the percentage of correct responses was lower in 1978 than in 1964. Item D05 required a knowledge of axioms of Euclidean geometry, and the decline in performance was clearly related to reduced emphasis on the topic in the curriculum. The same consistent relationship applied to item F63, dealing with the equation of a line. Both items E32 and E38 involved the solution of the roots of equations. The Opportunity-to-Learn ratings for these items indicated a reduced emphasis which was consistent with the lower performance. However the reasons were less clear for the other three items which showed a marked decline in performance: D09, dealing with basic trigonometrical ratios; F57, involving the application of a standard co-ordinate geometry formula; and F65, requiring a fairly basic anti-differentiation process. In each case there was no marked change in curriculum emphasis, and the Opportunity-to-Learn ratings were high in both 1964 and 1978.

Each of the items demonstrating an increase in the percentage of correct responses from 1964 to 1978 was associated with corresponding increased emphasis in the curriculum, and increased Opportunity-to-Learn ratings. Item D05 was an algebra item testing a concept that was poorly understood in 1964. The improved performance in items D22 and E31 probably reflected

Table 7.9 Mathematics Items Involving Major Change from 1964 to 1978: Population 3[a]

Item	Content area	NSW %	Vic. %	Qld %	WA %	Tas. %
D05	Algebra	+29	+22	+49	+52	
D08	Geometry	-23	-35	-32	-21	-23
D09	Trigonometry	-26	-19	-15	-18	
D22	Algebra	+51	+38	+34	+65	+19
E29	Arithmetic		+41	+24	-15	+19
E31	Relations and Functions	+24	+17	+17		
E32	Algebra	-15	-16		-15	
E35	Sets	+40	+24	+29	+31	
E38	Algebra[b]	-18	-15		-28	
F52	Sets	+56	+65	+19	+70	+30
F57	Co-ordinate Geometry	-16		-16	-16	
F63	Relations and Functions	-26	-27	-22		
F65	Calculus	-31	-16	-26		-19

Note: [a] This table presents the difference from the 1964 to the 1978R samples in the percentage of students obtaining the correct response on items in the Mathematics Test. Only differences equal to or greater than 5 per cent in three or more States have been included.

[b] Indicates a constructed-response item.

a better understanding of modern mathematical terminology, of the modulus for the former item and of relations and functions for the latter one. Item 29, dealing with complex numbers, showed a marked increase in performance in three States. However, there was a decrease in Western Australia where the topic was not regarded as important in the curriculum for 1964 and 1978. The items E35 and F52 dealt with sets, and the improved performance was clearly due to an increased understanding of the terminology employed in the items.

Relationships Between Background Factors and Achievement

The next stage in the discussion is to examine the relationships between various background factors and achievement. This section deals mainly with the changes in these factors from 1964 to 1978 in the five States with comparable data, and associated changes in achievement. However it also examined, separately for the five 1964 State samples and the seven 1978 total samples, the extent to which State mean differences in mathematics achievement were associated with these factors.

Age of Students

Most of the students at the Year 12 level are of age 17, 18 or 19 years, with a small percentage of younger and/or older students. Table 7.10 sets out the mean value of the variable Mathematics Total for students of age 16, 17, 18, 19 and 20.

Due to the restructuring of the secondary education system in New South Wales between 1964 and 1978, the modal age in that State increased from age 17 to age 18. In the other four States a homogenizing process occurred between 1964 and 1978, with a reduction in the percentage of students of age less than 17 or greater than 18; that is, there was an increasing tendency for Year 12 students to be age 17 or 18. From these data there was no evidence to suggest that the observed changes in mathematics achievement from 1964 to 1978 were due to changes in the age-distribution of Year 12 students.

There were only small correlation coefficients between mean Age and mean Mathematics Total across the States: 0.22 for 1964 and 0.12 for 1978. Overall these results suggested that the age of the students was not associated with mathematics achievement at this level.

Time Spent on Mathematics

As indicated in Chapter 5, the mean value of the variable Class Time, measuring the number of hours per week spent in class on mathematics, decreased from 1964 to 1978 in New South Wales, Victoria and Queensland, whereas there was an increase in Western Australia and Tasmania from fairly low levels in 1964. However, in each of these five States the Mathematics Total score increased from 1964 to 1978, so that there was apparently no positive association between changes in the time spent in class on mathematics and changes in mathematics achievement.

Students at this level are commonly expected to undertake additional study apart from the time spent in class on mathematics. This was measured in hours per week by the variable Mathematics Homework. The mean values for Class Time and Mathematics Homework for each State could be summed to give an estimate of the mean amount of time spent in total on mathematics. These

Table 7.10 Mean Mathematics Total by Age for Population 3[a]

		ACT	NSW	Vic.	Qld	SA	WA	Tas.
1964								
Age 16	Score		30.0		21.6			33.2
	(n%)		1%		4%			11%
Age 17	Score		27.7	30.5	24.8		20.5	31.2
	(n%)		63%	15%	30%		45%	50%
Age 18	Score		26.3	31.2	28.0		20.8	32.0
	(n%)		28%	60%	51%		49%	30%
Age 19	Score		23.5	30.9	28.1		21.2	29.8
	(n%)		5%	17%	12%		6%	7%
Age 20	Score		28.7	27.4	22.8			24.5
	(n%)		3%	8%	2%			2%
1978R								
Age 17	Score		28.8	37.3	29.3		22.6	32.2
	(n%)		1%	7%	49%		41%	13%
Age 18	Score		27.8	31.7	28.0		24.4	33.3
	(n%)		68%	72%	44%		54%	77%
Age 19	Score		25.2	28.2	26.1		18.3	33.4
	(n%)		23%	14%	6%		4%	9%
Age 20	Score		30.7	37.2				
	(n%)		3%	5%				
1978								
Age 16	Score							38.8
	(n%)							2%
Age 17	Score	24.9	27.3	35.9	29.6	28.8	23.3	33.2
	(n%)	8%	4%	10%	48%	51%	41%	16%
Age 18	Score	24.3	26.9	30.5	28.7	27.5	22.3	33.7
	(n%)	78%	74%	76%	46%	41%	54%	73%
Age 19	Score	21.3	26.0	28.0	25.9	32.0	21.0	33.3
	(n%)	13%	16%	11%	5%	6%	4%	8%
Age 20	Score	13.5	29.6	37.2		26.2		
	(n%)	1%	3%	2%		1%		

Note: [a] Percentages may not sum to 100 per cent where the sample contained students older than age 20.

summed values were lower in 1978 than in 1964 in all States except in Tasmania, where they were the same on both occasions. These results indicated that there was no positive association between changes in the total amount of time spent on mathematics and changes in achievement.

The measures of the mean amount of time spent on mathematics at the State level were only weakly associated with achievement differences. In 1964 the correlation coefficient between the State mean values for Mathematics Total and Class Time was 0.37, and between Mathematics Total and the summed values for Class Time and Mathematics Homework was 0.34. For 1978 the corresponding coefficients were 0.32 and 0.35.

Higher-level Students

The decrease in class time spent on mathematics between 1964 and 1978 in New South Wales, Victoria and Queensland was largely due to the decrease in the percentage of mathematics students taking higher-level courses, such as the combination of Pure Mathematics and Applied Mathematics in Victoria. These higher-level students were the ones most likely to proceed to technical or scientific occupations, so that it was considered important to examine changes in the structure and performance of this group who specialized in the study of mathematics at school.

Since no information was obtained from students in the study about the courses they were taking, it was decided to define higher-level students as those for whom the time spent in class on mathematics was more than five hours each week. Table 7.11 sets out the mean Mathematics Total scores for the higher-level students, together with the percentage of mathematics students in this category. In New South Wales, Victoria and Queensland, the percentage of mathematics students taking higher-level courses decreased from 1964 to 1978 but the State mean scores of these students increased. In Western Australia the percentage increased and the score increased. In Tasmania the percentage increased from a low level, and the score decreased.

In order to place these results in context, it was decided to relate the percentage of higher-level mathematics students to the year cohort. Table 7.11 also records the number of higher-level mathematics students expressed as a percentage of the year cohort. These values were obtained by multiplying the percentage of higher-level mathematics students by the percentage of all mathematics students in the year cohort. For New South Wales, Victoria and Queensland these results indicated a real decline, relative to the year cohort, in the percentage of students taking higher-level mathematics, although there was a corresponding increase in the achievement of this group from 1964 to 1978.

The performance of the higher-level students was higher in States where the relative size of the group was smaller. There were negative

Table 7.11 Mean Mathematics Total Score for Higher-level Students in Population 3[a]

	Mean Mathematics Total score	Higher-level students as % of all mathematics students	Mathematics students as % of year cohort	Higher-level students as % of year cohort
		%	%	%
ACT				
1978	30.5	39	45	15
NSW				
1964	30.6	71	15	11
1978R	35.2	35		
1978	33.5	30	26	8
Vic.				
1964	32.8	75	10	8
1978R	35.9	55		
1978	36.9	40	16	6
Qld				
1964	28.2	82	19	16
1978R	32.8	58		
1978	33.4	54	21	11
SA				
1978	32.7	57	19	11
WA				
1964	24.1	27	19	5
1978R	33.4	34		
1978	32.1	33	22	7
Tas.				
1964	36.9	22	3	1
1978R	33.0	46		
1978	34.0	44	8	4

Note: [a] Higher-level students were defined to include the mathematics students for whom the time spent in class on mathematics was more than five hours per week.

168

Table 7.12 Percentage of Population 3 Students Owning and Using Calculators: 1978

	ACT %	NSW %	Vic. %	Qld %	SA %	WA %	Tas. %
Own Calculator	66	66	96	86	89	75	86
Use of Calculator	28	11	79	39	58	32	25

correlation coefficients between the State mean Mathematics Total for the higher-level students and the percentage of these students in the year cohort: -0.40 for 1964 and -0.76 for 1978.

Calculators

The percentages of students owning hand-calculators and of those using them during the IEA testing program have been set out in Table 7.12. The extent to which students used calculators for the tests varied widely across States, and probably reflected State policies in the use of calculators for the public examinations at the Year 12 level. Even where the use of calculators was low, ownership reached a minimum level of 66 per cent. The percentage of students having access to calculators would probably be higher than the percentage owning them. There was a small positive correlation coefficient of 0.31 between the State mean values for the variables Use of Calculator and Mathematics Total. This indicated that States which supported the use of calculators by mathematics students tended to be the States with higher mathematics achievement levels.

Differences Between Students

In order to examine the influence of various factors on performance in mathematics at the student level, a series of regression analyses was conducted. Figure 7.4 presents the variables in the causal model designed to reflect the conceptual framework linking various explanatory factors to the criterion of mathematics achievement.

The following variables were included in the causal model:

X_1 = Father's Occupation (8-point scale)

X_2 = Sex of Student (coded male = 1, female = 2)

X_3 = Class Time (in hours)

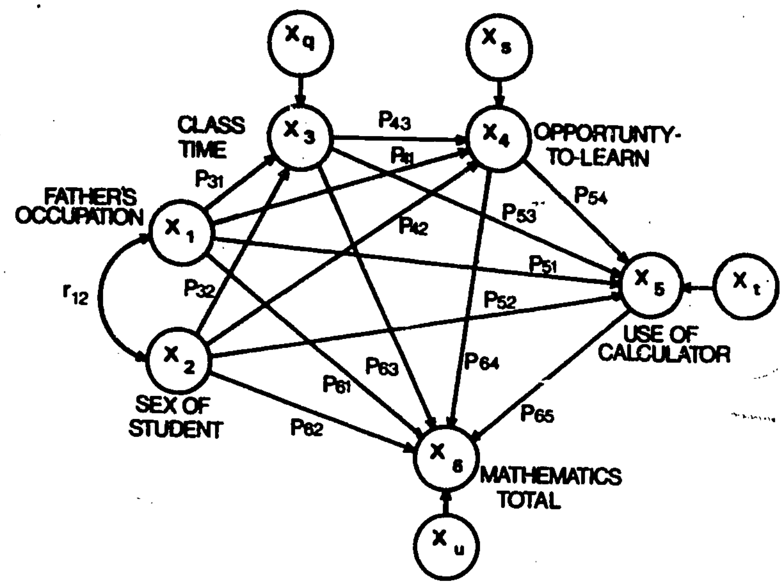


Figure 7.4 Path Diagram for Causal Model of Mathematics Total for Population 3

X_4 = Opportunity-to-Learn (OTL) (Mean score per item in the range 0 to 1)

X_5 = Use of Calculator (coded no = 1, yes = 2)

X_6 = Mathematics Total (test score corrected for guessing)

X_q = disturbance term for Class Time (X_3)

X_s = disturbance term for OTL (X_4)

X_t = disturbance term for Use of Calculators (X_5)

X_u = disturbance term for Mathematics Total (X_6)

The set of structural equations and conditions constraining the model were similar to those described in Chapter 6 for Population 1. There were two differences with respect to the Population 1 model: the variable Year was omitted since all Population 3 students were in Year 12, and the variable Use of Calculator was included at the penultimate stage. The variable Use of Calculator measured whether or not students had used calculators for the IEA mathematics tests. The variable was included in the causal model to examine the effect of the use of the calculator on mathematics achievement. No corresponding data were available for 1964, so the 1964 and 1978 results have been compared by estimating causal models which omitted this variable. The full model was estimated only for 1978.

Table 7.13 Sample Correlation Coefficients for Causal Model of Mathematics Total for Population 3: 1964[ab]

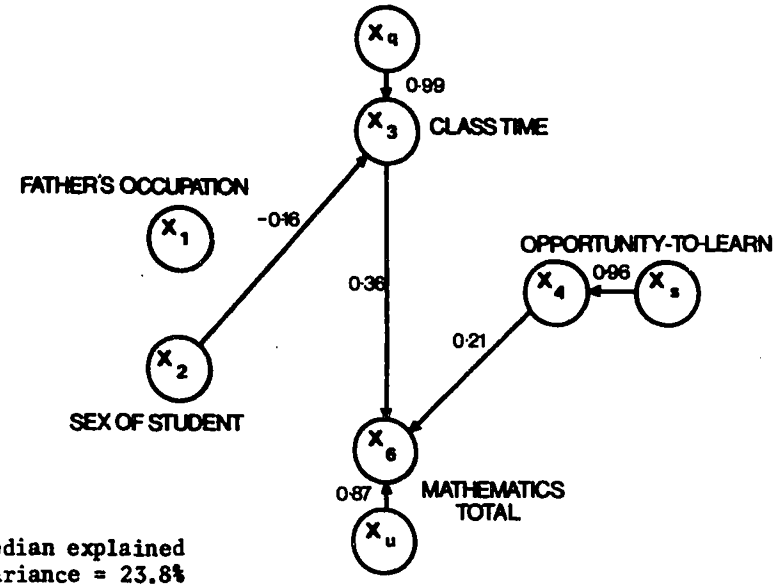
	NSW	Vic.	Qld	WA	Tas.	Median
r_{12}	-0.01	0.08	-0.03	0.13	0.03	0.03
r_{13}	-0.01	0.03	0.08	-0.12	-0.07	-0.01
r_{23}	-0.16	-0.12	-0.39	-0.22	-0.01	-0.16*
r_{14}	0.02	-0.03	0.00	0.00	-0.02	0.00
r_{24}	0.08	-0.27	0.06	-0.02	-0.04	-0.02
r_{34}	0.65	0.12	0.01	0.14	0.32	0.14
r_{16}	-0.02	0.06	0.16	-0.08	0.09	0.06
r_{26}	-0.07	-0.08	-0.08	-0.17	-0.05	-0.08
r_{36}	0.59	0.36	0.36	0.34	0.41	0.36*
r_{46}	0.50	-0.02	0.30	0.24	0.41	0.30*
Sample size	(233)	(176)	(241)	(224)	(197)	

Note: [a] Coefficients sugnificant at the 95 per cent confidence level have been underlined. An asterisk indicates a median value for a coefficient that was significant in a majority of States.

[b] Key to variable numbers: 1 = Father's Occupation, 2 = Sex of Student, 3 = Class Time, 4 = Opportunity-to-Learn, 6 = Mathematics Total.

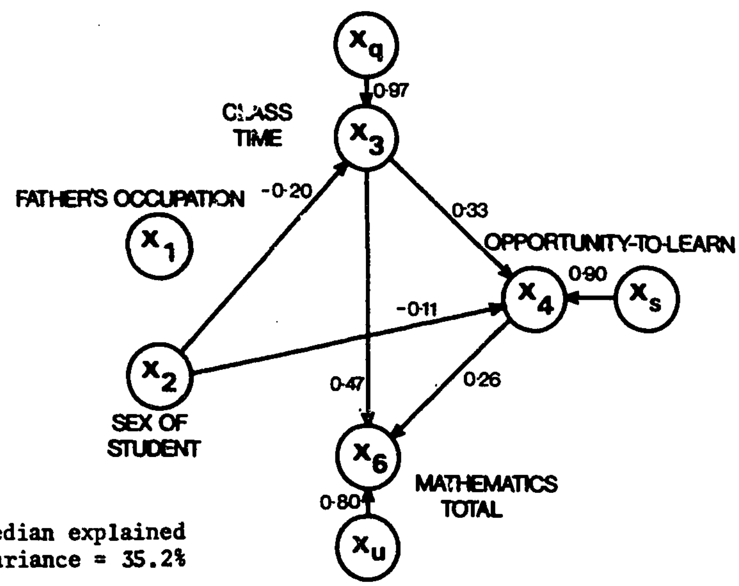
The correlation coefficients between the variables in the model for each of the replicated State samples have been presented in Tables 7.13 and 7.14 for 1964 and 1978 respectively. The path coefficients for the estimation of the models have been given in Tables 7.15 and 7.16, omitting paths associated with the variable Use of Calculator, and in Table 7:17 for the estimation of the full model. In each of these tables coefficients have been underlined where they were significantly different from zero at the 95 per cent level as defined in Chapter 6. The confidence limits for Population 3 were generally wider than for Population 1 due to the smaller number of cases in the samples. Median values have also been included to assist in summarizing the data; these have been marked with an asterisk where the coefficients were significant in a majority of the States. Summary path diagrams have been presented in Figures 7.5 to 7.7.

For 1964 the general causal picture based on the median values showed that Class Time had the major effect on Mathematics Total, operating both



Median explained
variance = 23.8%

Figure 7.5 Path Diagram for Causal Model of Mathematics Total with Median Values of Estimated Path Coefficients for Five States for Population 3: 1964 (excluding Use of Calculator)



Median explained
variance = 35.2%

Figure 7.6 Path Diagram for Causal Model of Mathematics Total with Median Values of Estimated Path Coefficients for Seven States for Population 3: 1978 (excluding Use of Calculator)

Table 7.14 Sample Correlation Coefficients for Causal Model of Mathematics Total for Population 3: 1978[a,b]

	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median
r_{12}	0.04	0.16	0.08	0.01	0.05	0.06	-0.04	0.05
r_{13}	0.18	0.16	0.06	0.09	0.14	-0.03	-0.05	0.09
r_{23}	-0.12	-0.12	-0.29	-0.28	-0.20	-0.26	-0.07	-0.20*
r_{14}	0.13	0.07	0.16	0.13	0.16	0.02	0.01	0.13
r_{24}	-0.04	-0.18	0.26	-0.04	-0.28	-0.27	-0.12	-0.12*
r_{34}	0.49	0.36	0.24	0.26	0.37	0.65	-0.09	0.36*
r_{15}	0.18	0.05	0.13	-0.06	0.06	0.07	-0.02	0.06
r_{25}	-0.03	-0.10	0.07	0.02	0.06	-0.04	0.03	0.02
r_{35}	0.25	0.16	0.07	0.15	0.15	0.14	-0.14	0.15*
r_{45}	0.08	0.13	0.05	-0.09	0.08	0.01	0.07	0.07
r_{16}	0.36	0.17	0.14	0.27	0.18	0.07	-0.02	0.17*
r_{26}	-0.02	-0.10	-0.08	-0.09	-0.11	-0.14	-0.15	-0.10
r_{36}	0.48	0.49	0.54	0.54	0.58	0.65	0.21	0.54*
r_{46}	0.53	0.44	0.36	0.35	0.26	0.57	0.38	0.38*
r_{56}	0.27	0.12	0.14	0.15	0.26	0.16	0.12	0.15*
Sample size	(155)	(623)	(422)	(446)	(378)	(443)	(235)	

Note: [a] Coefficients significant at the 95 per cent confidence level have been underlined. An asterisk indicates a median value for a coefficient that was significant in a majority of States.

[b] Key to variable numbers: 1 = Father's Occupation, 2 = Sex of Student, 3 = Class Time, 4 = Opportunity-to-Learn, 5 = Use of Calculator, 6 = Mathematics Total.

directly on the criterion, and also indirectly through a weak effect on Opportunity-to-Learn. The variable Father's Occupation had no significant effect. The only influence of Sex of Student was on Class Time, where the negative value indicated that the male students spent more time in class on mathematics than the female students.

