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ABSTRACT

In July 1983, the Board of Advanced Education, Queensland, Australia, considered the problem of the acute shortage of secondary science and mathematics teachers and the role of teacher education in remedying the situation. The Board of Teacher Education was approached and asked to investigate matters pertaining to the supply and education of mathematics and science teachers within the state. This document represents the report of the Working Committee appointed by the Board of Teacher Education, and is a result of the committee's numerous meetings and surveys. The report contains information pertaining to: (1) the teacher crisis in mathematics and science; (2) participation, achievement and attitudes of secondary students in science and mathematics; (3) mathematics and science in the curriculum (including a historical overview of curricula in Queensland from 1964 to 1984); (4) current education of science and mathematics teachers; and (5) future directions in the education of science and mathematics teachers. The appendices include a list of recommendations, the interim report of the working committee, an analysis of class teacher qualifications and descriptions of current programs available in Queensland for the preparation of science and mathematics teachers. (TW)

TEACHERS FOR MATHEMATICS AND SCIENCE

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SE

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THE WORKING PARTY

Chairman: Dr G.A.G. Jones, B.Sc., B.Ed.(Hons)(Qld), M.A.(San Diego), Ph.D.(Indiana), F.A.C.E., Campus Principal, Carseldine Campus, Brisbane College of Advanced Education.

Members: Professor B.L. Adkins, M.A.(Melb.), B.Sc., Ph.D.(Qld), Pro-Vice-Chancellor, Social Sciences, University of Queensland.

Mr N.H. Fry, B.A., B.Sc., B.Ed.(Melb.), M.Ed.Admin.(Qld), M.A.C.E., Executive Officer, Board of Teacher Education, Queensland.

Dr P.L. Galbraith, M.Sc., Dip.Ed.(Melb.), Ph.D.(Qld), M.R.S.V., Senior Lecturer, Department of Education, University of Queensland.

Mr G.F. Harvey, B.E.(Qld), Grad.I.E.Aust., Applied Mechanics Engineer, Queensland Electricity Commission.

Mrs J.A. Hempel, B.A.(Melb.), B.Ed.St.(Qld), M.A.C.E., Deputy Principal, All Hallows School, Brisbane.

Mr J.A. Leech, B.Sc., M.Ed.Admin.(Qld), M.A.C.E., Assistant Director, Secondary Curriculum, Department of Education, Queensland.

Dr K.B. Lucas, B.Sc.(Syd.), Dip.Ed.(N.E.), M.Ed.(Syd.), M.Sc.(Macq.), Ph.D. (Indiana), Head, Department of Science, School of Teacher Education, Kelvin Grove Campus, Brisbane College of Advanced Education.

Ms B.P. O'Rourke, B.Sc.(Syd.), Deputy Principal, Kenmore High School, Queensland.

Associate Professor M.E. Poole, B.A., B.Ed.(Qld), M.A.(N.E.), Ph.D.(La Trobe), M.A.Ps.S., Associate Professor in Education, Macquarie University.

Secretary: Dr C.J. Cliff, B.Sc.(Hons)(A.N.U.), Ph.D.(Keele), Dip.Env.St.(Macq.), A.R.A.C.I., M.A.S.M.F., Senior Administration Officer, Board of Advanced Education, Queensland.

Miss D.K. Cunningham and Mr G.J. Duck of the Board of Teacher Education provided the Working Party with considerable research support. The report and draft of the report were typed by Miss A.M. Condon of the Board of Advanced Education and Mrs A.M. Agnew of the Brisbane College of Advanced Education, Carseldine.

BACKGROUND

In July 1983 the Board of Advanced Education, Queensland considered the problem of the acute shortage of secondary science and mathematics teachers and the role of teacher education in remedying the situation. It approached the Board of Teacher Education to investigate matters pertaining to the supply and education of mathematics and science teachers within the State.

The Working Party on the Preparation of Teachers in Mathematics and Science was set up by the Board of Teacher Education, Queensland, under the aegis of its Teacher Education Review Committee to consider the issue of teacher supply and quality in the areas of mathematics and science. Under its terms of reference the Working Party was to undertake:

- a review of the projected needs for science and mathematics teachers in Queensland;
- an examination of the various routes and courses currently available for the education and training of science and mathematics teachers;
- an examination of the quality and quantity of entrants to such courses and possible means of obtaining sufficient numbers of entrants of the requisite quality;
- an examination of the mathematics/science curriculum in relation to the total secondary curriculum, with specific consideration being given to the attitudes developed in mathematics/science through the curriculum process and current methodologies;
- consideration of pathways in tertiary education for mathematics/science teaching including in-service education for teachers trained in these areas and conversion courses for teachers whose preparation was in other areas;
- a review of the literature on the participation of students in mathematics/science and mathematics/science teacher education courses;
- such other matters as may be relevant to the provision of an adequate supply of qualified teachers in these areas.

The Working Party met on 13 occasions between 30 September 1983 and 1 May 1985. Conscious of the urgent need for action to be taken to alleviate the shortage of mathematics and science teachers, the Working Party presented an Interim Report (Appendix 2) to the Board of Teacher Education at its meeting on 13 February 1984. That report was circulated by the Board for comment and action by employing authorities, colleges of advanced education, universities, co-ordinating authorities and other interested parties in Queensland. The response received was taken into account in the preparation of this report.