For 1964 there was generally less similarity in the path coefficients across the States than for Population 1. The overall picture presented by the median values failed to reveal certain important relationships for particular States. For New South Wales, the positive path from Sex of Student to Opportunity-to-Learn indicated that female students had a greater

Table 7.15 Estimated Path Coefficients for Causal Model of Mathematics Total for Population 3: 1964 (excluding Use of Calculator)[ab]

	NSW	Vic.	Qld	WA	Tas.	Median
Sample correlation						
r_{12}	-0.01	0.08	-0.03	0.13	0.03	0.03
Path coefficients						
p_{31}	-0.02	0.04	0.07	-0.10	-0.06	-0.02
p_{32}	-0.16	-0.12	-0.39	-0.21	0.01	-0.16*
p_{41}	0.14	-0.02	0.00	0.01	0.00	0.00
p_{42}	0.19	-0.26	0.08	0.01	-0.03	0.01
p_{43}	0.68	0.09	0.04	0.14	0.32	0.14
p_{61}	-0.02	0.05	0.13	-0.03	0.11	0.05
p_{62}	-0.02	-0.06	0.04	-0.10	-0.03	-0.03
p_{63}	0.46	0.36	0.36	0.29	0.27	0.36*
p_{64}	0.21	-0.07	0.30	0.20	0.32	0.21*
Disburbance terms						
X_q	0.99	0.99	0.92	0.97	1.00	0.99
X_s	0.74	0.96	1.00	0.99	0.95	0.96
X_u	0.79	0.93	0.87	0.91	0.87	0.87
Explained variance	0.375	0.138	0.238	0.165	0.244	0.238

Note: [a] Coefficients significant at the 95 per cent level have been underlined. An asterisk indicates a median value for a coefficient that was significant in a majority of States.

b Key to variable numbers: 1 = Father's Occupation, 2 = Sex of Student, 3 = Class Time, 4 = Opportunity-to-Learn, 6 = Mathematics Total.

opportunity to learn the material covered by the tests, while in Victoria the corresponding path was negative. Queensland was the only State with a significant path from Father's Occupation to the criterion, and also had a strong negative path from Sex of Student to Class Time. For Tasmania, neither Father's Occupation nor Sex of Student had any influence on subsequent variables in the model.

Table 7.16 Estimated Path Coefficients for Causal Model of Mathematics Total for Population 3: 1978 (excluding Use of Calculator)[ab]

	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median
Sample correlation								
r_{12}	0.04	0.16	0.08	0.01	0.05	0.06	-0.04	0.05
Path coefficients								
P_{31}	0.18	0.19	0.08	0.09	0.15	-0.01	-0.05	0.09
P_{32}	-0.13	-0.15	-0.29	-0.28	-0.20	-0.26	-0.07	-0.20*
P_{41}	0.04	0.04	0.11	0.11	0.12	0.05	0.00	0.05
P_{42}	0.02	-0.15	0.35	0.04	-0.23	-0.11	-0.13	-0.11*
P_{43}	0.48	0.33	0.33	0.26	0.31	0.62	-0.10	0.33*
P_{61}	0.27	0.09	0.07	0.20	0.09	0.07	-0.02	0.09
P_{62}	0.02	-0.01	-0.02	0.05	0.01	0.06	-0.09	0.01
P_{63}	0.25	0.37	0.47	0.49	0.55	0.51	0.24	0.47*
P_{64}	0.37	0.30	0.24	0.20	0.04	0.26	0.39	0.26*
Disturbance terms								
X_q	0.98	0.98	0.95	0.96	0.97	0.96	1.00	0.97
X_s	0.87	0.92	0.90	0.96	0.90	0.75	0.99	0.90
X_u	0.77	0.82	0.80	0.79	0.81	0.73	0.89	0.80
Explained variance	0.411	0.333	0.352	0.382	0.349	0.473	0.209	0.352

Note: [a] Coefficients significant at the 95 per cent confidence level have been underlined. An asterisk indicates a median value for a coefficient that was significant in a majority of States.

[b] Key to variable numbers: 1 = Father's Occupation, 2 = Sex of Student, 3 = Class Time, 4 = Opportunity-to-Learn, 6 = Mathematics Total.

The general causal picture for 1978 was similar, although there were two additional significant paths. Class Time was seen to operate indirectly through Opportunity-to-Learn as well as through its direct path to the criterion. There was also a weak negative path from Sex of Student to

Table 7.17 Estimated Path Coefficients for Causal Model of Mathematics Total for Population 3: 1978[ab]

	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median
Sample correlation								
r_{12}	0.04	0.16	0.08	0.01	0.05	0.06	-0.04	0.05
Path coefficients								
p_{31}	0.18	0.19	0.08	0.09	0.15	-0.01	-0.05	0.09
p_{32}	-0.13	-0.15	-0.29	-0.28	-0.20	-0.26	-0.07	-0.20*
p_{41}	0.04	0.04	0.11	0.11	0.12	0.05	0.00	0.05
p_{42}	0.02	-0.15	0.35	0.04	-0.23	-0.11	-0.13	-0.11*
p_{43}	0.48	0.33	0.33	0.26	0.31	0.62	-0.10	0.33*
p_{51}	0.15	0.04	0.12	-0.06	0.03	0.09	-0.03	0.04
p_{52}	0.00	-0.08	0.09	0.07	0.10	-0.02	0.03	0.03
p_{53}	0.26	0.11	0.09	0.21	0.15	0.24	-0.13	0.15*
p_{54}	-0.07	0.08	-0.01	-0.13	0.05	-0.16	0.06	0.05
p_{61}	0.25	0.09	0.06	0.20	0.08	0.07	-0.02	0.08
p_{62}	0.02	-0.01	-0.02	0.04	-0.01	0.06	-0.09	-0.01
p_{63}	0.22	0.37	0.46	0.46	0.53	0.48	0.25	0.46*
p_{64}	0.38	0.30	0.24	0.21	0.03	0.27	0.38	0.27*
p_{65}	0.14	0.01	0.09	0.11	0.17	0.09	0.13	0.11*
Disturbance terms								
X_q	0.98	0.98	0.95	0.96	0.97	0.96	1.00	0.97
X_s	0.87	0.92	0.90	0.96	0.90	0.75	0.99	0.90
X_t	0.84	0.98	0.99	0.98	0.98	0.98	0.99	0.98
X_n	0.76	0.82	0.80	0.78	0.79	0.72	0.88	0.79
Explained variance	0.428	0.333	0.361	0.393	0.378	0.480	0.224	0.378
Additional variance due X_5 Use of Calculators	0.017	0.000	0.009	0.011	0.029	0.007	0.015	0.016

Note: [a] Coefficients significant at the 95 per cent level have been underlined. An asterisk indicates a median value for a coefficient that was significant in a majority of States.

[b] Key to variable numbers: 1 = Father's Occupation, 2 = Sex of Student, 3 = Class Time, 4 = Opportunity-to-Learn, 5 = Use of Calculator, 6 = Mathematics Total.

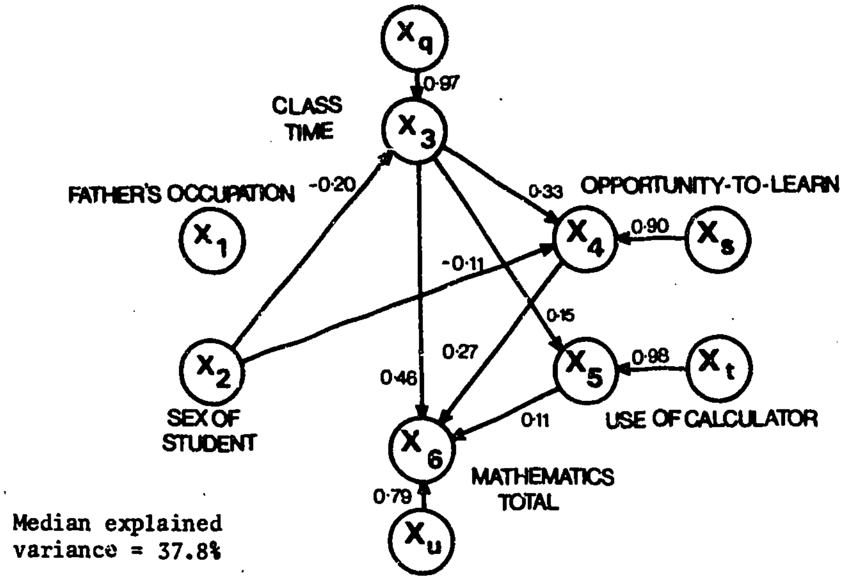


Figure 7.7 Path Diagram for Causal Model of Mathematics Total with Median Values of Estimated Path Coefficients for Seven States for Population 3: 1978

Opportunity-to-Learn, indicating that female students tended to have less opportunity to learn the material covered by the tests, which was also a function of the smaller amount of time they spent in class on mathematics. However, in spite of the negative paths between Sex of Student and explanatory variables, there was no significant direct path from Sex of Student to the criterion. The 1978 model accounted for 35.2 per cent of the explained variance, compared to 23.8 per cent for the 1964 model.

Several interesting relationships were present in the estimated causal models for individual States. In the Australian Capital Territory there was a fairly strong direct path from Father's Occupation to the criterion. Such an association between home background and achievement factors was observed in all States for the Population 1 causal model, due to the heterogeneity of the population of 13-year-old students. The association was not generally present for Population 3, which represented a more selective population. The existence of this path for the Australian Capital Territory was probably a function of its high holding power, and reflected a Year 12 cohort of students with much less selectivity on socio-economic criteria. In New South Wales there was a positive correlation coefficient linking the variables Father's Occupation and Sex of Student. This indicated that the female students studying mathematics came from homes with a higher mean socio-economic status than the male students. Finally, in Victoria there was a strong positive path from Sex of Student to Opportunity-to-Learn, indicating that female students had more opportunity to cover the curriculum reflected by the tests.

The inclusion of the variable Use of Calculator in the estimation of the 1978 model increased the explained criterion variance by a median value of 2.6 per cent. As shown in Figure 7.7 the only effect of the additional variable was to provide an indirect path from Class Time, which indicated that students spending more time in class on mathematics were more likely to have used calculators for the tests, and in turn they had slightly higher test scores.

Summary

In five of the Australian States - New South Wales, Victoria, Queensland, Western Australia and Tasmania - mathematics students in Year 12 were tested on an IEA Mathematics Test in both 1964 and 1978. In each of these States the mean test scores were higher in 1978. During the period under review the percentage of mathematics students in Year 12 relative to the percentage of students at the first secondary year level also increased. In other words, not only were there more Year 12 mathematics students, but they also obtained higher mean scores. This meant that the total 'yield' of mathematics achievement at Year 12 level clearly increased from 1964 to 1978.

Part of the growth in the numbers of Year 12 mathematics students were due to the increased range of mathematics courses. This was accompanied by a wider coverage of mathematics curriculum topics as rated by State curriculum officers. Ratings by the teachers of the students in the samples also indicated an increase in the percentage of students who had the opportunity to learn the aspects of the curriculum covered by the mathematics test items. Thus there was a clear positive relationship between the curriculum to which the students were exposed and their mean mathematics achievement at the State level.

The main factors explaining differences in achievement between individual students were the amount of time spent in class on mathematics by the students, and hence their increased opportunity to learn the type of mathematics covered by the test items. The sex of the student was not directly associated with mathematics achievement, although male students tended to have higher ratings on the two main explanatory factors. There was also a tendency for students who used calculators for the test to obtain higher scores, although these students were generally the ones studying more mathematics in any case.

Overall these results indicate a healthy situation for mathematics at the upper secondary level. The growth in achievement that was recorded from 1964 to 1978 was accomplished over a period when there was a large increase in the percentage of the year cohort who were studying mathematics in Year 12.

CHAPTER 8

STUDENT ATTITUDES TOWARDS MATHEMATICS

Although this study has concentrated on achievement on the IEA mathematics tests as the major outcome of mathematics education at the secondary school level, it is appropriate to pay some attention to student attitudes as an important complementary outcome. This chapter presents results describing changes in attitudes across both populations between 1964 and 1978. The initial section of this chapter discusses student scores on these scales. The latter part of the chapter provides some results on student attitudes derived from the background questionnaires.

From the Opinion Questionnaire completed by the students, five scales were constructed as described in Chapter 4:

1 Descriptive Scale (Mathematics Teaching) measured the students' perception of the tendency of teachers to emphasize problem-solving procedures rather than rote-learning in their teaching.

2 Attitude Scale A1 (Importance of Mathematics) measured students' attitudes to the importance of mathematics for employment or understanding the environment.

3 Attitude Scale A2 (Facility of Mathematics) measured the extent to which student's perceived that mathematics was a subject that could be learnt by most people, rather than being a highly specialized subject.

4 Attitude Scale A3 (School Enjoyment) measured students' liking of school and schoolwork.

5 Attitude Scale A4 (Control of Environment) measured students' opinion of the extent to which people could control their physical and social environment.

The State mean scores on these scales for 1964 and 1978 have been presented in Tables 8.1 and 8.2. The Descriptive Scale (Mathematics Teaching) was not completed by students in Queensland in 1964. These tables also give the mean correlation of each item with the total scale score. More detailed statistics including the percentage of students selecting each of the responses (agree, disagree or neutral) for each item have been included in an associated technical document (Rosier, 1980b).

Table 8.1 Attitude Scale Mean Scores: Population 1

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Mathematics Teaching							
1964		13.3	12.2	a		11.9	12.8
1978R		12.6	12.8	12.7		12.3	12.6
1978	12.6	12.6	12.6	12.6	12.5	12.4	12.6
A1: Importance of Mathematics							
1964		17.2	17.1	16.8		16.9	16.8
1978R		16.0	16.7	16.3		16.2	16.4
1978	15.8	16.0	16.6	16.3	15.6	16.2	16.4
A2: Facility of Mathematics							
1964		18.5	18.8	18.5		18.6	18.1
1978R		18.8	18.8	18.8		18.8	18.7
1978	19.0	18.7	18.8	18.7	18.6	18.8	18.8
A3: School Enjoyment							
1964		19.4	19.6	19.0		19.8	19.4
1978R		18.0	18.5	18.8		18.5	18.5
1978	18.8	18.0	18.5	18.6	18.1	18.6	18.6
A4: Control of Environment							
1964		14.3	14.2	14.1		14.4	14.1
1978R		12.7	12.9	12.8		12.4	13.0
1978	12.8	12.6	12.8	12.9	12.6	12.5	13.0

Note: [a] This scale was not answered by students in Queensland.

In order to facilitate comparisons of the scales across time and across populations, the State mean scores have been expressed in Tables 8.3 and 8.4 as mean standard scores. Since the same scales were used for both populations on both testing occasions, it was possible to base the standardization procedure on the four sets of data, so that the mean standard score was calculated according to the following formula:

$$\text{mean standard score} = \frac{\text{State mean score} - \text{grand mean score}}{\text{grand standard deviation}}$$

where

State mean score = mean value for a given scale score for that State,

Table 8.2 Attitude Scale Mean Scores: Population 3

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Mathematics Teaching							
1964		13.9	13.4	a		12.8	13.6
1978R		12.8	13.3	13.1		12.4	13.8
1978	12.3	13.0	13.0	12.8	13.2	12.5	13.9
A1: Importance of Mathematics							
1964		14.4	13.8	14.4		14.3	15.1
1978R		13.6	14.0	14.2		13.4	14.4
1978	13.3	13.7	13.6	13.9	13.8	13.3	14.2
A2: Facility of Mathematics							
1964		16.1	16.4	16.5		15.8	16.0
1978R		16.7	16.1	16.1		16.7	16.8
1978	16.7	16.6	16.0	16.1	16.4	16.7	16.7
A3: School Enjoyment							
1964		19.4	20.3	19.8		19.7	9.9
1978R		18.4	19.8	18.1		18.0	19.7
1978	18.1	18.6	19.4	17.9	18.4	17.9	19.5
A4: Control of Environment							
1964		13.4	13.0	13.3		13.5	13.1
1978R		11.9	11.9	12.0		11.7	11.7
1978	11.6	11.7	11.8	11.8	12.1	12.0	11.9

Note: [a] This scale was not answered by students in Queensland.

grand mean score = mean of the 20 mean values for that scale score for both Population 1 and Population 3 for the five 1964 State samples and the five 1978 State restricted samples, and

grand standard deviation = mean of the 20 student standard deviation values for that scale score for the same 20 samples.

It should be noted that there were only 18 values available for the calculation of mean standard scores for the scale Mathematics Teaching, since data were not available for Queensland in 1964.

The State mean standard scores have also been presented graphically, together with diagrams showing the mean scores across Australia for the

Table 8.3 Attitude Scale Mean Standard Scores: Population 1

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Mathematics Teaching							
1964		0.14	-0.27	a		-0.38	-0.04
1978R		-0.12	-0.05	-0.07		-0.22	-0.13
1978	-0.13	-0.12	-0.13	-0.11	-0.17	-0.21	-0.13
Change 1978R-1964		-0.26	0.22			+0.16	-0.09
A1: Importance of Mathematics							
1964		0.60	0.56	0.46		0.51	0.47
1978R		0.20	0.46	0.29		0.27	0.32
1978	0.13	0.19	0.40	0.30	0.08	0.27	0.33
Change 1978R-1964		-0.40	-0.10	-0.17		-0.24	-0.15
A2: Facility of Mathematics							
1964		0.39	0.48	0.38		0.42	0.24
1978R		0.51	0.51	0.49		0.49	0.49
1978	0.57	0.47	0.50	0.47	0.41	0.50	0.49
Change 1978R-1964		0.12	0.03	0.11		0.07	0.25
A3: School Enjoyment							
1964		0.06	0.12	-0.03		0.17	0.07
1978R		-0.28	-0.17	-0.09		-0.15	-0.15
1978	-0.08	-0.30	-0.15	-0.13	-0.26	-0.13	-0.14
Change 1978R-1964		-0.34	-0.29	-0.06		-0.32	-0.22
A4: Control of Environment							
1964		0.50	0.48	0.44		0.54	0.42
1978R		-0.14	-0.05	-0.07		-0.24	0.01
1978	-0.08	-0.17	-0.11	-0.06	-0.16	-0.23	-0.01
Change 1978R-1964		-0.64	-0.53	-0.51		-0.78	-0.41

Note: [a] This scale was not answered by students in Queensland.

individual items in the scales at both population levels for the five 1964 State samples and the seven 1978 State total samples.

It was assumed that the same sampling errors applied to the attitude scales as to the test achievement scores. At the Population 1 level this meant that a difference of at least 0.17 between the mean standard scores for a given scale derived from the data from two samples would be needed to establish that there were significant differences at the 95 per cent

Table 8.4 Attitude Scale Standard Scores: Population 3

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Mathematics Teaching							
1964		0.39	0.20	a		-0.06	0.28
1978R		-0.06	0.14	0.08		-0.18	0.37
1978	-0.23	0.02	0.03	-0.04	0.13	-0.15	0.38
Change 1978R-1964		-0.45	-0.06			-0.12	0.09
A1: Importance of Mathematics							
1964		-0.33	-0.54	-0.33		-0.36	-0.10
1978R		-0.61	-0.45	-0.40		-0.68	-0.34
1978	-0.69	-0.57	-0.60	-0.50	-0.52	-0.69	-0.41
Change 1978R-1964		-0.28	0.09	-0.07		-0.32	-0.24
A2: Facility of Mathematics							
1964		-0.52	-0.40	-0.37		-0.63	-0.57
1978R		-0.31	-0.50	-0.52		-0.30	-0.27
1978	-0.28	-0.34	-0.56	-0.53	-0.41	0.31	-0.29
Change 1978R-1964		0.21	-0.10	-0.15		0.33	0.30
A3: School Enjoyment							
1964		0.08	0.30	0.16		0.13	0.20
1978R		-0.18	0.17	-0.26		-0.28	0.14
1978	-0.25	-0.14	0.08	-0.30	-0.19	-0.31	0.10
Change 1978R-1964		-0.26	-0.13	-0.42		-0.41	-0.06
A4: Control of Environment							
1964		0.15	-0.02	0.11		0.20	0.05
1978R		-0.44	-0.44	-0.42		-0.52	-0.52
1978	-0.59	-0.52	-0.50	-0.51	-0.39	-0.43	-0.47
Change 1978R-1964		-0.59	-0.42	-0.31		-0.72	-0.57

Note: [a] This scale was not answered by students in Queensland.

probability level between the corresponding populations on that scale. The corresponding mean standard score difference would be about 0.28 for Population 3.