CHAPTER 1

THE TEACHER CRISIS IN MATHEMATICS AND SCIENCE

Abstract

Evidence of a chronic worldwide shortage of mathematics and science teachers is presented and a study of supply and demand for teachers is recommended. Fundamental causes of the shortage are identified, including: societal expectations and norms, the developing information and technological culture; status, stress and alternative career opportunities; support provisions for teachers; and the impact of sex differences

It is pointed out that the recursive nature of the problem will mean that long-term solutions might exacerbate the current shortage while more superficial short-term measures could be detrimental in the long term. Multifarious solutions to the shortage are adumbrated, including: changes to recruiting procedures, changes to the structure and entry requirements of teacher education programs; improvements to the secondary science and mathematics curricula; improved teacher support programs; and improved public support for mathematics and science teachers and programs.

1.1 Overview

In relation to a recent survey of the actual and potential supply of mathematics and science teachers in the United States of America, Snymansky and Aldridge (1983) wrote:

> "Our nation faces unprecendented problems in science and engineering education, the most severe of which is the critical shortage of qualified science and mathematics teachers. The problem is not new. Studies by the National Education Association (1981) and Akin (1980) have carried the message for several years. Yet school goes on. Is the problem not as severe as the data suggest or worse than we realise?"

A similar message echoed in other parts of the world and in Australia. Cockcroft (1982), reporting on the United Kingdom, noted that the shortage of good mathematics teachers had been a matter of concern for many years and, moreover, that mathematics was especially vulnerable to weak teaching. Characterising the Australian scene Leckey (1984) wrote.

> "The serious shortage of physics, maths and chemistry teachers often leads to these subjects being taught 'less than perfectly' by non-specialist teachers in junior high schools."

In Queensland the major employing authority, the Department of Education, has indicated that the present shortage in supply of secondary mathematics and science teachers is real, extensive and likely to be protracted. That view was supported by the most recent report of the committee convened by the Board of Advanced Education on the Review of Teacher Supply and Demand in Queensland (1982), which called for significant increases in quotas for all pre service courses in secondary mathematics and science teaching, at least until 1988. Moreover the Working Party was provided with evidence that the current low quotas were not being met.

The Working Party found two inter-related aspects of the crisis reflected in the reports before it. One was that the problem had existed for some time so that the discrepancy between supply and demand was continually worsening. The other was that a ready supply of potential mathematics and science teachers was not being generated by the school system, partly because many able students in those areas were turning to related areas such as computing and other scientific endeavours, but mainly because students were tending to avoid the study of traditional mathematics and science subjects in their high school years. (STEP REPORTS : 1975–1977, 1976–1979).

It may be that disenchantment with school mathematics and science reflects the quality of teaching experienced. If so, the situation is unlikely to be reversed while the present teacher shortage remains. The problem is clearly complex and resistant to simple solutions but the penalty for not acting is frightening for future generations of school-aged children and the nation at large.

1.2 Demand and Supply in Queensland

1.2.1 Board of Advanced Education Review

In October 1982 a committee convened by the Board of Advanced Education (BAE) presented its **Review of Teacher Supply and Demand Situation in Queensland.** It pointed out that, since secondary school enrolments were expected to continue increasing until the late 1980s, the shortage of secondary school teachers was likely to be exacerbated in the immediate future. The review also contained a recommendation that universities and colleges involved in secondary teacher education should, as a matter of urgency, adjust enrolment intakes from the beginning of 1983 to accommodate the increased intakes in the committee's projections.

The committee's proposed pattern of intakes underlined the fact that the most critical areas of shortage were in mathematics and science. At the Brisbane College of Advanced Education (BCAE), for example, the proposed increase in the number of mathematics and science students entering the Diploma of Teaching course for 1983 over 1982 was 248%, while in other secondary areas it was generally less than 100%.

1.2.2 Demand and Supply: Science/Mathematics Diploma Entrants at BCAE

The BCAE Diploma of Teaching (Secondary) with principal teaching areas in science and mathematics is a three-year course. It is one of the largest suppliers of beginning teachers in those areas to employing authorities in the State. The graph below shows the intake of science-mathematics entrants proposed for 1983–1987 by the BAE's Review Committee and the actual intakes in 1983–1985.

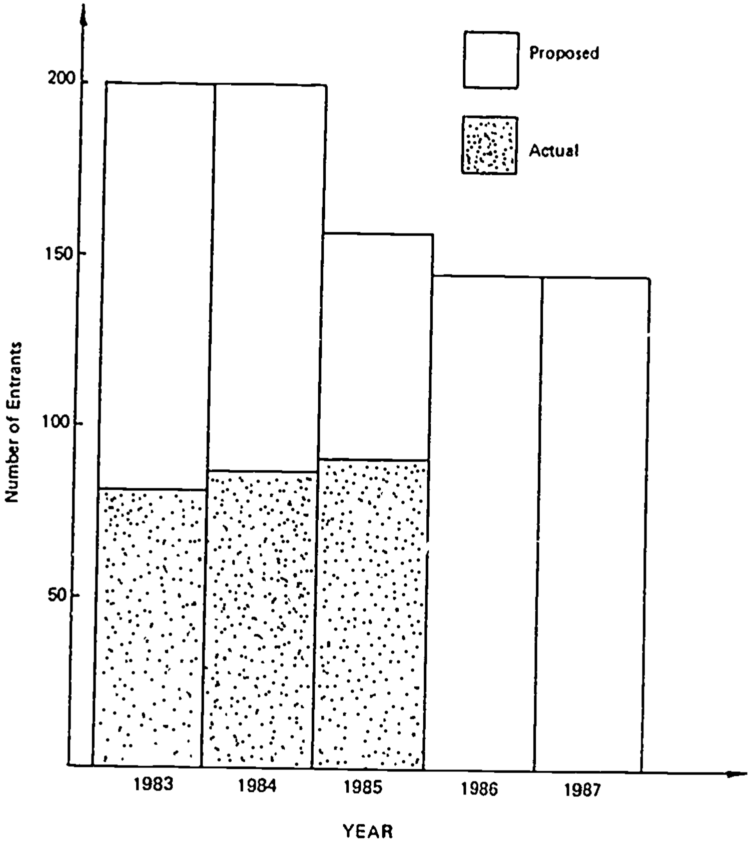

Figure 1.1: Proposed/Actual Number of Entrants : BCAE Diploma of Teaching (Secondary Science and Mathematics)