Student Attitude Scales

There was little variation across the States in the mean scores on the scale Mathematics Teaching for Population 1 in 1978, indicating that differences in State achievement levels were not associated with the opinions of students

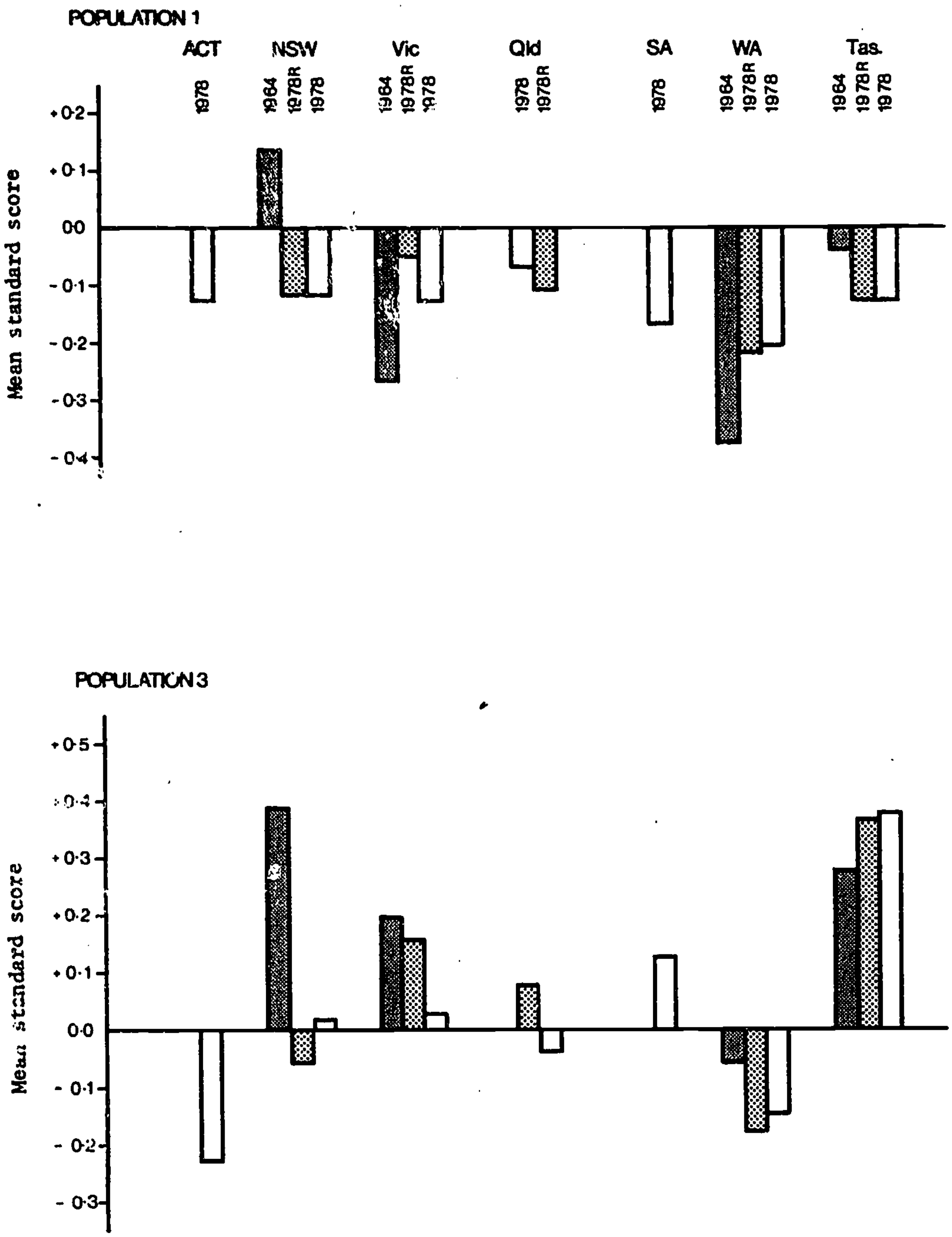


Figure 8.1 <u>Descriptive Scale (Mathematics Teaching) Mean Standard Scores</u>

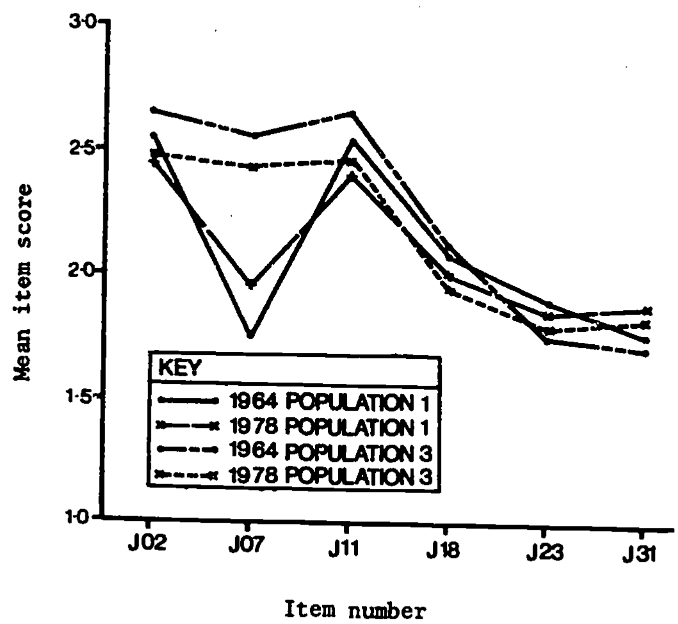


Figure 8.2 Descriptive Scale (Mathematics Teaching) Mean Item Scores

concerning the nature of their mathematics teaching. These mean scores were higher in 1978 than in 1964 in Victoria and Western Australia but lower in New South Wales and Tasmania. At the ·pulation 3 level the State mean scores for Mathematics Teaching were lower in 1978 in New South Wales, Victoria and Western Australia, but higher in Tasmania.

For both 1964 and 1978, the State mean scores for Mathematics Teaching were higher at the Population 3 level than at the Population 1 level, indicating a greater emphasis on the problem-solving approach to mathematics teaching at the upper secondary level. An examination of the mean item scores in Figure 8.2 indicates that the main difference between the two populations was associated with student responses to item J07:

> My mathematics teacher wants students to solve problems only by the procedures he or she teaches.

The Population 3 st ɯents had a higher level of disagreement with this item, indicating that :hey perceived that they had more freedom to solve problems using methods cther than those specified by their teachers.

In each of the five comparable States, the Population 1 students in 1978 obtained lower scores on the scale Importance of Mathematics in 1978 than

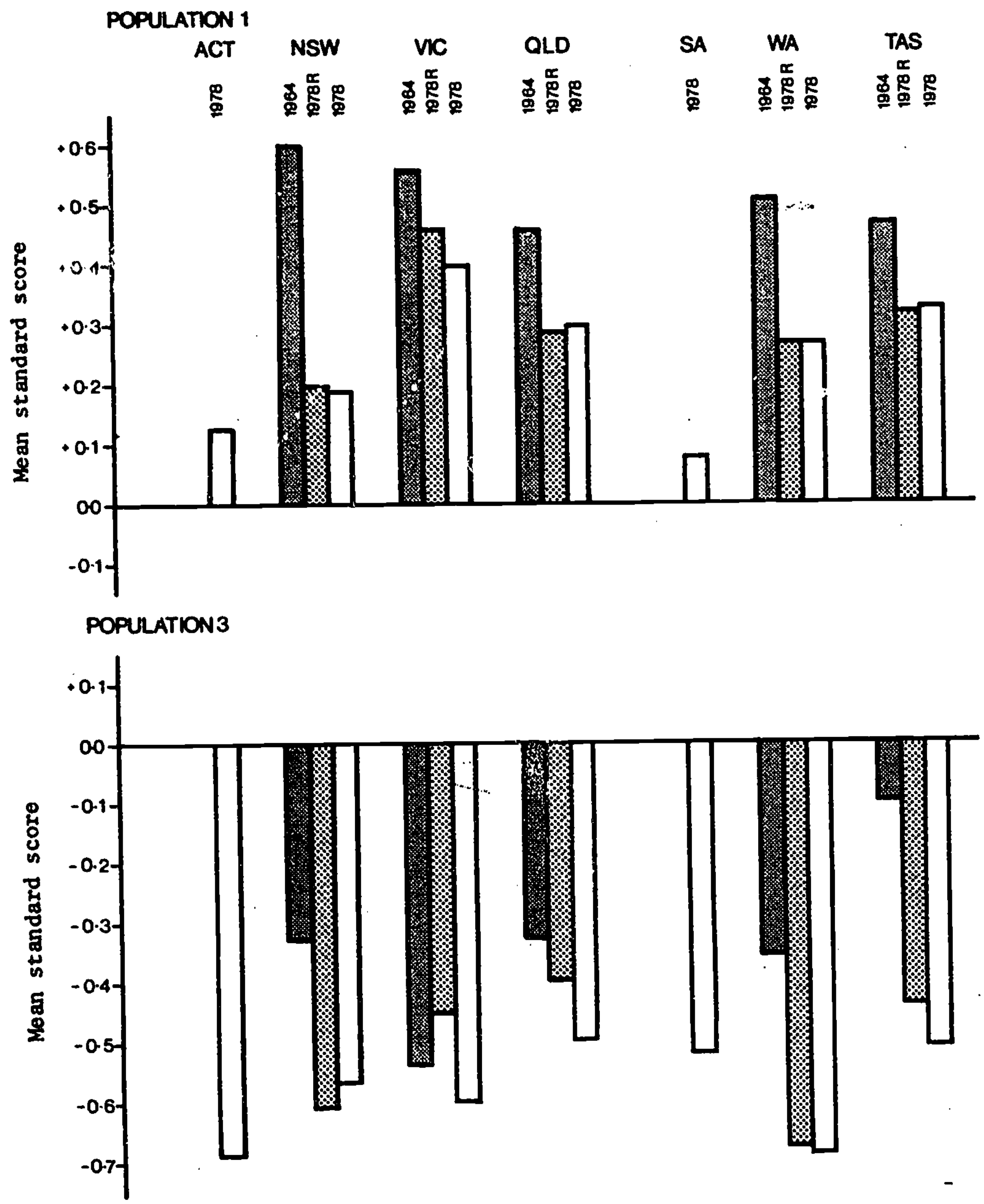


Figure 8.3 <u>Attitude Scale A1 (Importance of Mathematics) Mean Standard Scores</u>

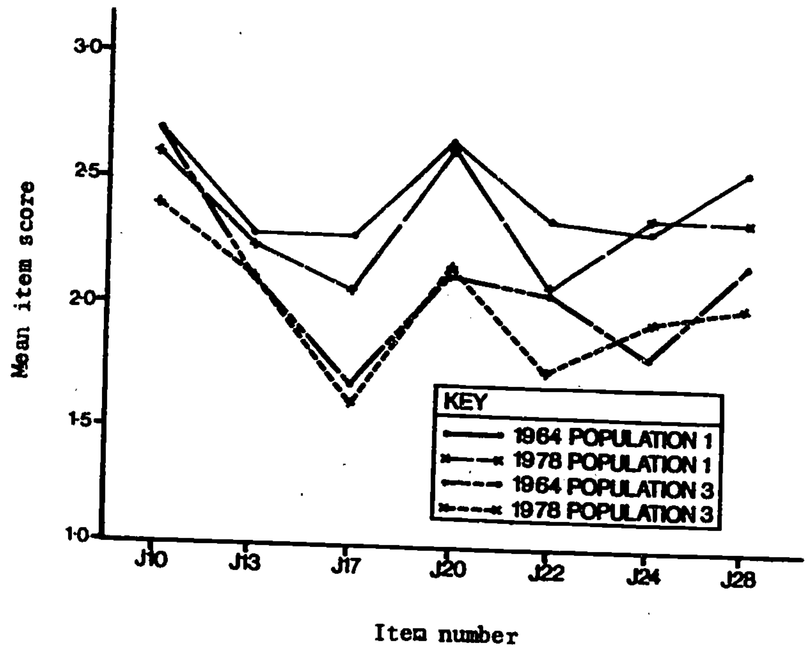


Figure 8.4 Attitude Scale A1 (Importance of Mathematics) Mean Item Scores

in 1964. The same pattern applied for Population 3, except for the 1978 restricted sample in Victoria. The largest decrease in mean item scores was for item J22, indicating that there was a decline in the support for mathematics as a field for creative people to enter. However the mean score for item J24 was higher in 1978 than in 1964 for both populations. By their responses to this item the students in 1978 considered that it was more important to study advanced mathematics if one planned to become a mathematician or scientist. They gave less support to the remaining items which dealt with the importance of mathematics in more general terms.

There was a clear dichotomy between the responses of Population 1 and Population 3 students on the scale Importance of Mathematics. The younger students considered that mathematics was rather important for employment or understanding their environment, while the mean position for the older students was fairly neutral. To some extent the observed difference could have been due to a more sophisticated analysis of the scale items by the Population 3 students, in which they gave support less readily to items where the wording was couched in general terms. Nevertheless, the differences between the populations were so marked that the observed scores clearly reflected real differences in attitude.

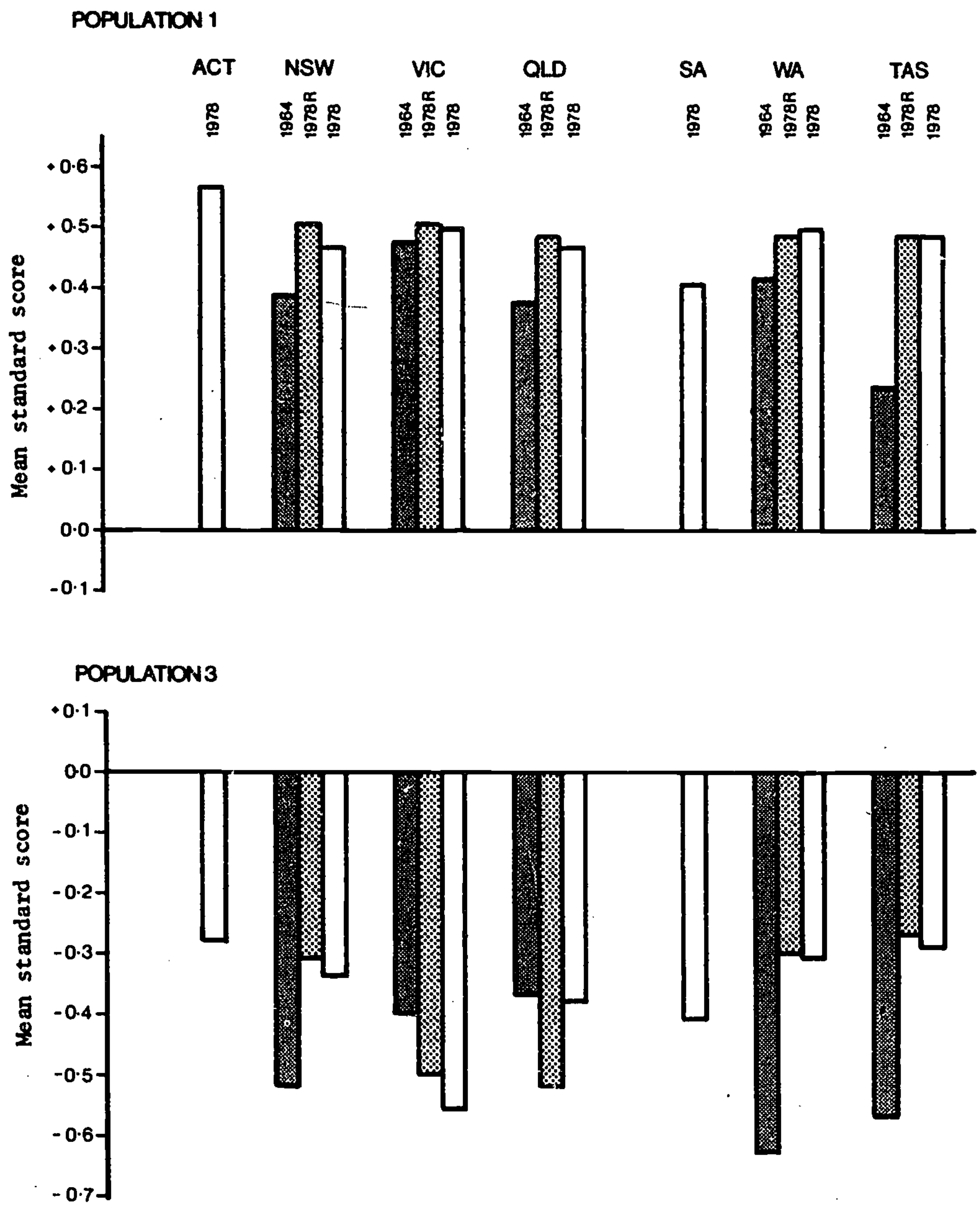


Figure 8.5 Attitude Scale A2 (Facility of Mathematics) Mean Standard Scores

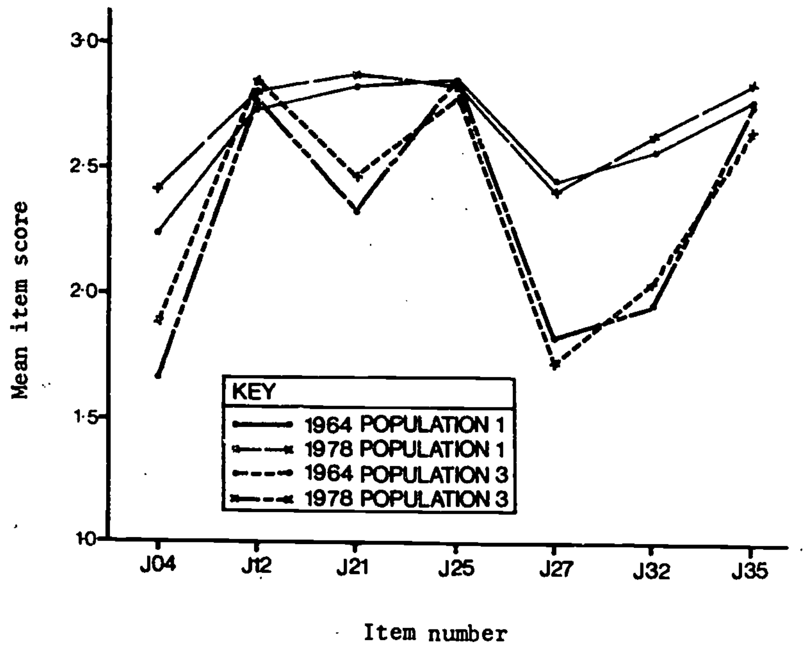


Figure 8.6 Attitude Scale A2 (Facility of Mathematics) Mean Item Scores

At the Population 1 level there were only slight changes between 1964 and 1978 on the scale Facility of Mathematics, with little variation in the State mean scores. At the Population 3 level the changes were also small, resulting in little variation across the States in the mean perception of students concerning the facility of mathematics even though there were marked State differences in the achievement scores.

There was a clear dichotomy between the students in the two populations in their perceptions of the facility of mathematics, with the younger students rating the subject as easier than the older students. The differences between the populations were associated with only four of the seven scale items:

J04 Anyone can learn mathematics.

J21 Almost anyone can learn mathematics if he or she is willing to study.

J27 Even complex mathematics can be made understandable and useful to every high school student.

J32 Almost all students can learn complex mathematics if it is properly taught.

As in the previous scale, part of the differences between the students in the two populations could have been due to the level of sophistication

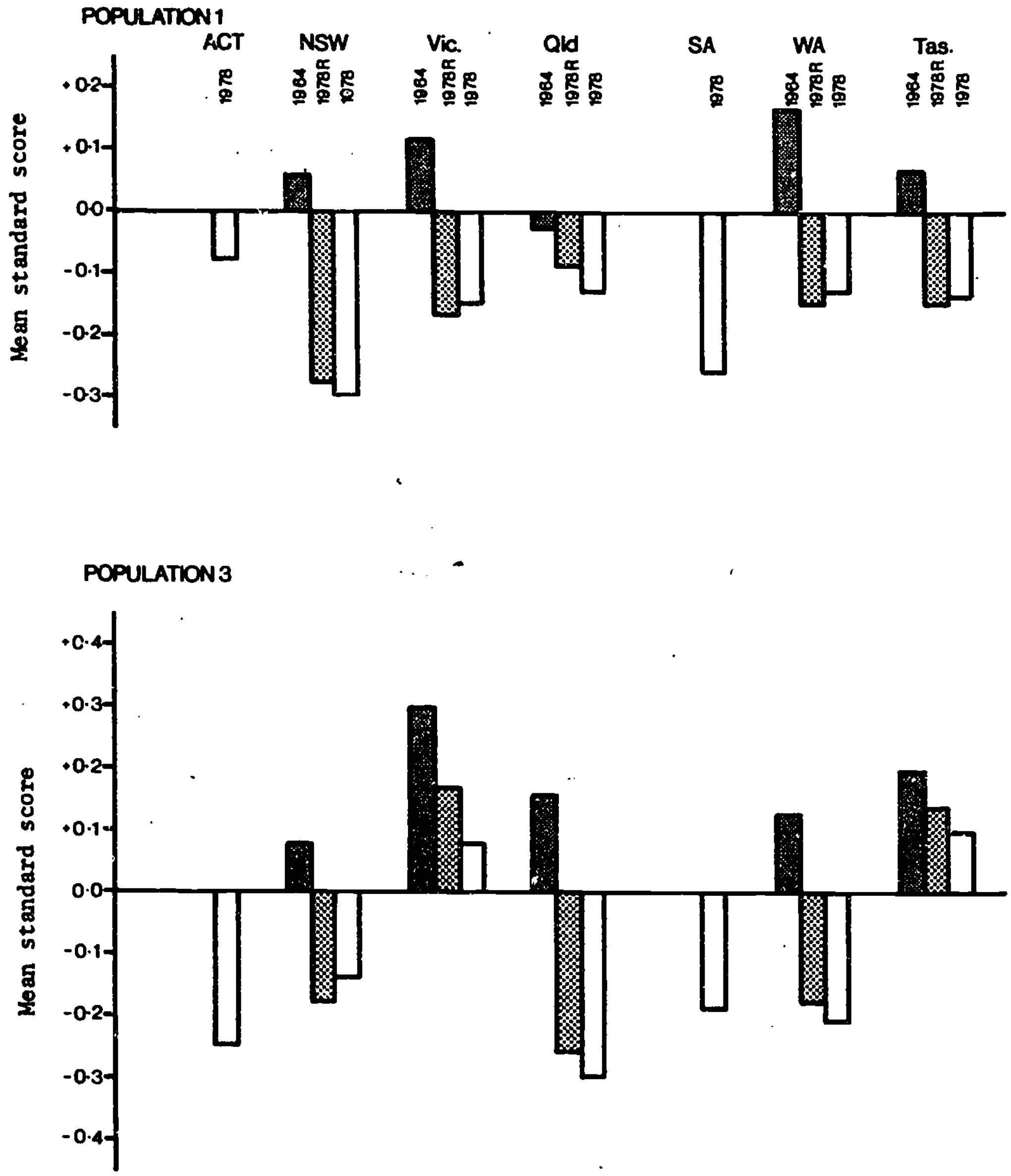


Figure 8.7 Attitude Scale A3 (School Enjoyment) Mean Standard Scores

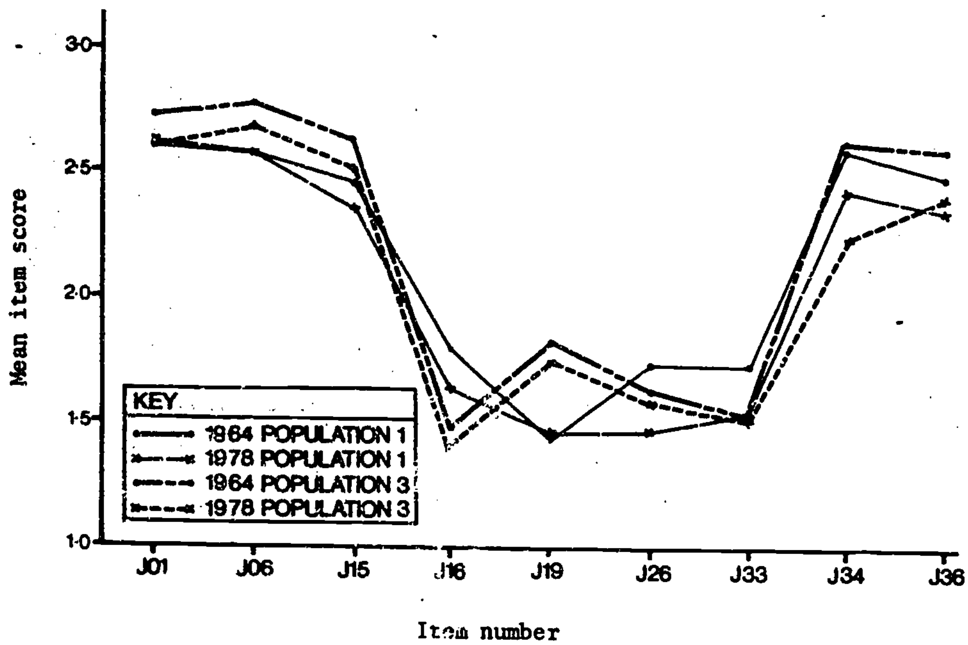


Figure 8.8 Attitude Scale A3 (School Enjoyment) Mean Item Scores

in responding to items worded in general terms. Nevertheless, the evidence indicates that the older students were not so optimistic about the ability of everyone to learn mathematics, at least at the level they were studying it.

The pattern of results for the scale School Enjoyment differed from that for the other scales. For this scale there were no systematic differences across the States between the two populations for either 1964 or 1978. However, for each population there was a decrease in the State mean score on School Enjoyment from 1964 to 1978. The results showed clearly that students enjoyed school less in 1978 than in 1964.

One item of particular interest was J19, where the Population 3 students were more strongly in agreement with the statement:

> School is not very enjoyable but I can see value in getting a good education.

This suggested that these students held a more utilitarian view of the purposes of schooling than the Population 1 students.

Finally, the results for the scale Control of Environment were very clear and unambiguous. For both populations there was a dramatic decrease in the students' perception of man's ability to control his physical and

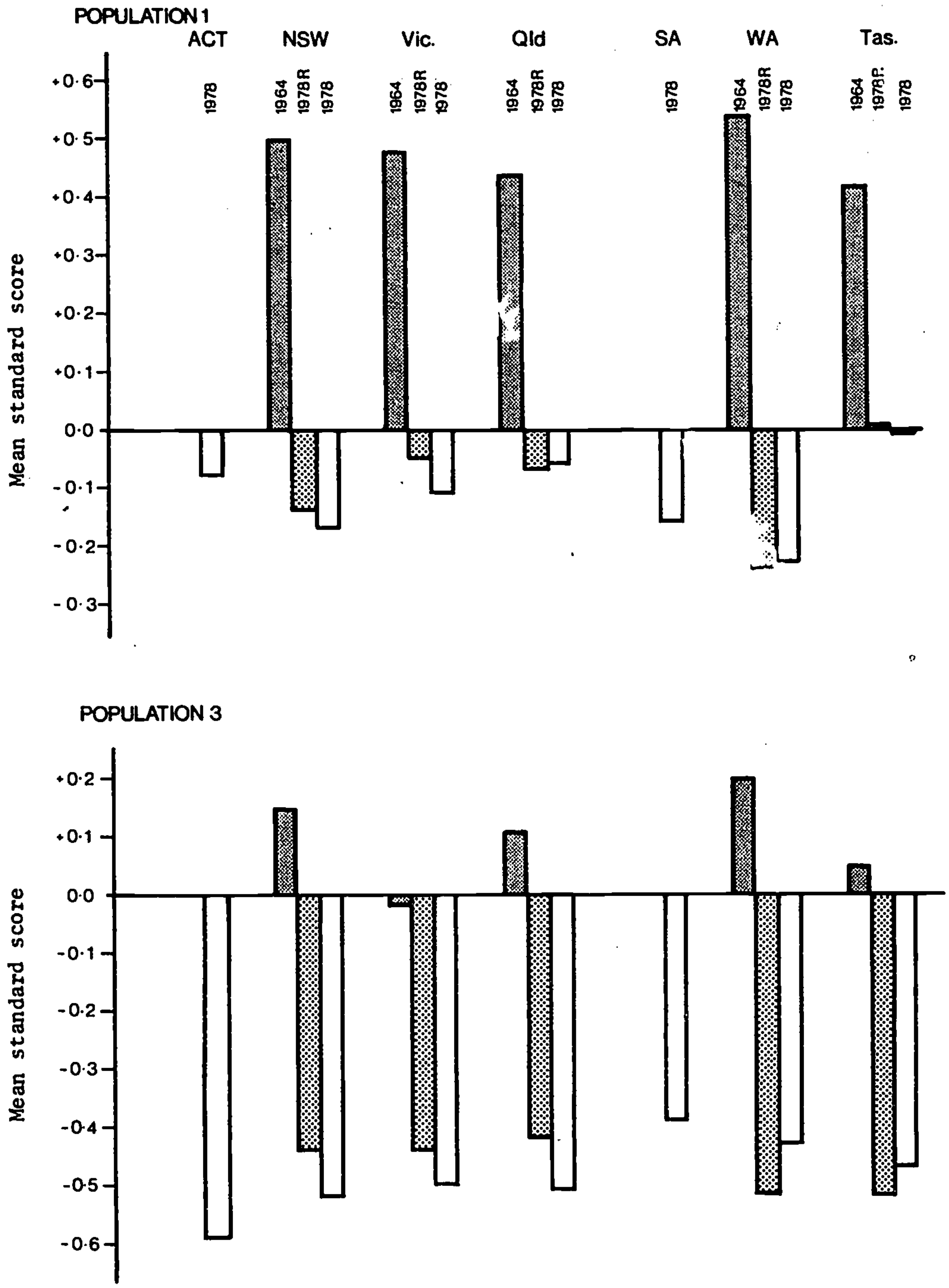


Figure 8.9 Attitude Scale A4 (Control of Environment) Mean Standard Scores

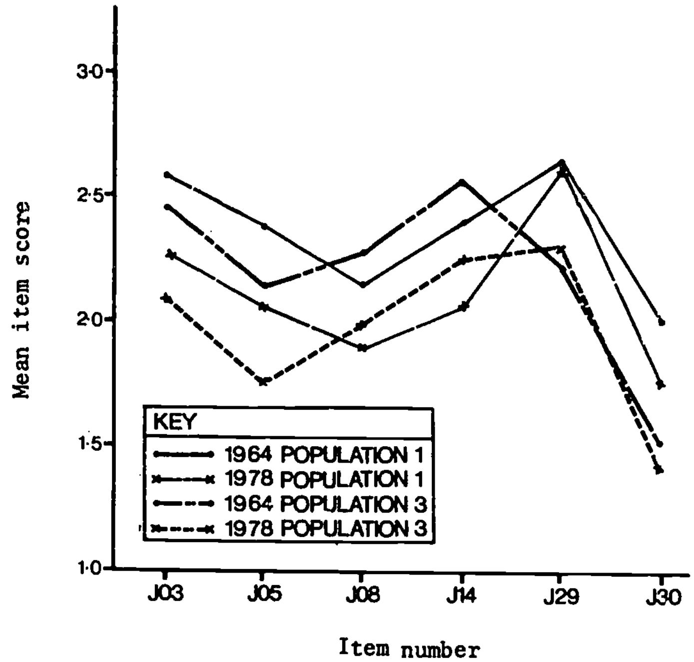


Figure 8.10 Attitude Scale A4 (Control of Environment) Mean Item Scores

social environment. However there was virtually no change in the responses to item J29:

With hard work anyone can succeed.

At the same time there was a marked decrease from the State mean values for Population 1 to the corresponding values for Population 3 in each of the 1964 and 1978 samples. The largest difference in mean item score between the populations was for item J30:

Almost every human problem will be solved in the future.

The older students were obviously less prepared to give agreement to this optimistic general statement.

Student Liking of Mathematics and Results in Mathematics

The attitude of students to mathematics was assessed by direct questions about their liking of the subject relative to other subjects in the curriculum. In the 1964 study students were presented with a list of more than 50 school subjects, including about 20 different mathematics subjects. They were asked to indicate which two subjects on the list they liked most, and which two subjects they liked least. The mean responses for the five States in the 1964 samples have been given in Table 8.5 for Population 1 and Table 8.6 for Population 3. The term 'high liking' for the 1964 samples refers to the percentage of students naming a mathematics subject as at least one of the two subjects they liked most. The term 'low liking' refers to the percentage naming a mathematics subject as at least one of the two subjects liked least.

A different approach to obtaining this information was adopted in the 1978 testing program in order to focus more specifically on mathematics and avoid the preparation of a long list of mathematics subjects. The following item K24 was included in the General Information Questionnaire:

How does your liking for mathematics compare with your liking for other subjects studied at school?

A Mathematics is one of my favourite subjects.
B I have generally liked mathematics.
C I have generally disliked mathematic- .
D Mathematics is one of the subjects I have liked least at school.

In Tables 8.5 and 8.6 the term 'high liking' for the 1978 samples refers to the percentage of students selecting response A. The term 'low liking' refers to the percentage selecting response D.

For 1964 and 1978 the mean percentages of students with a high liking for mathematics were generally higher at the Population 3 level than at the Population 1 level in all States, probably due to the elective nature of mathematics courses at the higher level in contrast to the compulsory nature at the lower level.

These data could be used to investigate changes from 1964 to 1978 as long as due attention was paid to the different questions on which the data were based.

For Population 1 the mean percentages of students with a high liking for mathematics were about the same on both occasions in New South Wales, Victoria, Queensland and Tasmania, and lower in Western Australia. On the other hand there were smaller percentages with a low liking for mathematics in all five States in 1978. The net effect was a general tendency for students' liking for mathematics to increase. There was certainly no clear evidence of a deterioration in their attitude to mathematics.

In 1978 there were lower mean percentages of the Population 3 students indicating a high liking for mathematics, associated in all States except Tasmania with lower mean percentages having a low liking for mathematics. This indicated a reduced polarization of mathematics students in terms of their liking for the subject. It may have reflected the wider range of courses available, and hence the increased possibility for the students to take courses suited to their interests and ability. These results did not provide evidence of any general decline in students' liking of mathematics.

Table 8.5 Liking for Mathematics: Population 1

	ACT %	NSW %	Vic. %	Qld %	SA %	WA %	Tas. %
1964							
High liking		21	19	17		33	13
Low liking		26	34	27		36	37
1978R							
High liking		16	22	21		20	15
Low liking		18	15	13		19	13
1978							
High liking	14	17	23	20	18	21	16
Low liking	15	18	15	14	17	17	14

Table 8.6 Liking for Mathematics: Population 3

	ACT %	NSW %	Vic. %	Qld %	SA %	WA %	Tas. %
1964							
High liking		43	55	33		29	54
Low liking		27	17	50		32	6
1978R							
High liking		27	41	22		22	22
Low liking		15	4	16		13	10
1978							
High liking	18	32	33	22	26	20	24
Low liking	16	12	7	17	9	14	9

The students were also asked to give their own assessment of their level of mathematics performance. In the 1964 study the students were asked to indicate which two subjects on the list provided were the ones in which they did best (or got the highest marks), and which were the two on which they did worst (or got the lowest marks).

Tables 8.7 and 8.8 present the State mean responses for Population 1 and Population 3. The term 'good results' for the 1964 samples refers to the percentage of students naming a mathematics subject as at least one of the two subjects on which they did best. The term 'poor results' refers to the percentage naming a mathematics subject as at least one of the subjects on which they did worst.

In 1978 the corresponding information was obtained from student responses to the following item K25 in the General Information Questionnaire:

> How do your test or exam results in mathematics compare with your results in other subjects studied at school?
>
> A Mathematics is usually one of my best subjects.
> B My mathematics results are usually about average.
> C Mathematics is usually one of my worst subjects.

In Tables 8.7 and 8.8 the term 'good results' for the 1978 samples refers to the percentage of students selecting response A. The term 'poor results' refers to the percentage selecting response C.

There was a tendency for the State mean percentages of Population 1 students with good results in mathematics to be lower in 1978, but also for the percentages with poor results to be lower. This suggested that there was less polarization of students in terms of their performance in mathematics. The results for mathematics achievement presented in Chapter 6 showed that the percentage of students with low scores on the IEA Mathematics Test increased from 1964 to 1978, particularly in Victoria. The results given here indicate that only a small percentage of the students in 1978 considered that they had poor results in mathematics relative to other subjects. One way of resolving the apparent inconsistency of these results would be to assume that in 1978 there were large percentages of students at low levels of performance in other subjects apart from mathematics, but this assumption could only be tested by collecting appropriate evidence.

At the Population 3 level the State mean percentages of students with good results decreased from 1964 to 1978 in New South Wales, Victoria, Queensland and Tasmania, but increased in Western Australia. The percentages with poor results decreased in four of the five States, Tasmania being the

Table 8.7 Student Rating of Mathematics Results: Population 1

	ACT %	NSW %	Vic. %	Qld %	SA %	WA %	Tas %
1964							
Good results		36	35	31		51	27
Poor results		28	44	38		45	40
1978R							
Good results		30	33	24		28	28
Poor results		19	13	20		18	16
1978							
Good results	26	31	33	26	32	29	31
Poor results	16	18	13	19	16	18	15

Table 8.8 Student Rating of Mathematics Results: Population 3

	ACT %	NSW %	Vic. %	Qld %	SA %	WA %	Tas. %
1964							
Good results		53	66	41		34	67
Poor results		37	39	57		43	17
1978R							
Good results		46	41	37		38	25
Poor results		17	14	26		20	26
1978							
Good results	30	40	36	36	30	33	27
Poor results	27	18	18	26	19	23	25

exception. As in the case of the corresponding results about students' liking of mathematics, these results suggest a reduced polarization of mathematics students with respect to their performance.

Summary

Student attitudes on several topics related to mathematics were assessed using identical scales at both population levels in 1964 and 1978. In 1978 there was a considerable degree of consistency in the Population 1 mean scores across the States on most of the scales: Mathematics Teaching, Facility of Mathematics, School Enjoyment and Control of Environment. This lack of variation across the States meant that the observed differences in mathematics achievement at the State level could not readily be explained in terms of differences in attitudes.

It was recognized that the results presented in this chapter were based on fewer items than generally used in such attitude scales. It was also possible that some of the observed differences across time and across levels of the secondary school were associated with increasing levels of sophistication in responding to the types of statements in the scales. Nevertheless, most of the findings reported here were consistent across the States, and were considered to represent marked shifts in the attitudes of students to the mathematics they were learning and the schools they were attending.

CHAPTER 9

SUMMARY AND CONCLUSION

Since the early 1960s there have been many changes in mathematics education at the secondary school level in Australia, although little effort has been expended on documenting these changes. However, Australia was in the fortunate position of possessing data on the mathematics achievement of students at the lower and upper secondary levels in 1964, arising from its participation in the First IEA Mathematics Study. It was therefore decided to conduct a second testing program to collect similar data in 1978. This report has presented the results from these two studies as a contribution to the important process of continuing to monitor changes in achievement of students in Australian schools.

For the first IEA Mathematics Study in 1964 and the Second IEA Mathematics Study in 1978 two target populations were defined. Population 1 referred to 13-year-old students in Years 7 to 9. Population 3 contained students in Year 12 who were studying mathematics as an integral part of their course, with the intention of undertaking further studies involving mathematics at the tertiary level. Both populations in 1964 were limited to students in government schools in five States: New South Wales, Victoria, Queensland, Western Australia and Tasmania. In 1978 the populations covered students in both government and non-government schools in all six States and the Australian Capital Territory. In order to enable comparisons between 1964 and 1978, sub-sets of the students in the 1978 samples were designated the 1978 'restricted' samples, containing only the students in the government schools in the five States with comparable data.

The instruments used in the 1964 testing program were also used, with only minor modifications in 1978. At the Population 1 level the IEA Mathematics Test contained 65 items answered by students on both occasions. The items in the test were originally selected by IEA after careful examination of the pattern of the mathematics curriculum across the 12 countries which participated in the First IEA Mathematics Study. It was possible to classify these items in terms of content areas: arithmetic, algebra, geometry and new mathematics. The items were also classified according to underlying teaching processes: computation, knowledge, translation and comprehension. For the complete test of 65 items a

Mathematics Total score was calculated for the items in the various content and process categories. As part of the testing program information was also collected on student background characteristics and attitudes, and on teacher and school background characteristics. Similar information was collected at the Population 3 level, where the IEA Mathematics Test contained 69 items common to the two testing programs. The teaching process categories were the same as for Population 1 although there was a different set of content categories.

Results for 13-year-old Students

As measured by the IEA Mathematics Test, there was a slight overall decline from 1964 to 1978 in the mathematics achievement of 13-year-old students in Australia. The mean score on the test increased slightly in Western Australia and decreased in the other four States. These results provided no support for the view that there had been a serious or widespread decline in the mathematics performance of students in this age-group.

As well as examining the scores for the total test, it was possible to examine the scores of various sub-tests, composed of items grouped according to various curriculum content areas. In general, the sub-test scores for arithmetic and algebra showed only a moderate decrease from 1964 to 1978, while the geometry sub-test scores displayed a more marked decrease. On the other hand, the sub-test measuring new mathematics content showed little change over this period. Sub-tests were also created to measure various teaching process emphases: computation, knowledge, application and comprehension. There was a slight tendency for scores to be lower in 1978 than in 1964 for each of these categories. There was no evidence to indicate improved performance at the higher levels of this hierarchy of skills, although such improvement was one of the aims behind the changes in the curriculum in the 1960s. At the same time, there was no evidence of a marked decline in skills of computation.

The test scores were also analysed by examining the percentage of students obtaining particular scores, arranged in 5-item bands. This analysis revealed a tendency for the percentage of students with lower scores to increase from 1964 to 1978. The increase in the percentage of low-scoring students was more marked for the students in government schools than in non-government schools. There was also a tendency for the percentage of students with higher scores to decrease, but this was less marked than at the lower end of the distribution.

In order to explain the observed changes in mathematics achievement, various curricular and structural factors were examined, although the scope for explanation was limited by the relatively small changes in the criterion. One proposition underlying this study was that changes in mathematics performance would be associated with changes in the context within which the teaching took place. A major component of this context was the curriculum, which was considered to consist of three sequential stages: the intended curriculum as specified by authorities in the educational system, the translated curriculum representing the detailed implementation of the intended curriculum by the teachers, and student performance demonstrating the extent to which students achieved the intended curriculum.

The intended curriculum was measured by means of Curriculum Content scores indicating the extent to which the test or sub-tests reflected the curriculum studied by the students. The translated curriculum was measured by means of Opportunity-to-Learn scores indicating the extent to which teachers provided students with the opportunity to learn the types of problems in the tests or sub-tests, although these scores were available only for 1978. The achieved curriculum was measured by the test scores.

The expected relationship between the intended curriculum and the achieved curriculum was not observed in 1964, since the States with higher Curriculum Content scores (Victoria and Tasmania) were not the States with higher test scores (especially Queensland). These Victorian and Tasmanian Curriculum Content scores probably reflected mathematics curricula at a more advanced level of revision than in the other States. These findings suggested that a balanced relationship between the stages of the curriculum sequence could only be observed in a stable system. The introduction of changes to the intended curriculum would probably disturb the balance. It would be necessary to allow sufficient time for the balance to be restored before the expected relationship could be observed. By 1978 the situation had altered. Sufficient time had elapsed since the curriculum changes of the 1960s. A stable relationship between the stages of the curriculum sequence was observed in 1978. There were positive correlations between the indices of the intended curriculum, translated curriculum and achieved curriculum. Unfortunately, due to the assumed unstable situation in 1964, it was not possible to relate changes in the mathematics achievement from 1964 to 1978 to changes in the intended curriculum.