The very large number of entrants perceived to be needed, and the shortfall that is occurring is obvious from the graph. Overall the number of students entering the course was less than 50% of the number seen to be required even though there have been some gains in recent years. Moreover it should be noted that additional entrants were not available, even at a minimally desirable level of entry

The median and range of TE scores for entrants into the science and mathematics strands of BCAE's Diploma of Teaching (Secondary) for 1981 through 1985 are listed in Table 1.1.

Table 1.1: Median and Range of TE Scores for Diploma of Teaching (Science and Mathematics : 1981–1985)

Statistic	1981*	1982*	1983	1984	1985
Median	845 (M) 840 (S)	860 (M) 855 (S)	860 (M) 830 (S)	900 (M) 890 (S)	880 (M) 875 (S)
Range	790–980 (M) 780–960 (S)	780–960 (M) 800–950 (S)	780–980 (M) 780–990 (S)	840–980 (M) 840–990 (S)	820–980 (M) 825–990 (S)

Key. M – Mathematics
S – Science
* – Kelvin Grove CAE figures prior to amalgamation.

Substantial numbers of students have entered the course with low TE scores and median entry levels for the science strand and for the mathematics strand have generally been lower than those for other strands. College staff have usually found that students with a TE score lower than 820 had difficulty completing the course. In 1984 there was a dramatic improvement in the minimum and median levels of entry. This was associated with a significant increase in the number of non-school-leaver applicants who were considered to be well qualified for entry. Whether that increase was indicative of a sustained renaissance is still at issue, particularly in view of the slight regression in minimum and median levels of entry in 1985. It appears that there are a number of unknown factors operating from year to year in relation to the size of both the school-leaver and the non-school-leaver pools of applicants. Certainly the College has maintained a high profile in marketing the course across the community at large.

An additional feature related to the issue of supply and demand is that the preferred science-teaching area of most students entering the course was biology – the area of least critical shortage for employing authorities. More critical areas of shortage were physics and chemistry – those least preferred by students.

1.2.3 Demand and Supply: Science/Mathematics Entrants in Pre-service Graduate Courses

The University of Queensland offers a one-year Diploma in Education course for graduates. That course has traditionally provided a substantial supply of new teachers in science and mathematics.

The graph below compares the actual numbers of entrants with the acceptable quotas set for the strands in biological science, chemistry, physics, multistrand science and mathematics for the years 1980 to 1985. It should be noted that the quotas set by the University for each of its curriculum strands were guideline figures and, in practice, it would be unusual for all of the individual quotas to be met, given the size of the overall intake. The quota figure does, however, give an indication of perceived needs in relation to curriculum strands.

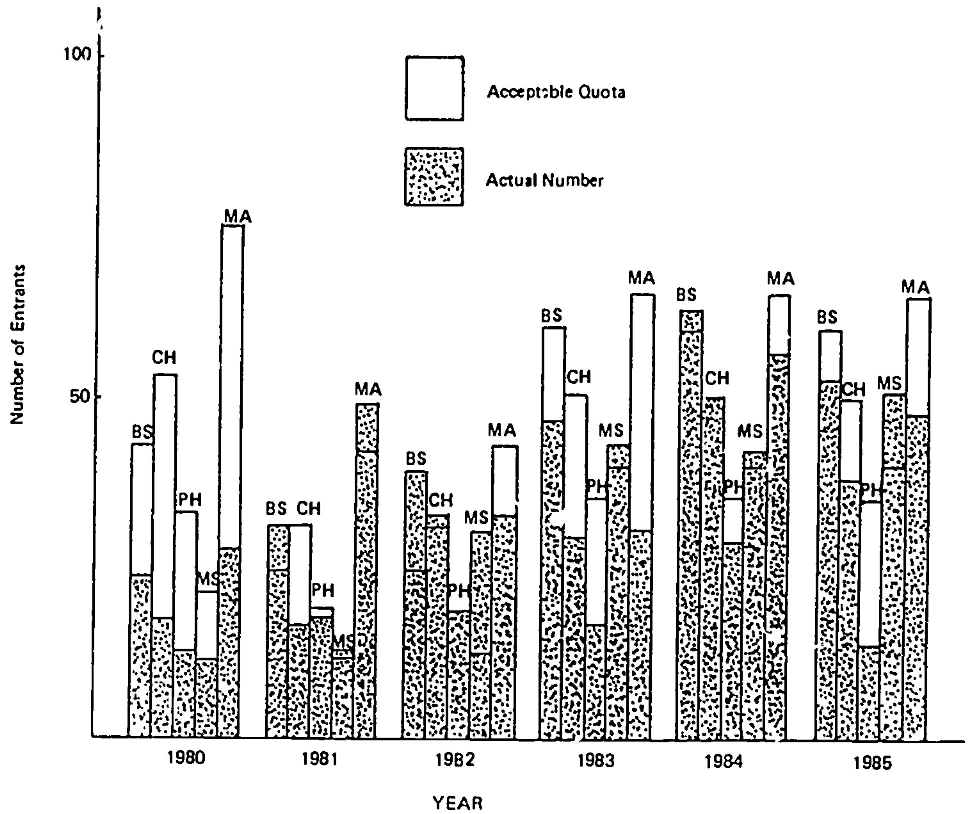

Figure 1.2: Acceptable Quotas/Actual Numbers of Entrants : University of Queensland Diploma in Education (Science and Mathematics Strands)

Key: BS – Biological Sciences
CH – Chemistry
PH – Physics
MS – Multistrand Science
MA – Mathematics

Clearly there were considerable fluctuations within each year as well as across years making it difficult to establish clear trends in the data. Overall, the total number of students studying the science and mathematics strands has increased. The largest increases, in 1983 and 1984, were presumably in response to the Review Committee's recommendation for adjustments.