In 1978 there was relatively little variation across the States in the Curriculum Content scores and Opportunity-to-Learn scores. This indicated a fairly high level of consensus across Australia with respect to the nature of the intended curriculum and the translated curriculum.

The importance of the curriculum as a factor in explaining achievement at the State level lies in its malleability. The underlying objectives of the intended curriculum and the specifications of content can be readily changed by the authorities in a State education system who are responsible for ensuring that the desired outcomes of the system are attained. The implementation of changes in the intended curriculum depends on the willingness and ability of the teachers, which implies an associated program for training teachers to teach the revised curriculum. The intended curriculum in Australia has traditionally been specified by authorities at the State level, although there have been recent moves to define the intended curriculum at the level of individual schools, which in turn implies that the schools themselves should be willing and able to provide for training to enable teachers to implement the changes.

In addition to the intended curriculum, there are other characteristics of the education systems which influence the mathematics achievement of students at the State level, although these characteristics have varying levels of malleability. Between 1964 and 1978 there was a decrease in the percentage of 13-year-old students in Year 7 and an associated increase in the percentage in Year 8. In most States the percentage in Year 9 also decreased. Thus the contribution of students in Year 8 to the mean test score for the State was greater in 1964 than in 1978. These changes in the distribution of students across year levels meant that a higher percentage of the 13-year-old students in 1978 was exposed to the curriculum being taught at higher year levels. This did not appear to be associated with higher mathematics achievement, indicating that increased exposure to the curriculum content did not necessarily result in increased performance.

The distribution of the 13-year-old students across year levels is a malleable characteristic of an education system that can be modified gradually by changes in policies concerning promotion from one year level to the next. In response to a growing awareness among educators and in the community of the psychological context of education, there was a tendency between 1964 and 1978 to develop policies of promoting students each year in order to keep students with their age-defined peer group. This policy reduced the percentage of students repeating particular year levels, and also reduced the amount of accelerated promotion. Although the association between achievement and the distribution of students across year levels should be noted by authorities responsible for developing policies on promotion, it was recognized that these policies should basically be justified on grounds other than their effects on achievement.

In practice, the distribution of students across year levels changes relatively slowly. A wider scope for intervention by policy-makers in factors associated with achievement is offered by the time allocated in class to the various subjects in the curriculum. The study showed that the amount of time spent in class on mathematics in Years 7 to 9 declined from 1964 to 1978. It was considered that this change was responsible, at least in part, for the observed decline in mathematics achievement.

In addition to examining the differences in mean mathematics achievement across the States, analyses were conducted to examine differences between the students in each of the States. In effect, the same analysis was replicated in the different State education systems to strengthen the generalizations that could be made. In order to summarize the large amount of information available in factors that might explain differences between students in terms of their achievement, a simple causal model was proposed. The earliest stage in the causal sequence was represented by an index of the socio-economic level of the home (the occupation of the student's father) and the sex of the student. The next stage in the sequence was the year level of the student, which in turn determined the amount of time spent in class on mathematics by the student. The final explanatory factor was the teacher's rating of the student's opportunity to learn the types of problems in the tests. The criterion for the model was the student's score on the IEA Mathematics Test.

In 1964 (for which unfortunately there were no data on the opportunity-to-learn ratings) the year level had the strongest direct influence on mathematics achievement. The only other important factor was the father's occupation which exerted its influence directly on the criterion as well as indirectly by means of its influence on the year level. The time spent in class on mathematics decreased as the year level increased, making allowance for the earlier factors in the sequence, the class time did not make any significant contribution to the explanation of the differences in mathematics achievement between students. The corresponding picture for

1978 was similar, with father's occupation and the year level exerting the main influence on mathematics achievement. The path from the year level to the class time was no longer significant, but the class time did have a weak direct influence on the criterion.

Further insight into the network of relationships in the model for 1978 was provided by including the opportunity-to-learn ratings. The influence of the year level on the criterion was then seen to operate primarily through its influence on the student's opportunity to learn the type of problems in the test. An important additional result was that part of the influence of father's occupation on achievement operated by means of its association with the opportunity-to-learn ratings. With the addition of the opportunity-to-learn ratings, the path from the class time to the criterion fell below the significance level.

The results from the model demonstrated one important general negative finding. The sex of the students was not significantly associated with any other factors in the model. There was no general pattern to suggest that female students spent less time in class on mathematics or had less opportunity to learn the curriculum or obtained lower test scores.

Results for Year 12 Mathematics Students

The State education systems were placed under great pressure during the period from 1964 to 1978 due to a doubling in student enrolments across Australia at the Year 12 level. This represented an increase from 22 per cent of the year cohort (defined in terms of the enrolment at the beginning of the secondary school) in 1964 to 35 per cent in 1978. The number of Year 12 mathematics students increased at approximately the same rate, from 13 per cent of the year cohort in 1964 to 21 per cent in 1978.

In spite of the increase in the number of mathematics students, the State mean scores on the IEA Mathematics Test at the Population 3 level increased from 1964 to 1978 in the five States with comparable data over this period. This meant that the total yield of the State systems increased from 1964 to 1978, where the term 'yield' was used as a measure of the achievement level which also took into account the percentage of persons in the year cohort who were studying Year 12 mathematics. This general increase in yield did not occur at the expense of the more able mathematics students. The percentage of Year 12 mathematics students in the year cohort who achieved high scores on the IEA Mathematics Test was higher in 1978 than in 1964.

Three sets of indices were prepared to measure the stages in the curriculum sequence: Curriculum Content scores to measure the intended curriculum, Opportunity-to-Learn scores to measure the translated curriculum and test scores to measure the achieved curriculum. For each of the five States which participated in both testing programs there was a consistent relationship between the Curriculum Content score, the mean Opportunity-to-Learn score and the mean test score for the total test. Thus mathematics achievement at the State level was positively associated with the two earlier stages in the curriculum sequence. In addition the relationship generally held for the various content sub-tests, so that increases and decreases in State mean achievement in particular content areas were seen to be linked to corresponding changes in the curriculum.

In addition to the mathematics curriculum, other background factors were examined for their influence on mathematics achievement at the State level. The mean amount of time spent in class on mathematics decreased from 1964 to 1978 in New South Wales, Queensland and Victoria. However, there were increases in Western Australia and Tasmania from fairly low levels in 1964, so that by 1978 there was little variation across the five States on this characteristic. At the same time there were decreases in all of these States in the amount of time spent on mathematics homework, so that a smaller mean amount of time in total was spent on mathematics in each State. Since the mathematics achievement increased in each State, the amount of time spent on mathematics did not contribute to an explanation of changes in achievement.

Finally, one major change between 1964 and 1978 was the introduction of relatively inexpensive electronic hand-calculators. They were not available in 1964, but by 1978 were owned by a majority of the Year 12 mathematics students. The extent to which the calculators were used by the students in the 1978 testing program varied widely across the States, from 11 per cent in New South Wales to 79 per cent in Victoria. This variation probably reflected policies for the use of calculators in Year 12 examinations in the various States. There was a slight tendency for the mean mathematics achievement to be higher in States where calculators were used.

A simple causal model was used as the basis for examining differences in mathematics achievement between students. In the model, which was similar to the one applied at the Population 1 level, the occupation of the student's father and the sex of the student were the explanatory factors proposed for the earliest stage. The succeeding explanatory factors involved the time spent in class on mathematics, the teacher's rating of the student's opportunity to learn the curriculum content covered by the test, and the student's use of a calculator during the testing program. The criterion was the student's score on the IEA Mathematics Test.

The general results from the model for 1964, for which there were no data on the student's use of a calculator, showed that the main effects on Mathematics achievement were due to the time spent on mathematics and the student's opportunity to learn the curriculum content, although these two factors were not themselves associated. The occupation of the student's father was not associated with any other factors in the model. The sex of the student was directly associated only with the measure of class time, so that male students tended to spend more time in class on mathematics. There was no direct effect of the sex of the student on the criterion, so that differences in achievement between male and female students could only be attributed to differences in the amount of time spent on the study of the subject.

The corresponding results for 1978 were similar, although in this case the amount of time in class was positively associated with the student's opportunity to learn the curriculum content. The sex of the student was also linked to this factor so that the higher mathematics achievement scores of the male students were associated with their higher levels of time spent on mathematics and associated greater opportunity to learn the subject. The addition to the 1978 model of information about the student's use of a calculator resulted in a slight increase in the variance explained by the model. Students spending more time on mathematics tended to make greater use of calculators, with a consequent tendency to obtain higher test scores.

Student Attitudes

The attitudes of students to their schooling represent important outcomes of the education system which complement the major achievement outcomes. The Population 3 students perceived that their teachers emphasized a problem-solving approach to teaching rather than one based on following procedures specified by the teachers. The Population 1 students reported slightly less emphasis on the problem-solving approach, although by 1978 there was little variation across the States on the mean scores for the scale measuring this attitude.

The Population 1 students considered that a knowledge of mathematics was rather important for employment or an understanding of the environment. The Population 3 students had lower mean ratings on this scale, reflecting a more neutral view of the importance of mathematics. For both populations, mathematics was considered to be less important in 1978 than in 1964.

There was a clear dichotomy between the Population 1 and Population 3 students in their perception of the facility of mathematics, in terms of the extent to which the subject could be learnt by most people, and not merely reserved for those with special skills; the younger students considered that the subject was much easier. There was little change from 1964 to 1978 in the attitudes of the respective populations on this scale.

Students were also asked about their general liking of school and schoolwork, without particular reference to mathematics. There were no systematic differences between the two populations in either 1964 or 1978. However, for each of the populations there was a marked decrease in scores on this scale over this period. Students clearly enjoyed school less in 1978 than in 1964.

Since mathematics is often regarded as a subject basic to science and technological development, students were asked about the extent to which they thought that people could control their physical and social environment. The results indicated a marked decline in confidence. In both 1964 and 1978 the Population 3 students considered that people had less control over their environment than did the Population 1 students. For both populations there was a large decline in the mean scale score from 1964 to 1978.

There was no evidence of a general deterioration in the liking of students for mathematics. However, at the Population 3 level there tended to be a decrease, both in the percentage of students with a high liking for mathematics and of those with a low liking for mathematics, which suggested a reduction in the polarization between students in their liking of the subject. Students were also asked for their own estimate of their performance in mathematics relative to other subjects. At both population levels there was an overall tendency from 1964 to 1978 for a reduction both in the percentage of students with good results in mathematics and of those with poor results. At the Population 1 level this meant that in 1978 a fairly small percentage of the students considered that their results in mathematics were worse than in other subjects, although the test data indicated a high percentage of students with low scores on the test relative to the 1964 results.

Final Comments

The IEA Mathematics Studies show that there has been a slight decrease in Australia in the mathematics achievement of 13-year-old students, but the results provide no evidence of any major decline in standards. One area of concern in the 1978 results was the relatively large percentage of students who obtained low scores on the test, especially in Victoria. For these students one must raise serious questions about the small amount of mathematics they appear to have learnt after approximately eight years of instruction.

In order to explain differences in the mean test scores from 1964 to 1978 in the Australian States, various background factors were examined. The most important of these factors was the curriculum to which the students were exposed. Although the relationship between the official curriculum and student achievement were not clear for the 13-year-old students, it was obvious that they were exposed to a much wider curriculum in 1978 than in 1964. However, it was possible that the 1978 curriculum content was not covered as thoroughly as the more limited 1964 curriculum content, particularly since less time was spent in class on the teaching of mathematics at the secondary school. The students' earlier experiences of mathematics at the primary school were not measured in the study, and it was possible that reasons for the observed decrease in achievement should also be sought earlier in the school life of the students. The results for Queensland tended to support this position, since the mean test scores for that State for both 1964 and 1978 were very high, where this achievement built on a very strong emphasis on mathematics in the primary school in Queensland.

Mathematics has generally been regarded as an important component of the range of subjects to be taught in secondary schools. For such an important subject there has been little public debate on the nature and content of the curriculum. The IEA studies have documented the existence of a considerable degree of consensus about the content of the curriculum in mathematics. The IEA Mathematics Test on which the results in this report were based reflected this consensus. However, the present curriculum has been largely influenced by professional mathematicians, and the resulting topics have not necessarily been pertinent to the needs and interests of the majority of students, and particularly to the needs and interests of the less able students.

The justification for the place of a subject in the school program and the scope covered by the subject require regular public review. It is hoped that this present study could lead to such a review of mathematics. If parents, employers and other interested members of the public were able to share in the process of reviewing the role and content of lower secondary school mathematics, it is likely that a more utilitarian view of mathematics would be proposed. Mathematics is seen by some as an isolated subject to be taught for its own sake. A more utilitarian approach would involve teaching mathematics in order to provide a wide repertoire of skills to be used in the formulation and solution of the kinds of practical problems which occur in the real world.

There are two important implications of a utilitarian view of school mathematics. Firstly, there would need to be constant co-operation between the mathematics teachers and the teachers of other subjects. This would assist the mathematics teachers to increase their knowledge of the range of practical problems to which the mathematics could be applied, and would also sensitize the other teachers to the possibility of enhancing their students' understanding of the key concepts of the other subjects by the application of quantitative analyses and procedures. The second implication is that there would be a greatly increased use of hand-calculators by students, so that they would have adequate computational power at their fingertips for the solution of practical problems.

Secondly, it is likely that a public review of secondary school mathematics would result in the specification of sets of mathematical skills, appropriate to the students' developmental level, which were needed in the solution of practical problems. Indeed it was likely that the observed decreases in mathematics performance from 1964 to 1978 were partly due to the tendency to replace carefully formulated sets of course specifications by more general guidelines.

The increase in mathematics achievement from 1964 to 1978 for the Year 12 mathematics students was achieved in spite of a large increase in student enrolments. Although less comment is needed on such positive results, it is worth noting one important contrast between the findings for Population 1 and Population 3. At both population levels a wider range of curriculum content was covered in 1978 than in 1964. However, the mean test score decreased at Population 1 level, while they increased at the Population 3 level. The probable explanation for the difference was the much stronger incentive for the Year 12 students to master the content of the curriculum, since their primary aim in taking the particular mathematics course was to obtain a satisfactory result for that subject as part of the public examination, or its equivalent in 1978.

The results for the Year 12 mathematics students should not lead to any major concern about the content of the curriculum at this level, particularly since all States have developed a range of courses to suit students with different ability and with different aims underlying their study of mathematics. However, persons responsible for the development of mathematics courses at this level should continue to be aware of the changing nature of the population of Year 12 students. If the holding power at this level increases, it is likely that the mean ability level of the students will decrease. There will probably remain an important minority of students with an intense interest in mathematics, for whom the intrinsic structure and concepts of the discipline are a source of great intellectual satisfaction. Nevertheless, most students would probably subscribe to a more utilitarian view of the subject, as was suggested earlier in discussing the lower secondary school mathematics curriculum. This implies a greater emphasis on the use of mathematics for solving real problems, and an associated emphasis on the use of hand-calculators and computers.

In rounding off these comments about the results, there remains a final element of disquiet about the place of the secondary school in 1978 due to the observed changes in student attitudes since 1964. The resources applied by the State education systems to the teaching of mathematics increased over the period, as exemplified by the reduction in the size of the mathematics classes and the increased level of teacher qualifications. At least at the Year 12 level student performance in mathematics increased. Nevertheless, students saw mathematics as less important, they saw people as less able to control their own physical and social environment, and they liked school less. In defining the overall aims of mathematics education in secondary schools, and in evaluating the outcomes which are associated with these aims, it is important to retain a proper balance between cognitive achievement and students' attitudes about their present schooling and the wider society into which they will enter after leaving school. Perhaps a more utilitarian view of the study of mathematics may assist in holding these cognitive and attitudinal components in balance.

APPENDIXES

APPENDIX 1

MEMBERS OF THE ADVISORY COMMITTEE AND STATE LIAISON OFFICERS

Advisory Committee for the Second IEA Mathematics Study

Dr John Keeves, Director, ACER Hawthorn, Victoria (Chairman)

Dr Malcolm Rosier, Chief Research Officer, ACER, Hawthorn, Victoria (Convenor)

Mr Ron Cowban, Gardenvale, Victoria (Previously Curriculum and Research Branch, Education Department, Victoria)

Mr Roy James, Wesley College, Prahran, Victoria

Mr Bill Newton, Curriculum and Research Branch, Education Department, Carlton, Victoria

Dr Glenn Rowley, School of Education, La Trobe University, Bundoora, Victoria

State Education Department Liaison Officers

Miss Lois Boyd, ACT Schools Authority, Canberra (1978)

Miss Robin Thornely, ACT Schools Authority, Canberra (1979-1980)

Mr Mick Canty, Department of Education, Sydney, New South Wales (1978)

Mr Bill Ackhurst, Department of Education, Sydney, New South Wales (1979-1980)

Mr Max Stephens, Secondary Division, Education Department, Melbourne, Victoria (1978-1979)

Mr Graeme Inchley, Secondary Division, Education Department, Melbourne, Victoria (1980)

Mr Stephen McPherson, Technical Division, Education Department, Melbourne, Victoria (1978-1980)

Mr Ron Boxall, Curriculum Section, Department of Education, Brisbane, Queensland (1978-1980)

Mr Bruce McBryde, Research Section, Department of Education, Brisbane, Queensland (1978-1980)

Mr Keith Hamann, Education Department, Adelaide, South Australia (1978-1980)

Dr Norman Hoffman, Education Department, Perth, Western Australia (1978-1980)

Mr Jim Kelly, Education Department, Hobart, Tasmania (1978-1980)

APPENDIX 2

1978 IEA MATHEMATICS TESTS A, B AND C

SECTION A: MATHEMATICS TEST (Items 1 to 24)

1 $43 \cdot 0 - 17 \cdot 6$ is equal to

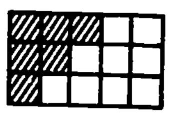
2 How many seven-man teams can you make out of 7 nine-man teams?

A 7 D 16
B 8 E 63
C 9

3 $(22 \times 18) - (47 + 59)$ is equal to

A 290 D 408
B 300 E 502
C 384

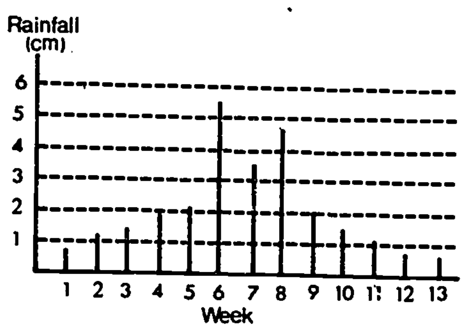
4 In the figure below the little squares are all the same size and the area of the whole rectangle is equal to 1.



The area of the shaded part is equal to

A $\frac{2}{15}$ D $\frac{3}{8}$
B $\frac{1}{3}$ E $\frac{1}{2}$
C $\frac{2}{5}$

5 In the graph below rainfall in cm is plotted for 13 weeks.



The average weekly rainfall during the period is approximately

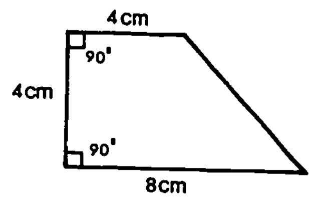
A 1 D 4
B 2 E 5
C 3

6 The value of $2^3 \times 3^2$ is

A 30 D 72
B 36 E none of these.
C 64

7 A box has a volume of 100 cm^3. Another box is twice as long, twice as wide and twice as high. How many cm^3 is the volume of the second box?

8 There is a brass plate of the shape and dimensions shown in the figure below.



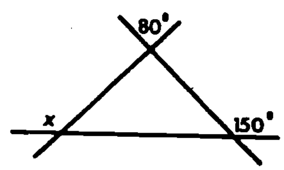
What is its area in square centimetres?

A 16 D 64
B 24 E 96
C 32

9 What is the square root of 12×75?

A 6·25 D 625
B 30 E 900
C 87

10 Three straight lines intersect as shown in the figure below.



What is x equal to in degrees?

A 30 D 110
B 50 E 150
C 60

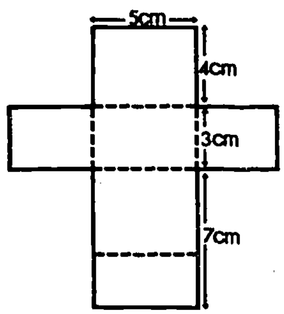
11 A shopkeeper has x kg of tea in stock. He sells 15 kg and then receives a new lot weighing $2y$ kg. What weight of tea in kg does he now have?

A $x - 15 - 2y$ D $x + 15 - 2y$
B $x + 15 + 2y$ E none of these
C $x - 15 + 2y$

12 If $\frac{x}{2} < 7$, then

A $x < \frac{7}{2}$ D $x > 5$
B $x < 5$ E $x > 14$
C $x < 14$

13 A piece of tin with dimensions as shown in the figure below is to be folded along the dotted lines to make a box.



What is the volume, in cubic centimetres, enclosed in the box?

14 If $\frac{4x}{12}=0$, then x is equal to

A 0
B 3
C 8
D 12
E 16

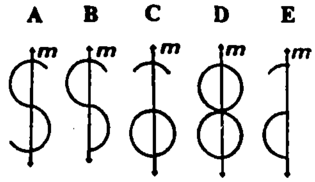
15 The floor of a room is covered with wooden rectangular blocks. When blocks measuring a cm by b cm are used, M blocks are needed. If blocks fit exactly, how many blocks will be needed if each block measures x cm by y cm?

A $\frac{Mab}{xy}$
B $\frac{ab}{Mxy}$
C $\frac{(a+b)M}{x+y}$
D $\frac{ab.xy}{M}$
E $\frac{Mxy}{ab}$

16 The figure shown below is part of a figure where m is an axis of symmetry.

Which of the following shows the complete figure?

A B C D E



17 Which of the following is (are) true?

I $(53\times 73)\times 17=53\times(73\times 17)$
II $133\times(78+89)=(133\times 78)+89$
III $133\times(78+89)=(133\times 78)+(133\times 89)$

A I only
B II only
C III only
D I and II only
E I and III only

18 There are 227 students in a school. Every student in the school belongs to either the music club or the sports club, and some students belong to both clubs. The music club has 120 members, and 36 of these are also members of the sports club. What is the total membership of the sports club?

19 The length of the sides of a triangle XYZ are 4, 7 and 10. If a triangle of the same shape has a perimeter of 147, what is the length of its shortest side?

20 In the solution of the following system of equations,

$$\left.\begin{aligned} 2x+y&=7 \\ x-4y&=4 \end{aligned}\right\}$$

the value of y is equal to

A $\frac{5}{3}$
B -9
C $\frac{1}{9}$
D $-\frac{1}{9}$
E $\frac{5}{3}$

21 Which of the following is true for any parallelogram $ABCD$ which has an acute angle at B and diagonals AC and BD?

A $AB<BC$
B $AB=BC$
C $AB>BC$
D $AC<BD$
E none of these

22 The distance between two towns, P and Q, is 150 kilometres. This distance is represented on a certain map by a length of 30 centimetres. The scale of this map is

A 1:500 000
B 30:150
C 1:20 000
D 1:5000
E 1:200 000

23 Which of the following equals $7\times(3+9)$?

A $(7\times 3)+(7\times 9)$
B $(7\times 9)+(3\times 9)$
C $(7\times 3)+(3\times 9)$
D 7×27
E $21+9$

24 $\frac{3}{5}=$

A 6%
B 15%
C 23%
D 30%
E 60%

END OF SECTION A

SECTION B: MATHEMATICS TEST (Items 25 to 48)

25 $\frac{2}{5}+\frac{3}{8}$ is equal to

A $\frac{5}{13}$ **D** $\frac{16}{15}$

B $\frac{5}{40}$ **E** $\frac{31}{40}$

C $\frac{6}{40}$

26 Peter and Alison decided to start saving money. Peter can save $3 each month and Alison can save $5. At this rate, after how many months will Alison have exactly $10 more than Peter?

A 2 **D** 5

B 3 **E** 8

C 4

27 $0{\cdot}004\overline{)24{\cdot}56}$

In the division shown above, the correct answer is

A 0·614

B 6·14

C 61·4

D 614

E 6140

28 The average (arithmetic mean) of 1·50, 2·40, 3·75 is equal to

A 2·40 **D** 7·65

B 2·55 **E** none of these.

C 3·75

29 Which of the following operations with whole numbers will **always** give a whole number?

I Addition

II Multiplication

III Division

A I only **D** I and II only

B II only **E** II and III only

C III only

30 If the selling price of an article was $55 and a profit of 10% was made on the cost price, what was the cost price in dollars?

31 The value of 0·2131 × 0·02958 is approximately

A 0·6 **D** 0·0006

B 0·06 **E** 0·00006

C 0·006

32 Joe had three test scores of 78, 76, and 74, while Mary had scores of 72, 82, and 74. How did Joe's average compare with Mary's?

A Joe's was 1 mark higher.

B Joe's was 1 mark lower.

C Both averages were the same.

D Joe's was 2 marks higher.

E Joe's was 2 marks lower.

33 Which of the following is **false** when a and b are different real numbers?

A $(a+b)+c=a+(b+c)$

B $ab=ba$

C $a+b=b+a$

D $(ab)c=a(bc)$

E $a-b=b-a$

34 If $P=LW$ and if $P=12$ and $L=3$, then W is equal to

A $\frac{3}{4}$ **D** 12

B 3 **E** 36

C 4

35 Simplify: $5x+3y+2x-4y$

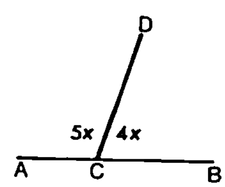
A $7x+7y$ **D** $7x-y$

B $8x-2y$ **E** $7x+y$

C $6xy$

36 What is the value of $(-6)-(-8)$?

37 If AB is a straight line, what is the measure in degrees of angle BCD in the figure below?



A 20 **D** 80

B 40 **E** 100

C 50

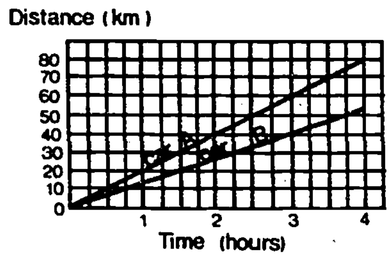
38 If $x=y=z=1$, then $\frac{x-z}{x+y}$ is equal to

A -2
B -1
C 0
D $\frac{1}{2}$
E 1

39 If $x=-3$, the value of $-3x$ is

A -9
B -6
C -1
D 1
E 9

Use the graph shown below in answering the two following items 40 and 41.



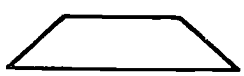
40 Three hours after starting, car *A* is how many km ahead of car *B*?

A 2
B 10
C 15
D 20
E 25

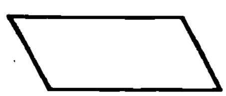
41 How much longer does it take car *B* to go 50 km than it does for car *A* to go 50 km?

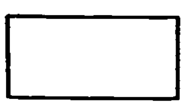
A 1 hour 15 minutes
B 1 hour 30 minutes
C 2 hours
D 2 hours 30 minutes
E 2 hours 45 minutes

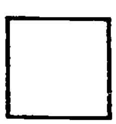
42 Which of the following quadrilaterals has 4 axes of symmetry?

A 

B 

C 

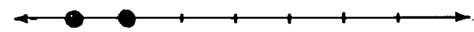
D 

E 

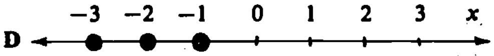
43 The distance between two schools on a map with a scale of 1:10 000 is 20 cm. What is the actual distance in kilometres between the two schools?

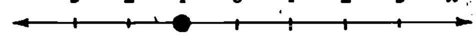
44 In which of these graphs of x, where x is an integer, is $x>-1$?

A 

B 

C 

D 

E 

45 Which of the following numbers in base two is (are) even?

I 110011
II 110010
III 110101
IV 100100

A I only
B III only
C I and III only
D II and IV only
E I, III and IV

46 20% of \$125 =

A \$6·25
B \$12·50
C \$15
D \$25
E \$50

47 Lemonade costs a cents for each bottle but there is a refund of b cents on each empty bottle. How much will Helen have to pay for x bottles if she brings back y empties?

A $ax+by$ cents
B $ax-by$ cents
C $(a-b)x$ cents
D $(a+x)-(b+y)$ cents
E none of these

48 From a stick of wood a man cut 6 short sticks each 2 cm long. He then found he had 1 cm left over. Which of the following would tell him the length of the original stick of wood?

A $6\times(2+1)$
B $(6\times2)+1$
C $(6\div2)-1$
D $(6\times2)-1$
E $(6\div2)+1$

END OF SECTION B

217

SECTION C: MATHEMATICS TEST (Items 49 to 72)

49 Which of the following is the same as a quarter of a million?

A 25 250
B 40 000
C $\frac{1}{4\,000\,000}$
D 250 000
E 2 500 000

50 $0{\cdot}40 \times 6{\cdot}38$ is equal to

A 0·2552
B 2·452
C 2·552
D 24·52
E 25·52

51 The sum of $9\frac{4}{5}$ and $13\frac{1}{4}$ is equal to

A $22\frac{5}{9}$
B $22\frac{9}{20}$
C 23
D $23\frac{1}{20}$
E $23\frac{1}{5}$

52 The ratio of 2 to 5 equals the ratio of what number to 100?

53 In a given triangle the measures of two angles in degrees are 60 and 70. What is the measure of the third angle in degrees?

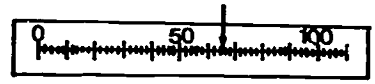
54 On level ground, a tree 5 m tall casts a shadow 3 m long. At the same time a nearby building 45 m high casts a shadow the length of which, in metres, is

A 24
B 27
C 30
D 60
E 75

55 A runner ran 3000 metres in exactly 8 minutes. What was his average speed, in metres per second?

A 3·75
B 6·25
C 16·0
D 37·5
E 62·5

56



On the scale above, the reading indicated by the arrow is between

A 51 and 52
B 57 and 58
C 60 and 62
D 62 and 64
E 64 and 66

57 If $x+y=4$ and $x-y=2$, then x is equal to

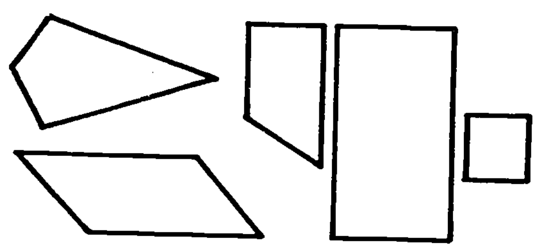
A 0
B 1
C 2
D 3
E 6

58 One bell rings every 8 minutes, while another bell rings every 12 minutes. They have rung together once at the same moment. After how many minutes will they ring together again (a) for the first time, (b) for the second time, and (c) for the tenth time?

59 At 4 o'clock, the measure of the angle between the minute hand and the hour hand of a clock, in degrees, is

A 30
B 45
C 60
D 90
E 120

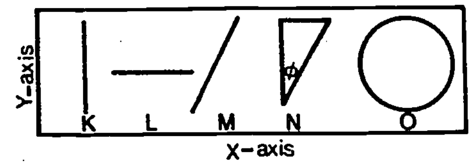
60



Which one of the following statements about the above figures is true?

A Each of the figures has an axis of symmetry.
B Each of the figures has a right angle.
C Each of the figures is a quadrilateral.
D Each of the figures has point symmetry.
E Each of the figures has a pair of equal sides.

Use the information below for items 61 to 63.



Imagine that the geometrical figures *K*, *L*, *M*, *N* and *O* have been drawn on a rubber sheet. The lines are assumed to have no width. The rubber sheet is stretched parallel to the *X*-axis while leaving all the distances measured parallel to the *Y*-axis unchanged. The stretching is uniform, that is, the same for every part of the sheet.

61 For which of the segments *K*, *L*, *M* will the length remain unchanged?

A only *K*
B only *L*
C only *M*
D *K* and *L*
E *K* and *M*

62 What will happen to the measure of angle ø of triangle *N*?

A It will remain the same.
B It will become larger.
C It will become smaller.
D One cannot tell from the data whether *A*, *B* or *C* is correct.

63 What will happen to circle *O*?

A It will still be a circle.
B It will no longer be a circle.
C One cannot tell from the data whether *A* or *B* is correct.

64 A factory produces *m* units per week. How many units per week will it produce after production is increased *p* per cent?

A $100p+m$
B $100m+mp$
C $\frac{m+mp}{100}$
D $m+\frac{mp}{100}$
E $\frac{p}{100}+m$

65 Let the symbol $\overline{a, b}$ denote the set of integers between *a* and *b*. For example, $\overline{3, 7}$ consists of the integers 4, 5, and 6. Which of the following pairs of sets has a larger number of integers in common than any of the other pairs?

A $\overline{0, 15}$ and $\overline{7, 20}$
B $\overline{5, 15}$ and $\overline{16, 30}$
C $\overline{5, 14}$ and $\overline{5, 17}$
D $\overline{4, 18}$ and $\overline{8, 20}$
E $\overline{0, 12}$ and $\overline{6, 12}$

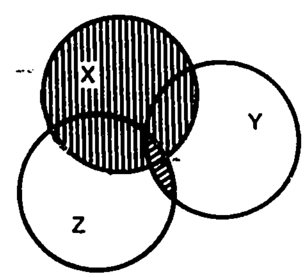
66 What are all values of *x* for which the inequality

$$5x+\frac{5}{3}<-2x-\frac{2}{3}$$

is true?

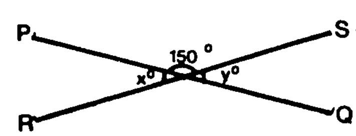
A $x<-\frac{7}{9}$
B $x<-\frac{1}{3}$
C $x>0$
D $x>\frac{7}{3}$
E $x>\frac{9}{3}$

67 The symbol $P \cap Q$ represents the intersection of sets *P* and *Q* and the symbol $P \cup Q$ represents the union of sets *P* and *Q*. Which of the following represents the shaded portion of the diagram below?



A $(X \cap Y) \cup Z$
B $X \cup (Y \cap Z)$
C $X \cap (Y \cup Z)$
D $(X \cap Y) \cap Z$
E $(X \cup Y) \cap Z$

68 If, in the figure below, *PQ* and *RS* are intersecting straight lines, then $x+y$ is equal to

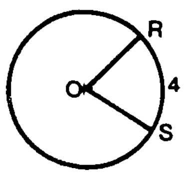


A 15
B 30
C 60
D 180
E 300

69 Each of 9 children had t marbles. In order to play a game they divided the marbles among 12 children in such a way that each had the same number. How many marbles did each of the 12 have?

A $\frac{3t}{4}$
B $t-3$
C $\frac{4t}{3}$
D $9t-12$
E $12t-9$

70 The length of the circumference of the circle shown below with centre at O is 24 and the length of arc RS is 4.



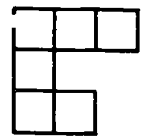
What is the measure in degrees of the central angle ROS?

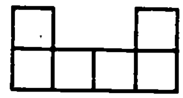
A 24
B 30
C 45
D 60
E 90

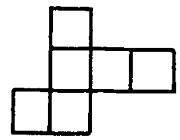
71 Given any fraction whose numerator is less than the denominator, if you then add 2 to both the numerator and the denominator, the new fraction is

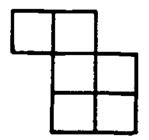
A equal to the original fraction.
B larger than the original fraction.
C twice the original fraction.
D smaller than the original fraction.
E 1 more than the original fraction.

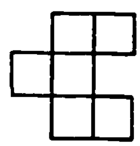
72 Which one of the following figures is the net of a cube?

A


B


C


D


E


END OF SECTION C

H

SECTION D: MATHEMATICS TEST (Items 1 to 24)

1 If $a=20$, $b=0$, $c=10$, $x=8$, $y=12$, then the value of $2aby+2cx$ is

- **A** 100
- **B** 160
- **C** 400
- **D** 640
- **E** none of these.

This information refers to items 2 to 5.

For each of the following equations or pairs of equations, concerned with real numbers, mark on the answer sheet

- **A** if there is **no** solution,
- **B** if there is **one** solution,
- **C** if there are **two** solutions,
- **D** if there are **three** solutions, or
- **E** if there are **more than three** solutions.

2 $x+y=12$, $x-y=4$

3 $m+n=2$, $3m+3n=9$

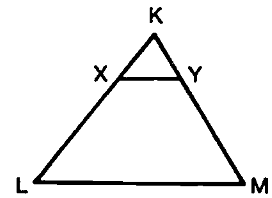
4 $x^2-5x+6=0$

5 $3p+q=16$

6 If $xy=1$ and x is greater than 0, which of the following statements is true?

- **A** When x is greater than 1, y is negative.
- **B** When x is greater than 1, y is greater than 1.
- **C** When x is less than one, y is less than 1.
- **D** As x increases, y increases.
- **E** As x increases, y decreases.

7 In the figure below,
$KX=\frac{1}{3}KL$ and $KY=\frac{1}{3}KM$.

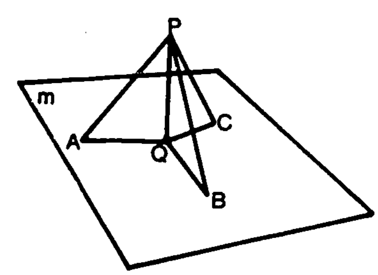


Which of the following statements are true?

- I $XY=\frac{1}{3}LM$
- II Line XY is parallel to line LM.
- III Area $KXY=\frac{1}{3}$ area KLM
- IV Area $KXY=\frac{1}{9}$ area KLM

- **A** I and II only
- **B** II and III only
- **C** I and III only
- **D** I, II and III only
- **E** I, II and IV only

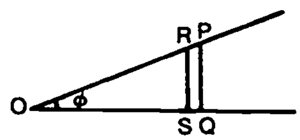
8 In the figure below, m represents a plane, and PQ is a straight line which is perpendicular to the plane at the point Q.



Points A, B and C lie on the plane. If $QA=QB=QC$, then the triangles PQA, PQB, and PQC are

- **A** congruent (two sides and included angle).
- **B** congruent (two sides and angle not included).
- **C** congruent (two angles and corresponding side).
- **D** similar but not congruent.
- **E** neither similar nor congruent.

9 In the figure below, $PQ \perp OQ$, and $RS \perp OQ$.



If the measures of OQ and of OR equal 1 and ø is the measure of $< POQ$, then the measure of the intercept PQ is equal to

A sin ø

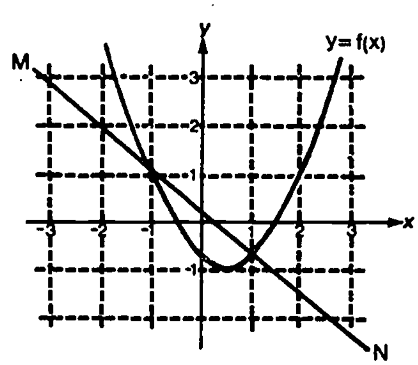
B cos ø

C tan ø

D 2 sin ø

E 1 − cos ø

Items 10 and 11 are based upon the graph of a quadratic function which is shown in the figure below.



10 For what value of x is the quadratic function a minimum?

A -1

B $-\frac{1}{2}$

C $\frac{1}{2}$

D 1

E $1\frac{1}{2}$

11 The values of x for which the function represented by the straight line MN exceeds the quadratic function are given by

A $-1 < x < 1$

B $x < -1$ and $x > 1$

C $-\frac{3}{4} < x < 1\frac{1}{4}$

D $x > 0$

E $x > y$

12 A square plate of the largest possible size is cut from a circular plate of 16 cm diameter. The area of the square plate, in cm^2, will be

A 64

B 96

C 128

D 192

E 256

13 The locus of all mid-points of chords drawn from a point on the circumference of a circle is

A a semi-circle.

B a circle.

C a straight line.

D a rectangle.

E none of these.

14 A piece of wire 52 cm long is cut into two parts and each part is bent to form a square. The total area of the two squares is 97 cm^2. What is the length in cm of the side of the smaller square?

15 The complex number $(1+i)^2$ is equal to

A 0

B 2

C $2i$

D $1+i$

E $2+2i$

16 Given $\log_b 2 = \frac{1}{3}$, $\log_b 32$ is equal to

A 2

B 5

C $-\frac{3}{5}$

D $\frac{5}{3}$

E $\frac{3}{\log_2 32}$

17 Below there are several definitions of new operations named * in terms of the usual operations on real numbers. For which of the definitions is the property $y * x = x * y$ valid for all positive real numbers x and y?

A $x*y=\frac{x}{y}$ **D** $x*y=\frac{xy}{x+y}$

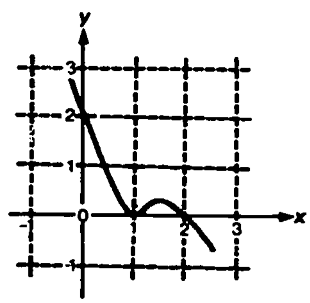
B $x*y=x-y$ **E** $x*y=x^2+xy^2+y^4$

C $x*y=x(x+y)$

18 Solve the equation

$$\sqrt{x+5}-\sqrt{x-3}=\sqrt{x}$$

19 The graph below is the representation of one of the following equations.



Which one does it represent?

A $y=(1-x)(x-2)$

B $y=(1-x)(2-x)$

C $y=(1-x)(2-x)^2$

D $y=(1-x)^2(x-2)$

E $y=(1-x)^2(2-x)$

20 The expression

$$\frac{2}{\sqrt{5}}+\frac{\sqrt{45}}{5}+\frac{1}{\sqrt{5}-2}$$

is equal to

A $2\sqrt{5}+2$ **D** $2\sqrt{5}$

B $2\sqrt{5}-2$ **E** $2-2\sqrt{5}$

C 2

21 Chords of the same length are drawn in two circles of unequal radii. Which of the following is true?

A The chord in the larger circle could be equal to the radius of the smaller circle.
B The chord in the smaller circle could not be a diameter.
C The distance from the centre to the chord is less in the larger circle.
D The minor arc intercepted on the larger circle is longer.
E The minor arc intercepted on the larger circle subtends the greater angle at the centre.