Steady increases have occurred in the numbers of students entering the biological science, chemistry and multistrand science areas while the numbers entering the physics and mathematics strands have tended to fluctuate. The University has attempted to gear the acceptable quota to the demand for teachers. It is therefore noteworthy that mathematics and, to a lesser extent, physics were the areas where the acceptable quota was most often not attained.

The BCAE Graduate Diploma in Teaching is a similar one-year course for graduates The total entry for the course has varied from 70 to 100 and the quota for the science and mathematics strands has ranged from 20 to 35.

The graph below compares the actual numbers of entrants with the numbers of entrants proposed by the Review Committee for the science and mathematics strands in 1982 through to 1985.

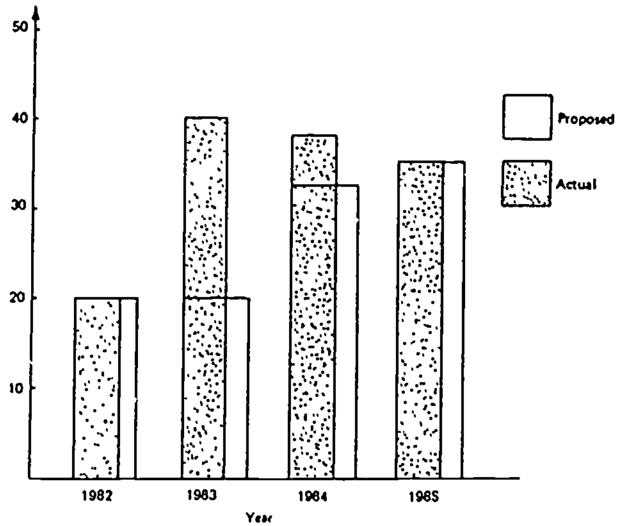

Figure 1.3: Proposed/Actual Numbers of Entrants : BCAE Graduate Diploma in Teaching (Science and Mathematics Strands)

The pattern of entry to the BCAE Graduate Diploma in Teaching is similar to that of the University of Queensland Diploma in Education. The availability of qualified entrants since 1982 has increased and in 1983, 1984 and 1985 the actual number of entrants was at least as large as the proposed figure put forward by the Board of Advanced Education Committee of Review.

In 1984 there were 59 additional applicants for the science and mathematics strands who met the criteria for admission but could not be given places because of the unavailability of staffing resources and pressure on the College to meet commitments in other pre-service teacher-education courses. No additional applicants were turned away in 1985, indicating that those students who had been amongst the 1984 surplus had been lost in the ensuing period. Clearly, tertiary institutions involved in pre-service graduate courses in science and mathematics teacher education need to be able to act promptly and flexibly to accept applicants when they are available.

In summary, the apparent increase in the availability of graduates in science and mathematics who wish to enter teaching through the University of Queensland and BCAE graduate programs offers considerable potential for effecting a short-term solution to the problem of supply. It is vital that resources be provided so that quotas can be raised and applicants admitted when they are available.

1.2.4 Demand and Supply: Science/Mathematics Entrants to the Bachelor of Education course at James Cook University of North Queensland

The James Cook University of North Queensland offers a four-year Bachelor of Education degree which has supplied a small number of mathematics and science teachers. Graduates with suitable degrees may be given advanced standing in the course: these graduates are then able to complete the degree in the equivalent of two years of full-time study. There is no quota on the number of entrants to the course. The number of students commencing the mathematics/science strand of the Bachelor of Education degree is shown below in Table 1.2.

Table 1.2: Number of entrants to James Cook University of North Queensland Bachelor of Education degree mathematics/science strand

Year	No. of Entrants
1981	2
1982	7
1983	5
1984	26
1985	29

The table shows that there has been a very substantial increase in the number of students entering the mathematics/science strand of the Bachelor of Education degree in 1984 and 1985. About half of these entrants in 1984 and 1985 were graduates required to undertake two years' study in order to complete the degree.

The increase in demand by students for the degree is likely to have been a result of the publicity given to the shortage of mathematics and science teachers over the last few years and the particularly high profile adopted by the university in publicising the shortage.

1.2.5 Demand and Supply: Conclusion

The Working Party wishes to acknowledge the work of the Board of Advanced Education's Committee which prepared the Review of Teacher Supply and Demand Situation in Queensland. It noted with pleasure that the Board of Advanced Education had reconvened that Committee which will review the teacher supply and demand position in Queensland in the light of actual intakes and of the recently announced increases in State teaching service staff ceilings.

The Working Party recommends:

R1.1 that annual reviews of teacher supply and demand in Queensland be conducted during the first half of each year.

1.3 Who is Teaching Science and Mathematics?

Since employing authorities are expressing genuine concerns in relation to the shortage of science and mathematics teachers and since there is clear evidence that the shortage has not only persisted over a substantial period of time, but also is unlikely to be accommodated in the near future, it is appropriate to examine the qualifications and teaching competence of those who are currently teaching mathematics and science in schools.