22 The expression $|x-1|=1$ implies that

A x is between 0 and 2. **D** x is 0.
B x is either 0 or 2. **E** x is 2.
C x is less than 2.

23 When $(1+p)^6$ is expanded, the coefficient of p^4 is

A 6 **D** 20
B 10 **E** 30
C 15

24 What is the converse of the statement, 'If two angles are vertically opposite, then they are equal'?

A If two angles are vertically opposite, then they are not equal.
B If two angles are equal, then they are vertically opposite.
C If $\angle x$ and $\angle y$ are vertically opposite angles, then $\angle x=\angle y$.
D If two angles are not vertically opposite, then they are not equal.
E If two angles are not equal, then they are not vertically opposite.

END OF SECTION D

SECTION E: MATHEMATICS TEST (Items 25 to 48)

25 Suppose you have proved the two theorems:

I If p then q.
II If s then not q.

Which of the following theorems is implied by theorems I and II?

A If p then s.
B If not p then not q.
C If p or q then s.
D If s then not p.
E If not s then q.

26 A train travelled a certain distance at a constant speed. Had the speed been 8 km h^{-1} greater, the trip would have taken one hour less. Had the speed been 12 km h^{-1} less the trip would have taken two hours more. How many km did the train go?

27 A wholesale merchant bought a television set at a certain price and then sold it to a retail merchant at an increase of P per cent of this price. The retail merchant sold the set to a consumer for P per cent more than he paid for it. If the customer paid 65 per cent more than the price originally paid by the wholesale merchant, then P satisfies the equation:

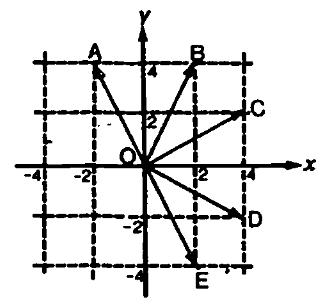
A $1+\frac{2P}{100}=1\cdot65$
B $\left(1+\frac{P}{100}\right)^2=1\cdot65$
C $1+\left(\frac{P}{100}\right)^2=1\cdot65$
D $1+P^2=1\cdot65$
E $1+2P=1\cdot65$

28 If a relation R is such that xRy and yRz implies xRz for each x, y, and z of a given set, the relation R is said to be transitive on that set. Which of the following relations are transitive?

I 'is father of'
II 'is contemporary of'
III 'is admirer of'
IV 'is multiple of'
V 'is perpendicular to'

A II, IV and V
B I and II
C II, III and IV
D II and IV
E V only

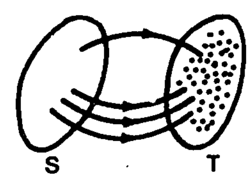
29 In the figure shown below, which vector is a graphical representation of the complex number $4-2i$?



A vector A
B vector B
C vector C
D vector D
E vector E

30 Solve $0<x^2-3x+3<7$

31 A relation R from a set S to a set T is a function if and only if given an $x\varepsilon S$ there exists at most one $y\varepsilon T$ such that xRy.



Which of the following relations are functions?

I x is a factor of y.
II y is the mother of x.
III x is parallel to y.
IV $y=2x$
V x is less than y.
VI $x^2=y$

A I, II and III
B II, IV and V
C II, IV and VI
D IV, V and VI
E I, IV and V

32 What is the equation whose roots are the squares of the roots of

$$x^2-5x+3=0?$$

A $x^2-19x+9=0$

B $x^2+19x+9=0$

C $x^2-20x+9=0$

D $x^2+19x-9=0$

E $x^2-9x+19=0$

Use the following information for items 33 and 34.

In the development of a new algebra six operations are defined as follows:

$$A=\begin{pmatrix}1&2&3\\2&3&1\end{pmatrix}\quad B=\begin{pmatrix}1&2&3\\3&1&2\end{pmatrix}\quad C=\begin{pmatrix}1&2&3\\1&3&2\end{pmatrix}$$

$$D=\begin{pmatrix}1&2&3\\3&2&1\end{pmatrix}\quad E=\begin{pmatrix}1&2&3\\2&1&3\end{pmatrix}\quad F=\begin{pmatrix}1&2&3\\1&2&3\end{pmatrix}$$

The operation $A=\begin{pmatrix}1&2&3\\2&3&1\end{pmatrix}$, for example, means that the numbers in the upper row are transformed into the digits in the lower row, so that $1\to2$ (1 becomes 2), $2\to3$ (2 becomes 3), and $3\to1$ (3 becomes 1).

$A\cdot B$ shows that operation B is to be performed after operation A; that is, according to A, $1\to2$, $2\to3$, $3\to1$, and then, according to B, $2\to1$, $3\to2$, $1\to3$. Therefore, $A\cdot B$ will be $1\to2\to1$, $2\to3\to2$, and $3\to1\to3$. This produces the same outcome as $F=\begin{pmatrix}1&2&3\\1&2&3\end{pmatrix}$. Let us write this $A\cdot B=F$.

In like manner $A\cdot C$ is $1\to2\to3$, $2\to3\to2$, $3\to1\to1$, and is the same as D: that is to say $A\cdot C=D$.

33 Which one operation is equal to $C\cdot D$?

34 What operation must be performed after operation B so that the combined operations are to be the same as operation F?

35 If x and y belong to the set of real numbers, and sets P, Q and R are defined as follows,

$P=\{(x,y)\mid x^2+y^2=4\}$

$Q=\{(x,y)\mid x-y=2\}$

$R=\{(x,y)\mid (x^2+y^2-4)(x-y-2)=0\}$,

which of the following is true?

A $R=P\cap Q$

B $R=P\cup Q$

C $R=\{(2,0)(0,2)(-2,0)(0,-2)\}$

D $R=\{\,\}$ (the empty set)

E $R=\{(2,0)(0,-2)\}$

36 The value of the determinant $\begin{vmatrix}4&2&1\\0&0&1\\1&1&0\end{vmatrix}$ is

A -2

B 0

C 2

D 7

E 9

37 Each root of $x^2-2x+5=0$ differs from the cube of the other by a positive constant c. What is the value of c?

38 Two of the roots of the equation
$x^4-27x^2-14x+120=0$
are 2 and 5. Find the two other roots of the equation.

39 If $\log_b 8=\frac{3}{2}$, what is the value of b?

A $\frac{2}{3}$

B 2

C 4

D 5

E 6

40 A warning system installation consists of two independent alarms having probabilities of operating in an emergency of 0·95 and 0·90 respectively. What is the probability that at least one alarm will operate in an emergency?

A 0·995

B 0·975

C 0·95

D 0·90

E 0·855

41 If x and y are real numbers, for which values of x can you define y by

$$y=\frac{x}{\sqrt{9-x^2}}?$$

A All x except $x=3$

B All x except $x=3$ and $x=-3$

C $x<-3$ and $x>3$

D $-3<x<3$

E $x<3$

42 A set of 24 cards is numbered with the positive integers from 1 to 24. If the cards are shuffled and if only one is selected at random, what is the probability that the number on the card is divisible by 4 or 6?

A $\frac{1}{6}$

B $\frac{5}{24}$

C $\frac{1}{4}$

D $\frac{1}{3}$

E $\frac{5}{12}$

43 An angle θ is known to be between 180° and 270° and $\cos^2\theta=\frac{16}{25}$. The value of $\sin 2\theta$ is then

A $-\frac{24}{25}$

B $-\frac{15}{25}$

C $-\frac{7}{25}$

D $\frac{7}{25}$

E $\frac{24}{25}$

44 For some functions the relationship holds that $f(x+y)=f(x)+f(y)$ for all numbers x and y. For example, when $f(x)=2x$, then $f(x+y)=2(x+y)=2x+2y=f(x)+f(y)$; that is, $f(x+y)=f(x)+f(y)$. We call such functions as these additive. Which of the following functions is additive by this definition?

A $f(x)=x^2$

B $f(x)=\sin x$

C $f(x)=\log_{10}x$

D $f(x)=2^x$

E None of these is additive.

45 If determinants are used to solve the system of equations

$$\begin{cases}2x+y=3\\ x+4y=7\end{cases}$$

then y is equal to

A $\dfrac{\begin{vmatrix}2&1\\1&4\end{vmatrix}}{\begin{vmatrix}2&3\\1&7\end{vmatrix}}$

B $\dfrac{\begin{vmatrix}2&1\\1&4\end{vmatrix}}{\begin{vmatrix}3&1\\7&4\end{vmatrix}}$

C $\dfrac{\begin{vmatrix}2&3\\1&7\end{vmatrix}}{\begin{vmatrix}2&1\\1&4\end{vmatrix}}$

D $\dfrac{\begin{vmatrix}3&1\\7&4\end{vmatrix}}{\begin{vmatrix}2&1\\1&4\end{vmatrix}}$

E $\dfrac{\begin{vmatrix}3&7\\2&1\end{vmatrix}}{\begin{vmatrix}2&1\\1&4\end{vmatrix}}$

Items 46 to 48 refer to the information below.

Consider the following abstract mathematical system:

Undefined terms:

elements $a, b, c \ldots$ of set C;

operations λ and $*$; relation $=$, having the conventional meaning of "equals".

Postulates:

If a, b, and c are any elements of C, then

(1) $a\lambda b$ and $a*b$ are elements of C.

(2) $a\lambda b=b\lambda a$.

(3) $a*(b*c)=(a*b)*c$.

(4) $a*b\neq b*a$, provided $a\neq b$.

(5) $a\lambda(b*c)=(a\lambda b)*(a\lambda c)$.

DIRECTIONS: Answer each item, using the code

A if the proposition follows logically from the postulates,

B if the proposition is inconsistent with the postulates (i.e., contradicts the postulates), or

C neither A nor B (i.e., the proposition neither follows from the postulates nor is contradicted by them).

46 $(a*b)\lambda c=(c\lambda a)*(c\lambda b)$

47 $(a*b)\lambda c=(a\lambda c)*(b\lambda c)$

48 $a\lambda(b*c)=(a\lambda c)*(a\lambda b)$

END OF SECTION E

SECTION F: MATHEMATICS TEST (Items 49 to 72)

49 The graph of $y=f(x)$ is a parabola with axis parallel to the Y-axis. If the maximum value of y is 2, and if the parabola crosses the X-axis at $x=-\frac{1}{2}$ and at $x=\frac{3}{2}$, then its equation is

A $y=-2x^2+2x+\frac{3}{2}$
B $y=-4x^2-4x+3$
C $y=-4x^2+4x+3$
D $y=4x^2-4x-3$
E $y=4x^2+4x-3$

50 For what values of the real number x is $y=\frac{1}{x}$ a decreasing function?

A no x
B $x<0$
C $x\neq 0$
D $x>0$
E all x

51 Solve: $2.7^{2+x}+3.7^{3+x}=161$

52 Given two sets X and Y, which of the following sets is equivalent to the set

$$(X\cup Y)\cap(X\cap Y)?$$

A X
B Y
C $X\cup Y$
D $X\cap Y$
E $(X\cup Y)\cup(X\cap Y)$

53 Consider the matrices

$$A=\begin{pmatrix}1 & x\\ 0 & 1\end{pmatrix} \text{ and } B=\begin{pmatrix}1 & 0\\ y & 1\end{pmatrix}$$

where x and y are real numbers and $x^2+y^2\neq 0$. For which values of x and of y is the product of the matrices commutative?

I $x=0$
II $y=0$
III $x=y$

A only I
B only II
C only III
D both I and II
E I, II, and III

54 Calculate $\arcsin\frac{1}{2}+\arcsin\frac{1}{\sqrt{2}}$

[Note: $\arcsin x=\sin^{-1}x$]

A $\frac{5\pi}{12}$
B $\frac{7\pi}{18}$
C $\frac{\pi}{3}$
D $\arcsin\left(\frac{1+\sqrt{2}}{2}\right)$
E $\arcsin\frac{\sqrt{3}}{2}$

55 For what values of x is the function

$$\frac{(1-x)(1+3x)}{(2x-1)(x-2)}$$

positive?

56 Five points are placed randomly in the xy plane, not on the axes. What is the probability that exactly one point will lie in the first quadrant?

A $\frac{405}{1024}$
B $\frac{81}{1024}$
C $\frac{15}{16}$
D $\frac{4}{5}$
E $\frac{1}{5}$

57 In a Cartesian co-ordinate system, what is the equation of the straight line passing through the point $(0, -5)$ and parallel to the straight line whose equation is $y=2x+3$?

A $x+2y+5=0$
B $2x-y-5=0$
C $2x+3=-5$
D $2x-5y+3=0$
E $2x+y+5=0$

58 An open cylindrical vessel of capacity 9000π cm^3 is to be made with the curved surface of sheet metal and a wooden base. If the weight of 1 cm^2 of the metal is three times the weight of 1 cm^2 of the wood, each being of uniform small thickness, what will be the radius of the vessel (in cm) when its total weight is a minimum?

59 The derivative with respect to x of $\frac{4}{\sqrt{3x-4}}$ is

A $12\sqrt{3x-4}$
B $\frac{4}{\sqrt{3}}$
C $\frac{-2}{(3x-4)^{3/2}}$
D $\frac{-6}{(3x-4)^{3/2}}$
E $6\sqrt{3x-4}$

60 The value of $\int_0^1 \frac{dx}{x^2-5x+6}$ is

A $\frac{1}{2}\log_e 2$
B $\frac{1}{3}$
C $\log_e\frac{4}{3}$
D $\tan\frac{-11}{4}$
E $\frac{1}{2}$

61 $\int (x-1)^2\,dx$ is equal to

A $2(x-1)+c$
B $\frac{1}{2}(x-1)^2+c$
C $\frac{1}{3}(x-1)^3+c$
D $\frac{1}{3}(x^3-x)+c$
E $\frac{(x-1)^3}{x}+c$

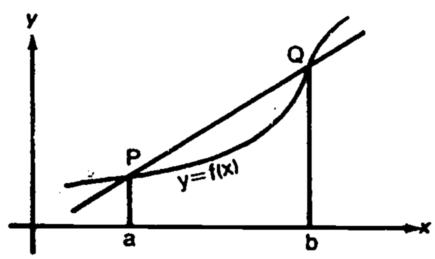
62 Determine k so that the graph of the function $y=3x^3+6x^2+kx+9$ has a point of inflexion and a horizontal tangent for the same value of x.

63 What is the equation in x and y of the curve with parametric equations

$$x=t+\frac{1}{t},\ y=t-\frac{1}{t}?$$

A $x+y=1$
B $x+y=2$
C $x^2+y^2=4$
D $x^2-y^2=4$
E $2x^2-y^2=4$

64



The graph of a polynomial function of x is shown in the diagram above, the equation of the curve being $y=f(x)$. Which of the following statements is (are) true for that part of the curve for which $a < x < b$?

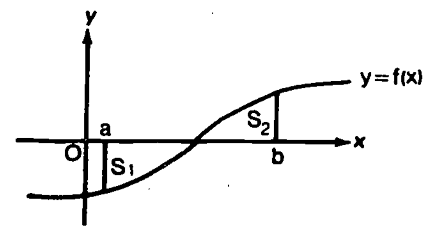
I $f''(c)=0$ for some value c between a and b.
II $\frac{f(b)-f(a)}{b-a}=f'(c)$ for some value c between a and b.
III If there is a point of inflexion at Q, $f''(b)$ can have no value but 0.
IV $\int_a^b f(x)\,dx<\frac{1}{2}(b-a)[f(a)+f(b)]$

A I, II, III and IV
B II, III and IV
C I and II
D I and III
E II and IV

65 Given that $3\frac{dy}{dx}=x^2-5$, and $y=1$ when $x=2$, what is the value of y when $x=0$?

A $-\frac{5}{3}$
B $-\frac{2}{3}$
C $\frac{1}{3}$
D $\frac{25}{9}$
E $\frac{31}{9}$

Items 66 and 67 are based on the figure shown below, which shows a graph of $y=f(x)$, a being less than b. S_1 is the area enclosed by the x-axis, $x=a$, and $y=f(x)$. S_2 is the area enclosed by the x-axis, $x=b$, and $y=f(x)$. S_1 and S_2 are to be considered positive.



66 The value of $\int_a^b f(x)\,dx$ is

A S_1+S_2
B S_1-S_2
C S_2-S_1
D $|S_1-S_2|$
E $\frac{1}{2}(S_1+S_2)$

67 The value of $\int_a^b |f(x)|\,dx$ is

A S_1+S_2
B S_1-S_2
C $|S_2-S_1|$
D $|S_2|-|-S_1|$
E $\frac{1}{2}(S_1+S_2)$

68 The function $f(x)=\frac{x^2-1}{x-1}$ is defined and continuous for all x except $x=1$. What value must be assigned to $f(x)$ for $x=1$ in order that the function be continuous there?

69 Find the difference $\vec{b}-\vec{a}$ of the vectors $\vec{a}=(4,2)$ and $\vec{b}=(0,3)$.

A $(-4,-2)$
B $(-4,1)$
C $(4,-1)$
D $(4,2)$
E $(4,5)$

70 In a triangle with area a, the mid-points of the three sides are joined so as to form a new triangle. In the triangle thus constructed, another new triangle is inscribed in the same way. This process is continued indefinitely. What is the sum of all the areas of this sequence of triangles, including the original one?

A $\frac{9a}{7}$

B $\frac{4a}{3}$

C $\frac{7a}{5}$

D $\frac{3a}{2}$

E $\frac{5a}{3}$

71 The value of $\lim_{h \to 0} \frac{\sqrt{2+h} - \sqrt{2}}{h}$ is

A 0

B $\frac{1}{2\sqrt{2}}$

C $\frac{1}{2}$

D $\frac{1}{\sqrt{2}}$

E ∞

72 The probability of guessing the correct response to a multichoice question is $\frac{1}{5}$. What is the probability of a score of 8 correct on a test containing 10 questions by guessing on all questions?

A 0

B $\left(\frac{1}{5}\right)^8$

C $\left(\frac{1}{5}\right)^8 \left(\frac{4}{5}\right)^2$

D $8\left(\frac{1}{5}\right)^8 \left(\frac{4}{5}\right)^2$

E $45\left(\frac{1}{5}\right)^8 \left(\frac{4}{5}\right)^2$

END OF SECTION F

APPENDIX 4

MATHEMATICS TEST ITEM STATISTICS

Table A4.1 Percentage of Correct Responses for Mathematics Items: Population 1

Item/ sample	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median disc.
A01/A01								
1964		70	78	88		73	66	0.23
1978R		67	69	80		78	69	0.31
1978	80	70	70	81	81	77	70	0.29
A02/02								
1964		69	74	77		64	65	0.46
1978R		61	61	72		66	67	0.48
1978	78	62	63	75	68	67	68	0.48
A03/A03								
1964		79	80	92		76	75	0.32
1978R		72	78	86		75	79	0.28
1978	77	74	80	85	73	77	80	0.27
A04/A04								
1964		59	65	75		67	50	0.47
1978R		62	61	65		64	56	0.50
1978	70	64	63	66	61	66	57	0.49
A05/A05								
1964		43	45	47		39	32	0.39
1978R		44	41	50		52	42	0.35
1978	56	44	45	53	51	54	43	0.37
A06/A06								
1964		44	56	54		49	46	0.49
1978R		52	44	60		58	48	0.42
1978	55	54	52	62	58	60	51	0.42
A07/A07								
1964		8	9	11		4	6	0.24
1978R		7	6	9		7	5	0.28
1978	8	8	6	10	5	7	6	0.30
A08/A08								
1964		36	36	40		21	20	0.41
1978R		35	31	32		29	27	0.35
1978	39	34	29	34	24	30	28	0.36

... contd

Table A4.1 Percentage of Correct Responses for Mathematics Items: Population 1 (contd)

Item/ sample	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median disc.
A09/A09								
1964		33	44	63		29	22	0.54
1978R		43	23	52		41	35	0.55
1978	55	46	30	53	37	42	38	0.55
A10/A10								
1964		25	27	23		20	18	0.34
1978R		14	11	15		18	12	0.20
1978	17	15	13	17	14	17	13	0.24
A11/A11								
1964		72	81	72		76	69	0.42
1978R		72	69	82		74	72	0.43
1978	83	75	72	84	79	76	74	0.42
A12/A12								
1964		33	37	32		32	33	0.23
1978R		32	28	40		36	28	0.31
1978	36	34	30	41	34	37	29	0.33
A13/A13								
1964		20	16	17		11	10	0.46
1978R		20	17	29		17	14	0.52
1978	23	22	17	30	20	17	15	0.51
A14/A14								
1964		55	34	33		46	39	0.17
1978R		53	50	51		65	54	0.29
1978	57	56	52	52	52	67	55	0.30
A15/A15								
1964		32	32	43		24	30	0.24
1978R		28	17	30		21	22	0.22
1978	25	28	21	31	22	21	23	0.21
A16								
1964								
1978R		36	34	48		38	34	0.31
1978	46	37	34	48	43	36	34	0.30

... contd

Table A4.1 Percentage of Correct Responses for Mathematics Items: Population 1 (contd)