Shymansky and Aldridge (1982) commenting on the situation in the USA reported that half of all newly employed science and mathematics teachers were unqualified to teach science or mathematics. They added: "The number of these emergency teachers is staggering.", and quoted figures as high as 84% in some school regions.

In the United Kingdom, the Cockcroft Report (1982) painted a similar picture based on a survey of secondary staffing. It stated:

> "On a national basis, the information provided by the survey suggests that there were in 1977 some 1,500 (about 35%) secondary schools in which at least 70% of the mathematics teaching was in suitable hands; and that these included some 240 schools (mainly sixth form colleges and grammar schools) in which all mathematics teaching was by teachers with a suitable qualification. On the other hand, the results of the survey suggest that there were nearly 1,300 schools (about 30%) in which less than half of the mathematics teaching was in suitable hands and that those included some 150 schools (mainly modern schools) in which none of the teaching was by teachers with a suitable qualification. In the remaining 1,500 schools, between 50% and 70% of the mathematics teaching was suitably staffed."

The United Kingdom survey showed that, overall, 38% of all mathematics teaching in maintained secondary schools was being undertaken by teachers whose qualifications to teach mathematics were either weak or non-existent; in other words, almost two-fifths of all mathematics teaching was in unsuitable hands.

Both surveys made judgements of suitability in terms of qualifications rather than in terms of criteria based on teaching proficiency. Teaching proficiency is by its very nature a much more intangible and subjective criterion but probably of greater value in judging suitability. This Working Party has examined suitability in terms of both criteria: qualifications and teaching proficiency.

1.3.1 Survey of the Adequacy of Current Staffing in Science and Mathematics in Queensland Schools*

In November 1983 the principals of all Queensland government and non-government schools with secondary students were surveyed in order to ascertain their perceptions of the adequacy of their staffing in science and mathematics.

Two types of information were sought. First, factual information was requested concerning the number of students enrolled in science and mathematics subjects at both junior and senior levels, and the number of classes in each area. Second, for each subject area, principals were asked to give their opinions concerning the number of classes being taught by teachers they considered to be (1) well qualified to teach the subject, (2) adequately qualified to teach the subject, and (3) poorly qualified to teach the subject.

Principals' comments and responses suggested that some defined well qualified as simply being a registered teacher, others defined it as having post-secondary qualifications in the subject area, while others related it to practical teaching effectiveness. Some principals suggested that their responses would have been quite different if the question had sought information on teaching competency rather than adequacy of qualifications.

* The survey was part of a larger study conducted by the Teacher Education Review Committee of the Board of Teacher Education on Future Requirements for Secondary Teachers: The Views of Queensland Principals.

Table 1.3 presents the survey results for junior level Board of Secondary School Studies subjects in Science and Mathematics.

Table 1.3: **Perceived Quality of Staff in Years 8–10 Board Subjects in Mathematics and Science**

Subject Area	Number of Schools	Number of Classes	Percentage of Classes Taught by Teachers Considered to be:		
			Well Qualified	Adequately Qualified	Poorly Qualified
Science	206	2,737	83	13	4
Mathematics*	206	2,960	82	15	2

* Includes core Mathematics in Years 8 and 9, Advanced, General and Ordinary Mathematics.

Thus 83% of the 2,737 science classes and 82% of the mathematics classes were perceived by principals to be taught by well qualified teachers. While those figures *per se* do not suggest any cause for alarm, it should be noted that in relation to the wider sample of all Years 8 – 10 Board subjects, mathematics and, to a lesser extent, science teachers were perceived to be in the less well qualified subject categories.

Table 1.4 provides the survey results information relating to Years 11 – 12 Board subjects in mathematics and science.

Table 1.4: **Perceived Quality of Staff in Years 11–12 Board Subjects in Science and Mathematics**

Subject Area	Number of Schools	Number of Classes	Percentage of Classes Taught by Teachers Considered to be:		
			Well Qualified	Adequately Qualified	Poorly Qualified
Biology	157	736	91	7	2
Chemistry	151	428	91	8	1
Physics	149	375	91	9	0
Multistrand Science	42	109	81	19	0
Mathematics I	152	608	91	9	1
Mathematics II	149	334	96	4	0
Social Mathematics	127	508	82	15	3

Once again the data based on principals' perceptions give little real cause for concern. In comparison with all Year 11 and Year 12 Board subjects, Mathematics II was in the category of subjects whose teachers are rated most favourably while Multistrand Science and Social Mathematics were in the category rated least favourably.

Overall, the pattern of ratings of teacher adequacy differed from junior to senior school. Teachers at the senior level were rated as being well qualified more often than teachers at the junior level. This may reflect a tendency for principals to assign more competent teachers to Year 11 and Year 12 classes.

In addition to providing information on the adequacy of teachers' qualifications, principals were invited to comment on the general staffing situation in their schools. The mathematics and science teachers shortage was the area most frequently mentioned by principals. Principals also commented that academic qualifications did not ensure teachers' possession of effective teaching techniques or the ability to relate to adolescents.

1.3.2 Survey of the Qualifications of Science and Mathematics Teachers in Queensland Schools

The Working Party carried out a survey of the qualifications of science and mathematics teachers in Queensland schools with a view to gauging their level of background and confidence in content areas. As has already been stated in this report, the Working Party was aware that professional qualifications do not necessarily reflect the quality of teaching actually provided.

Population and Sample

The population for the investigation was the set of science and mathematics classes in Queensland Government Secondary Schools, for Years B through 12, which operated in the second semester of 19B4. The population of classes was stratified by region (Brisbane North, Brisbane West, Brisbane South, Darling Downs, South-Western, Wide Bay, Central, Northern, and North-Western), by year level and/or separate subject in the case of Years 11 and 12 science subjects.

The characteristics of the 5% sample of classes which was studied are presented in Table 1.5.

Table 1.5: Sample of Science and Mathematics Classes by Region and Year Level/Subject

Region	BN	BW	BS	DD	SW	WB	C	N	NW	Total
Year 8 Maths	13	7	14	4	2	5	9	9	2	65
Years 9, 10 Maths	24	16	30	11	4	14	16	19	3	137
Senior Maths	17	10	21	6	2	7	9	13	2	87
Junior Science	29	23	39	13	5	16	23	24	5	177
Earth Science	0	1	0	0	0	1	0	0	0	2
Biological Science	8	6	9	2	1	4	5	6	1	42
Multistrand Science	2	2	2	0	0	0	2	1	0	9
Chemistry	3	4	4	2	0	3	2	4	0	22
Physics	3	3	4	1	0	2	3	3	0	19
TOTAL	99	72	123	39	14	52	69	79	13	560

Methodology

Each class in the sample was categorized as follows:

Group 1: Those classes taught by teachers whose qualifications had been obtained by major curriculum studies and major content studies in that subject. Classes whose teachers had completed a Diploma in Education, Graduate Diploma in Teaching, Diploma of Teaching or a Bachelor of Education course with a principal teaching area in the subject under consideration formed the major part of this group.

Group 2: Those classes taught by teachers whose qualifications had been obtained through minor curriculum studies and minor content studies in that subject. For the most part teachers of classes in this group were graduates of a Diploma of Teaching or a Bachelor of Education course with a second teaching area in the subject under consideration.

Group 3: Those classes taught by teachers whose qualifications included substantial content studies but no curriculum studies in the class subject.

Group 4: Those classes taught by teachers whose qualifications comprised minimal or no content studies and no curriculum studies in the class subject. In essence this group contained classes which could not be categorised under Groups 1 through 3.

Results*

The aggregated results of the survey are presented in Table 1.6.

Table 1.6: Class Teacher Qualifications by Category, Year and Subject

CUMULATIVE RESULTS

Subject	Sample Size	Group 1	(%)	Group 2	(%)	Group 3	(%)	Group 4	(%)
Year 8 Maths	65	25	(38)	18	(28)	6	(9)	16	(25)
Years 9, 10 Maths	137	56	(41)	26	(19)	8	(6)	47	(34)
Senior Maths	87	58	(67)	17	(20)	5	(6)	7	(8)
Junior Science	177	118	(67)	33	(19)	3	(2)	23	(13)
Earth Science	2	1	(50)	1	(50)	0		0	
Biological Science	42	35	(83)	4	(10)	1	(2)	2	(5)
Multistrand Science	9	3	(33)	6	(67)	0		0	
Chemistry	22	15	(68)	5	(23)	0		2	(9)
Physics	19	10	(53)	4	(21)	1	(5)	4	(21)
Maths	289	139	(48)	61	(21)	19	(7)	70	(24)
Science	271	182	(67)	53	(20)	5	(2)	31	(11)
TOTAL	560	321	(57)	114	(20)	24	(4)	101	(18)

* Class teacher qualifications by category, region, year and subjects are listed in Appendix 3

Overall, science classes appeared to be taught by more highly qualified teachers than mathematics classes. There were also fewer science classes than mathematics classes taught by less well qualified teachers (Group 4).

Generally, mathematics classes in Years 11 and 12 were taught by more appropriately qualified teachers than was the case for those subjects in Years 8—10. In science, the results were less conclusive, although Biological Science classes in the senior school were taught by more appropriately qualified teachers than science classes in the junior school. The situation in Physics was somewhat surprising where only 53% of classes were in Group 1 and 21% were in Group 2. This may have resulted from the fact that Physics has been a senior subject for a long time and has not in actual practice undergone extensive curriculum changes. A complementary explanation is that the best qualified and more recent graduates were not given Physics classes to teach and that those classes were taught by more experienced but often less well qualified teachers. A third possible explanation is that there was not a sufficient number of well qualified Physics teachers available.

At the junior level particularly in Years 9 and 10, a substantial number of classes (34%) fell into Group 4. That situation was not replicated in Junior Science where 86% of classes were taught by teachers in Groups 1 and 2.

Conclusion

Science classes were generally taught by more suitably qualified teachers than mathematics classes. The situation of Years 9 and 10 mathematics classes seemed to be particularly serious since those years comprised the formative stage, both in a cognitive and in an affective sense, for studies in Senior Mathematics.

Senior classes tended to be taught by more suitably qualified teachers of Mathematics and Biological Science than junior classes.

1.4 Context of Science and Mathematics Teaching

So far this report has concentrated on issues related to the shortage of well qualified science and mathematics teachers and the inadequacy of current methods of supply in meeting the growing crisis. The problem is an international one which has existed for a considerable period of time. Attempts at resolution when they have occurred were generally short term and band aid at best.

Consequently, the Working Party considers that the questions raised in this investigation must be explored beyond the level of a supply-demand response. As a result the Working Party has examined the context of science and mathematics teaching in order to search for fresh insights into the long-term problem. Areas that appeared most relevant to that examination included. societal expectations and norms, the developing information and technological culture, status, stress and alternative career opportunities, support provisions for teachers; and the impact of sex differences.