Item/ sample	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median disc.
A17/A17								
1964		23	15	19		16	17	0.20
1978R		19	15	39		21	14	0.30
1978	23	20	19	41	22	23	15	0.34
A18/A18								
1964		57	59	64		56	53	0.38
1978R		45	48	49		48	47	0.36
1978	59	46	51	51	54	50	48	0.34
A19/A19								
1964		15	12	22		7	2	0.42
1978R		10	6	17		9	6	0.44
1978	17	11	8	17	8	10	6	0.45
A20/A20								
1964		9	7	9		12	7	0.13
1978R		9	7	8		9	6	0.08
1978	10	10	8	8	7	9	7	0.13
A21/A21								
1964		18	24	18		21	23	-0.04
1978R		21	23	18		23	21	-0.07
1978	15	19	18	23	24	21	21	-0.08
A22/A22								
1964		12	8	10		8	7	0.14
1978R		9	10	13		8	7	0.10
1978	9	10	10	15	10	9	7	0.22
A23/A23								
1964		75	54	81		52	62	0.41
1978R		62	63	77		61	58	0.43
1978	67	64	64	79	66	62	60	0.43
A24								
1964								
1978R		61	54	67		63	59	0.57
1978	66	63	57	69	59	65	61	0.56

... contd

Table A4.1 Percentage of Correct Responses for Mathematics Items: Population 1 (contd)

Item/ sample	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median disc.
B25/B1								
1964		59	72	84		68	49	0.42
1978R		55	52	66		49	53	0.55
1978	64	57	57	66	64	54	55	0.53
B26/B2								
1964		68	70	71		69	64	0.45
1978R		62	64	69		67	66	0.44
1978	74	65	67	72	70	69	66	0.44
B27/B3								
1964		26	40	58		27	28	0.39
1978R		25	27	41		35	26	0.44
1978	45	28	32	43	43	37	28	0.46
B28/B4								
1964		44	56	41		50	46	0.48
1978R		37	28	40		40	30	0.49
1978	45	40	31	43	34	42	33	0.51
B29/B5								
1964		59	54	57		53	50	0.40
1978R		57	52	67		58	54	0.38
1978	63	59	54	67	61	60	55	0.39
B30/B6								
1964		10	6	28		22	8	0.35
1978R		8	7	4		6	5	0.16
1978	10	8	7	5	6	6	4	0.17
B31/B7								
1964		13	16	31		13	15	0.27
1978R		21	21	27		27	16	0.26
1978	34	22	20	28	33	27	18	0.27
B32/B8								
1964		89	88	88		86	86	0.22
1978R		80	77	82		80	82	0.23
1978	87	81	79	83	86	81	82	0.21

... contd

Table A4.1 Percentage of Correct Responses for Mathematics Items: Population 1 (contd)

Item/ sample	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median disc.
B33/B9								
1964		47	30	45		29	30	0.45
1978R		34	33	59		41	36	0.48
1978	47	35	37	63	40	42	39	0.49
B34/B10								
1964		71	67	72		52	62	0.50
1978R		57	47	70		61	47	0.50
1978	70	59	53	72	56	62	50	0.51
B35/B11								
1964		42	56	47		59	52	0.52
1978R		37	28	32		29	37	0.48
1978	50	39	33	35	32	31	39	0.49
B36/B12								
1964		36	36	32		31	28	0.08
1978R		31	34	30		26	34	0.29
1978	41	33	35	33	36	28	35	0.33
B37/B13								
1964		63	61	59		60	51	0.32
1978R		52	48	64		62	53	0.33
1978	61	53	49	64	61	63	54	0.32
B38/B14								
1964		38	33	37		32	29	0.24
1978R		36	31	35		40	31	0.37
1978	39	36	33	37	35	41	33	0.38
B39/B15								
1964		29	35	23		29	19	0.32
1978R		37	29	36		30	31	0.43
1978	45	38	34	38	31	30	32	0.45
B40/B16								
1964		46	53	50		41	41	0.42
1978R		47	42	58		53	48	0.47
1978	58	50	45	59	54	56	48	0.48

... contd

Table A4.1 Percentage of Correct Responses for Mathematics Items: Population 1 (contd)

Item/ sample	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median disc.
B41/B17								
1964		45	53	49		38	41	0.46
1978R		45	42	51		47	41	0.41
1978	56	45	44	53	49	48	42	0.42
B42								
1964								
1978R		59	49	58		50	46	0.25
1978	55	59	50	58	60	51	44	0.25
B43/B19								
1964		7	8	7		4	5	0.23
1978R		7	7	12		6	4	0.20
1978	9	9	8	13	8	6	4	0.30
B44								
1964								
1978R		33	25	28		35	20	0.29
1978	36	33	29	29	28	36	22	0.33
B45/B21								
1964		53	44	52		37	42	0.27
1978R		43	44	53		50	43	0.26
1978	44	43	48	53	53	53	44	0.26
B46								
1964								
1978R		55	49	65		55	51	0.39
1978	59	57	52	66	61	57	53	0.41
B47/B23								
1964		37	28	45		32	35	0.37
1978R		29	23	35		29	24	0.36
1978	36	30	26	39	27	29	25	0.34
B48/B24								
1964		80	78	81		72	69	0.41
1978R		68	70	73		68	62	0.39
1978	77	70	70	76	69	69	64	0.41

... contd

Table A4.1 Percentage of Correct Responses for Mathematics Items: Population 1 (contd)

Item/ sample	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median disc.
C49/C1								
1964		76	77	85		73	69	0.38
1978R		73	72	76		74	68	0.40
1978	81	75	73	77	70	75	70	0.40
C50/C2								
1964		40	57	66		52	45	0.23
1978R		47	44	56		58	44	0.27
1978	59	47	47	56	61	58	46	0.28
C51/C3								
1964		57	61	79		72	52	0.44
1978R		47	48	55		48	44	0.51
1978	57	48	52	57	47	52	47	0.48
C52/C4								
1964		37	41	64		25	28	0.55
1978R		36	30	56		38	35	0.57
1978	43	36	35	58	43	40	37	0.60
C53/C5								
1964		74	77	68		74	58	0.47
1978R		60	43	55		65	51	0.44
1978	65	61	45	56	52	65	53	0.45
C54/C6								
1964		58	57	71		62	52	0.52
1978R		44	38	54		42	41	0.50
1978	53	46	43	56	48	44	43	0.51
C55/C7								
1964		42	37	58		37	36	0.49
1978R		25	25	28		23	22	0.31
1978	31	27	26	30	26	24	23	0.34
C56/C8								
1964		44	47	48		38	40	0.46
1978R		39	40	48		43	37	0.48
1978	51	41	43	51	46	45	39	0.48

... contd

Table A4.1 Percentage of Correct Responses for Mathematics Items: Population 1 (contd)

Item/ sample	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median disc.
C57/C9								
1964		39	44	41		31	38	0.48
1978R		40	39	51		43	41	0.49
1978	52	41	43	53	47	46	43	0.43
C58/C10								
1964		15	11	18		11	9	0.40
1978R		12	14	17		12	9	0.41
1978	17	13	15	17	15	13	10	0.40
C59/C11								
1964		58	62	61		48	40	0.44
1978R		53	49	56		56	47	0.45
1978	66	55	50	58	61	57	48	0.47
C60								
1964		45	39	56		46	40	0.39
1978R		45	39	56		46	40	0.39
1978	50	47	42	57	47	47	42	0.40
C61/C13								
1964		27	29	24		25	23	0.18
1978R		21	21	25		26	17	0.19
1978	23	23	23	25	25	25	18	0.21
C62/C14								
1964		40	36	36		40	36	0.22
1978R		39	36	39		37	36	0.15
1978	40	39	37	40	39	38	36	0.12
C63/C15								
1964		56	57	55		55	48	0.38
1978R		52	50	57		50	51	0.35
1978	64	51	52	58	55	51	53	0.34
C64/C16								
1964		12	11	15		10	10	0.05
1978R		10	9	14		13	9	-0.06
1978	13	11	10	13	10	12	8	0.00

... contd

Table A4.1 **Percentage of Correct Responses for Mathematics Items: Population 1 (contd)**

Item/ sample	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median disc.
C65/C17								
1964		16	10	17		16	11	0.12
1978R		21	15	25		21	17	0.24
1978	26	22	16	26	19	23	17	0.26
C66/C18								
1964		21	20	21		22	19	0.15
1978R		20	19	23		20	20	0.13
1978	19	20	20	23	19	20	20	0.11
C67/C19								
1964		23	21	19		21	20	0.16
1978R		38	22	31		37	23	0.22
1978	37	39	25	33	31	40	25	0.23
C68/C20								
1964		39	38	42		37	33	0.42
1978R		27	26	34		31	27	0.34
1978	31	28	28	35	33	32	27	0.35
C69/C21								
1964		27	29	45		27	26	0.40
1978R		27	20	33		22	21	0.30
1978	31	28	23	34	24	23	21	0.33
C70/C22								
1964		48	49	48		45	34	0.41
1978R		35	33	42		44	30	0.39
1978	40	36	34	43	40	44	32	0.38
C71/C23								
1964		45	47	48		41	42	0.28
1978R		36	37	41		40	35	0.19
1978	45	37	36	41	41	40	36	0.17
C72								
1964								
1978R		52	38	55		22	32	0.33
1978	65	49	37	57	41	24	32	0.33

Table A4.2 Percentage of Correct Responses for Mathematics Items: Population 3

Item/ sample	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median disc.
D01/5.01								
1964		92	93	96		87	97	0.16
1978R		87	98	93		87	97	0.22
1978	82	89	96	95	92	87	96	0.22
D02/5.02								
1964		46	51	67		44	64	0.25
1978R		57	66	75		63	69	0.20
1978	69	58	64	75	63	59	70	0.23
D03/5.03								
1964		62	66	72		59	69	0.22
1978R		55	68	73		53	74	0.28
1978	56	58	69	71	61	54	75	0.27
D04/5.04								
1964		94	95	93		91	95	0.06
1978R		81	95	86		80	93	0.25
1978	66	85	95	88	88	79	94	0.25
D05/5.05								
1964		28	31	30		11	50	0.29
1978R		57	53	79		63	64	0.28
1978	62	57	51	75	68	61	65	0.27
D06/5.06								
1964		92	94	89		82	86	0.20
1978R		82	88	87		85	92	0.34
1978	70	85	88	87	86	83	92	0.31
D07/5.07								
1964		65	54	59		73	57	0.28
1978R		58	63	62		53	65	0.21
1978	55	59	62	62	59	56	64	0.23
D08/5.08								
1964		84	94	93		88	94	0.14
1978R		61	59	61		67	71	0.23
1978	62	61	58	63	46	67	69	0.21

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Table A4.2 Percentage of Correct Responses for Mathematics Items: Population 3 (contd)

Item/ sample	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median disc.
D09/5.09								
1964		70	70	58		52	60	0.29
1978R		44	51	43		34	57	0.38
1978	38	39	51	42	27	33	58	0.29
D10/5.10								
1964		71	79	81		46	78	0.26
1978R		71	84	76		62	89	0.32
1978	58	72	80	77	80	64	87	0.35
D11/5.11								
1964		35	47	30		30	61	0.27
1978R		46	56	46		40	55	0.29
1978	46	40	52	44	43	40	58	0.28
D12/5.12								
1964		49	59	57		51	63	0.27
1978R		38	52	49		39	57	0.36
1978	34	36	54	48	38	41	58	0.37
D13/5.13								
1964		53	53	61		37	50	0.17
1978R		45	34	38		40	44	0.27
1978	42	41	38	36	32	36	42	0.23
D14/5.14								
1964		45	58	51		49	65	0.26
1978R		63	54	58		48	59	0.31
1978	59	60	53	56	41	47	58	0.28
D15/5.15								
1964		30	30	12		15	40	0.31
1978R		25	51	49		16	47	0.35
1978	35	20	41	48	87	17	48	0.39
D16/5.16								
1964		79	82	60		67	67	0.36
1978R		64	79	57		71	87	0.37
1978	52	68	76	60	56	72	86	0.37

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Table A4.2 Percentage of Correct Responses for Mathematics Items: Population 3 (contd)

Item/ sample	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median disc.
D17/5.17								
1964		19	23	24		18	67	0.18
1978R		31	29	35		22	64	0.38
1978	26	32	33	36	39	21	62	0.37
D18/5.18								
1964		47	51	26		29	24	0.38
1978R		21	36	42		28	34	0.36
1978	20	18	32	37	21	27	40	0.37
D19/5.19								
1964		42	63	33		25	69	0.25
1978R		41	55	32		32	70	0.29
1978	34	38	54	31	41	29	70	0.32
D20/5.20								
1964		64	76	45		65	60	0.33
1978R		57	73	50		29	67	0.32
1978	40	57	46	48	52	30	70	0.32
D21/5.21								
1964		59	62	59		48	66	0.24
1978R		36	47	48		41	56	0.28
1978	43	36	46	50	36	41	56	0.32
D22/7.01								
1964		25	28	34		5	58	0.31
1978R		76	66	68		70	77	0.31
1978	64	79	65	73	64	69	80	0.33
D23/7.02								
1964		68	74	67		55	83	0.32
1978R		44	79	64		29	80	0.40
1978	38	42	73	60	57	32	82	0.38
D24/7.03								
1964		38	31	31		31	38	0.06
1978R		21	17	28		27	30	0.11
1978	23	22	19	30	18	27	28	0.10

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Table A4.2 Percentage of Correct Responses for Mathematics Items: Population 3 (contd)

Item/ sample	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median disc.
E25/7.04								
1964		60	71	65		60	68	0.22
1978R		56	54	62		60	68	0.23
1978	57	52	58	64	55	58	69	0.22
E26/7.05								
1964		9	32	16		3	26	0.31
1978R		9	8	8		5	18	0.36
1978	4	6	7	8	2	3	16	0.31
E27/7.06								
1964		24	46	35		11	36	0.39
1978R		22	25	26		15	24	0.30
1978	17	20	30	25	19	15	27	0.33
E28/7.07								
1964		25	22	26		17	26	0.14
1978R		32	29	36		32	30	0.24
1978	30	31	33	36	30	29	31	0.24
E29/7.08								
1964		26	6	22		22	23	0.04
1978R		22	47	46		7	42	0.34
1978	27	18	39	49	84	10	43	0.29
E30/7.09								
1964		8	16	3		1	31	0.27
1978R		23	24	9		11	34	0.35
1978	8	20	19	9	18	10	36	0.32
E31/7.10								
1964		5	10	12		11	19	0.04
1978R		29	27	29		22	30	0.33
1978	21	29	29	27	21	20	33	0.33
E32/7.11								
1964		51	45	40		34	44	0.43
1978R		26	29	34		19	42	0.30
1978	18	22	26	33	31	18	45	0.30

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Table A4.2 <u>Percentage of Correct Responses for Mathematics Items: Population 3</u> (contd)

Item/ sample	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median disc.
E33/7.12								
1964		40	60	41		38	58	0.24
1978R		52	55	59		45	73	0.28
1978	53	53	56	62	42	43	73	0.31
E34/7.13								
1964		33	49	34		31	53	0.23
1978R		48	53	59		44	67	0.35
1978	46	50	53	61	45	40	68	0.30
E35/7.14								
1964		3	2	7		6	25	0.00
1978R		43	26	36		37	39	-0.02
1978	32	39	29	34	31	34	37	-0.02
E36/7.15								
1964		15	10	13		3	11	0.14
1978R		5	26	5		2	7	-0.03
1978	7	5	28	6	48	2	6	0.11
E37/7.16								
1964		2	9	3		1	7	0.16
1978R		1	2	1		0	4	0.24
1978	1	1	2	3	5	0	10	0.22
E38/7.17								
1964		37	50	37		46	53	0.37
1978R		19	35	26		18	40	0.38
1978	16	16	32	26	47	15	42	0.38
E39/8.01								
1964		76	73	61		48	65	0.39
1978R		52	63	47		52	77	0.49
1978	34	52	65	44	44	54	80	0.46
E40/-								
1964								
1978R		20	50	18		26	23	0.27
1978	20	23	47	23	30	25	21	0.26

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Table A4.2 Percentage of Correct Responses for Mathematics Items: Population 3 (contd)

Item/ sample	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median disc.
E41/8.02								
1964		38	52	25		26	32	0.34
1978R		37	52	33		29	48	0.33
1978	29	39	44	35	25	29	49	0.31
E42/8.03								
1964		53	55	48		49	63	0.24
1978R		57	65	65		62	61	0.24
1978	62	57	67	66	54	57	62	0.25
E43/8.04								
1964		41	58	53		37	41	0.35
1978R		23	50	28		23	48	0.31
1978	18	20	41	26	28	23	46	0.33
E44/8.05								
1964		41	47	47		32	53	0.19
1978R		52	56	48		48	48	0.18
1978	45	54	54	51	52	47	49	0.25
E45/8.06								
1964		27	10	24		7	23	0.24
1978R		21	31	23		10	20	0.08
1978	17	15	29	21	33	10	15	0.25
E46/8.07								
1964		33	44	42		16	64	0.26
1978R		46	46	52		37	59	0.24
1978	40	46	49	55	48	33	61	0.28
E47/8.08								
1964		24	32	37		18	61	0.21
1978R		37	44	53		25	51	0.27
1978	37	35	48	55	47	24	53	0.30
E48/8.09								
1964		18	30	26		12	43	0.25
1978R		26	30	40		21	44	0.29
1978	30	26	34	29	35	22	45	0.27

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Table A4.2 <u>Percentage of Correct Responses for Mathematics Items: Population 3</u> (contd)

Item/ sample	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median disc.
<u>F49/8.10</u>								
1964		31	51	30		29	31	0.18
1978R		41	42	31		39	26	0.10
1978	40	37	40	30	36	40	26	0.09
<u>F50/8.11</u>								
1964		10	12	19		11	23	0.04
1978R		23	25	15		20	19	0.13
1978	24	23	23	15	23	18	19	0.10
<u>F51/8.12</u>								
1964		32	53	18		14	37	0.33
1978R		33	26	29		32	43	0.41
1978	19	27	26	32	35	29	49	0.36
<u>F52/8.13</u>								
1964		9	8	14		8	34	0.04
1978R		65	73	33		78	64	0.26
1978	59	68	73	61	48	77	67	0.29
<u>F53/8.14</u>								
1964		11	8	17		9	18	-0.6
1978R		23	53	33		12	24	0.17
1978	24	18	53	36	50	11	22	0.21
<u>F54/8.15</u>								
1964		43	68	47		40	57	0.35
1978R		32	68	48		23	69	0.47
1978	26	32	58	48	47	21	68	0.52
<u>F55/8.16</u>								
1964		1	8	0		0	31	0.23
1978R		3	7	1		1	30	0.26
1978	1	2	5	1	14	1	30	0.29
<u>F56/-</u>								
1964								
1978R		16	19	11		11	13	0.18
1978	10	16	20	13	12	11	11	0.19

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Table A4.2 **Percentage of Correct Responses for Mathematics Items: Population 3** (contd)

Item/ sample	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median disc.
F57/9.01								
1964		91	92	78		82	92	0.19
1978R		75	78	62		66	89	0.33
1978	60	77	77	70	65	63	91	0.42
F58/9.02								
1964		14	19	18		3	10	0.34
1978R		8	3	4		4	3	0.23
1978	4	6	2	6	3	4	4	0.21
F59/9.03								
1964		53	60	44		36	36	0.43
1978R		63	58	50		28	56	0.40
1978	35	64	55	51	52	26	54	0.40
F60/9.04								
1964		14	20	9		7	10	0.11
1978R		24	42	16		12	12	0.24
1978	22	23	31	18	15	12	13	0.23
F61/9.05								
1964		77	81	65		51	62	0.34
1978R		74	79	54		36	44	0.47
1978	43	77	71	54	63	29	48	0.43
F62/9.06								
1964		28	24	20		8	25	0.34
1978R		18	18	10		9	13	0.36
1978	7	18	16	10	14	9	11	0.37
F63/9.07								
1964		48	56	41		10	31	0.33
1978R		22	29	19		13	24	0.27
1978	17	21	26	23	22	12	23	0.27
F64/9.08								
1964		17	22	23		6	24	0.17
1978R		35	24	27		20	23	0.28
1978	23	36	26	27	28	18	26	0.35

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Table A4.2 Percentage of Correct Responses for Mathematics Items: Population 3 (contd)

Item/ sample	ACT	NSW	Vic.	Qld	SA	WA	Tas.	Median disc.
F65/0.09								
1964		60	64	51		13	51	0.42
1978R		29	48	25		15	32	0.50
1978	16	28	39	25	25	12	36	0.49
F66/9.10								
1964		25	36	38		12	19	0.17
1978R		27	27	36		19	27	0.25
1978	29	25	27	35	29	15	27	0.19
F67/9.11								
1964		28	25	26		10	14	0.27
1978R		41	43	36		24	26	0.36
1978	28	43	41	35	22	22	26	0.36
F68/9.12								
1964		21	24	9		11	26	0.23
1978R		20	13	9		16	22	0.37
1978	10	18	15	10	10	14	23	0.29
F69/9.13								
1964		42	50	42		26	51	0.11
1978R		41	58	46		23	46	0.22
1978	41	41	53	46	68	24	44	0.21
F70/9.14								
1964		46	35	45		31	29	0.27
1978R		30	25	23		25	33	0.40
1978	24	27	25	23	18	23	33	0.17
F71/9.15								
1964		7	21	7		6	10	0.20
1978R		13	11	9		15	11	0.13
1978	9	11	10	9	18	13	17	0.19
F72								
1964								
1978R		19	42	15		22	11	0.41
1978	12	19	39	21	20	20	13	0.37

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