1.4.1 Societal Expectations and Norms

Bishop and Nickson (1982) writing in the United Kingdom made the following statements in relation to societal expectations and norms:

> "The idea of the autonomous teacher guides much of our system's thinking about planning, teacher education and resource allocation, but the teacher as slave to everyone else's good ideas is more akin to the perceived self of many teachers."

"It may be preferable to think of the ideal science and mathematics teacher as a creative and resourceful curriculum developer skilfully combining the various ideas he has learnt from courses, books and those in advisory roles, to create a satisfactory education for each of his pupils. However, the teacher's reality may be more unpleasant – a harassed cynic feeling utterly frustrated in his genuine attempts to help his pupils by the rigid and unhelpful conditions, created by others, in which he must operate."

Newspaper and other media reports bear ample evidence of the constraining forces that are brought to bear on teachers and schools, e.g. more rigorous standards, the advocacy of greater time allocation to science, mathematics and technology thus lengthening the school year, a return to the curriculum of the fifties or sixties, more emphasis on problem solving and various claims of trivialisation of the mathematics and science taught in school. Moreover the pressures generated by those societal forces are often at variance with each other and with the kinds of directions adumbrated by the profession itself.

If the resulting situation for the science and mathematics teachers is consistent with the picture described by Bishop and Nickson, and this is then reflected in their attitudes to pupils and to the community within which they interact, then it has the potential to be a significant factor in dissuading young people from turning toward a teaching career.

1.4.2 The Developing Information and Technological Culture

Children are rapidly becoming part of a new technological culture as they interact with television, video recordings, and to a lesser but growing extent with microcomputers. Schools on the other hand often represent a conservative trend in society to which teachers and parents subscribe. Consequently there is a widening gap between the school curriculum in science and mathematics and the alternative curriculum of the child stimulated by technology.

The consequence for science and mathematics teachers may be that they become frozen in inflexible attitudes which will not change or on the other hand that they make changes which are at variance with the societal norms described in Section 1.4.1. One alternative to this dilemma is of course to move out of teaching and there is some evidence that increasing numbers of young science and mathematics teachers follow this avenue of retreat.

1.4.3 Status, Stress, and Alternative Career Opportunities

Science and mathematics tend to be high status subjects in the curriculum and some would even suggest that they create a certain elitism among the teachers and students who are involved with them. Nevertheless failure in these subjects is extremely visible for both teachers and students and consequently there is often a sharp division made between those science and mathematics teachers who are successful – high status teachers and those who are unsuccessful – low status teachers.

That teaching is a stressful activity is undeniable and many studies illustrate the problems of the moment-by-moment decision-making required of teachers (Berliner, 1983; Good and Brophy, 1978; Hargreaves, 1972; Jackson, 1968). It would appear that in the classroom setting of science and mathematics learning, pupils are quick to sense when it is not just a small number of them who do not understand what is being taught. They may therefore turn on the teacher and exhibit what Blyth (1965) refers to as corporate hostility. This happens in other subjects as well, but it is more likely to happen in science and mathematics lessons because of their public nature. Moreover it is especially obvious in the case of teachers who are not confident in teaching these subjects.

Research into teacher stress also suggests that pressure of time is one of the principal components leading to stress (Kyriacou and Sutcliffe, 1978). Consequently, in the secondary science and mathematics classrooms, with limited time available to help individual students and an extensive curriculum to be covered, teacher frustration can be great. This may account for research findings which suggest that mathematics teachers in particular are not rated highly for a personalised approach (Jones, 1983; Evans, 1981; Cooper and Petrosky, 1976).

Related to the above discussions on status and stress is the fact that alternative career paths for science and mathematics teachers are available. Besides the within education career paths in administration, curriculum divisions and tertiary institutions, there are viable openings in the computer industry and other scientific industries where shortages of scientists and mathematicians are also being felt.

1.4.4 Support Provisions for Teachers

The subject master/mistress of a science or mathematics department provides curriculum leadership at secondary level and evidence suggests that the degree of effectiveness of science and mathematics teaching in secondary schools is directly related to the quality of leadership they provide (Cockcroft, 1982, submissions, B25, J61; Neill, 1978). This leadership role is a crucial one and investigations by Hall and Thomas (1977) suggest that the post brings with it feelings of anxiety, futility and mistrust of fellow staff members. They went on to add

> "With adverse attitudes to mathematics generally on the part of those teaching it as well as those taught, it could well be important for the department head to involve members of the department in more curricular planning in order to help create a stronger feeling of unity and identification. However, there appears to be some evidence of reluctance on the part of heads of departments to hold regular meetings and hence, it would seem, possibly also a reluctance to encourage such involvement and share the responsibility."

While the investigation by Hall and Thomas occurred in the United Kingdom, several reports read by the Working Party made reference to the difficulties young teachers experienced during their early years of teaching. Such difficulties were often exacerbated by the fact that they were given immediate and full responsibility for teaching classes where students experienced substantial learning difficulties in mathematics. In other cases, beginning teachers were given teaching loads which lacked variety, such as the teaching of mathematics to multiple classes at one year level only. There were even instances, seemingly incredible in the present situation, where young teachers of science and mathematics were teaching in curriculum areas other than science and mathematics. The Working Party considers that subject masters/mistresses have a vital role to play in the effective and sympathetic induction of beginning teachers.

The Department of Education and Science (DES 1979) reported that in 78% of all schools in the United Kingdom there was a need to foster closer links between science and mathematics departments and other departments within a school. Such co-operation could be enhanced by school-based in-service programs that brought staff in science and mathematics into contact with staff in other departments. Fletcher (1975) noted that science and mathematics teachers were also being asked to forge stronger links with the science and mathematics professional community. He concluded that such demands should not be seen as conflicting ones since an increase in sensitivity to the relevance of their subject to other subjects could only add to their professionalism as teachers. Otte (1979) supported that position specifically in the case of mathematics teachers.

On the subject of resource materials there have been consistent exhortations for more appropriate resource materials to be made available for teachers of science and mathematics. The Working Party's attention was particularly drawn to the lack of availability of resource materials for secondary mathematics.

The Working Party therefore wishes to draw attention to the importance of systematic in-service training, both school-based and systemic and the importance of appropriate resource materials.

1.4.5 The Impact of Sex Differences

The literature abounds with studies on the differences between boys and girls in relation to both performance and participation in mathematics and attitude towards mathematics. While investigations in science have not received the same degree of interest the findings appear to be similar.

In a series of studies of children between 10 and 14 Fennema (1974) concluded that:

> "Girls performed slightly better than did boys in the least complex skill (computation) . . . . In the 77 tests of more complex skills (comprehension, application and analysis) five tests had results that favoured girls, while 54 tests showed significant differences in favour of boys. The conclusion is inescapable that the boys of the population learned the mathematics measured by these tests better than did the girls."

Fennema and Carpenter (1981) also analysed the 1978 mathematics test of the USA National Assessment of Education Progress (NAEP). Testing was carried out at ages 9, 13 and 17, and the test was analysed into scores on knowledge, skills, understanding and applications. It was found that with the exception of the skill scores of the 9 and 13 year olds, boys did better than girls in all cases and the higher the cognitive level, the greater were the differences between the sexes. Moreover in items related to geometry, such as measurement skills, geometric manipulations and items on perimeter area and volume, the differences were particularly large.

Although Leder (1984) warned that data gathered in other countries might not be descriptive of the Australian situation, studies by Moss (1982), Thomas (1981), Atkins and O'Halloran (1978), and Clements and Wattanawaha (1977), Kudilczak, Alaimo and Powell (1979), reflected similar findings in Australia.

It is widely believed in the USA that the most important influence on learning and achievement is how great an opportunity the pupil has to learn mathematics; and in that boys take more advanced courses than girls do, so they have more opportunity to learn mathematics. Shuard (Cockcroft Report 1982) confirmed that finding in the United Kingdom, as did Dekkers *et al* (1983), Douglas (1982), Brown and Fitzpatrick (1981), Firkin (1981), and Leder (1978). Nevertheless recent writers in the field have suggested that sex typing of mathematics is decreasing and the retention of girls in advanced mathematics courses in increasing.

Keeves and Mason (1981) concluded that sex differences in mathematics were related to societal expectations more strongly than in science. They also suggested from their findings that generally boys held more favourable attitudes towards mathematics than girls. Leder (1981) stated that the attributional pattern of boys was more functional than that of girls, and that girls tended to attribute failure in **learned helplessness** and the motive to avoid **success**. Shuard (1982) made a similar comment when she concluded that:

> "Mathematically gifted girls fear that achievement will have negative consequences for their relationships with boys and that girls who under-achieve in mathematics see intellectual achievement as appropriate for men."

The implications for this report can be broadly stated as follows:

(i) the supply of girls entering mathematics teaching and to a lesser extent, science teaching, is greatly reduced by the prevailing state of sex differences in relation to performance, participation and attitudes; and

(ii) there is a need for teachers of science and mathematics to be aware of the manner in which sex factors impinge on classroom learning and teaching in science and mathematics, so that action can be taken to improve the situation, particularly in respect of greater participation of girls.

1.5 Summary and Framework for Analysing the Problem

This chapter has outlined the critical problem facing the nation and this state with regard to the provision of quality science and mathematics teachers. In subsequent chapters an analysis will be made of the participation of students in secondary science and mathematics; the nature of the secondary curriculum in science and mathematics; and current teacher education programs for science and mathematics teachers. As a consequence of this analysis the Working Party will make recommendations to address the following questions:

1. How can the supply of secondary science and mathematics teachers be improved through short-term and long-term changes to recruiting procedures, admission requirements, and the structure of teacher-education programs?

2. How can the curriculum in secondary science and mathematics, its teaching and learning be improved so that teachers find science and mathematics teaching a more satisfying career and students across the board are stimulated to increased and successful participation in these subjects?

3. What steps can be taken to support teachers, particularly beginning teachers, through staff development, in-service and continuing education programs?

4. How can public support for science and mathematics teachers and for science and mathematics programs be enhanced?

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CHAPTER 2

PARTICIPATION, ACHIEVEMENT AND ATTITUDES OF SECONDARY STUDENTS IN SCIENCE AND MATHEMATICS

Abstract

Participation patterns of secondary students in science and mathematics in Queensland and elsewhere in Australia are examined and a study to determine the reasons for school subject choices is recommended.

The literature on achievement and attitudes of secondary science and mathematics students is reviewed and investigations of factors affecting attitudes and performance are recommended. The development of training packages to counter scientific and mathematical reluctance in female students is proposed.

2.1 The Participation of Students in Science and Mathematics

The Working Party analysed the participation patterns of secondary students in science and mathematics in the light of three major data sources: the Victorian STEP Report (1980), a study by Dekkers, Malone, de Laeter, de Laeter and Hamlett (1983) and the Queensland Board of Secondary School Studies' Information Bulletins.

The data suggested that a swing away from more traditional science courses such as Physics and Chemistry had occurred while the proportion of students enrolled in mathematics had remained high. Mathematics enrolments had been boosted by a swing to terminal courses, such as Social Mathematics, and away from more traditional courses, such as Mathematics I and Mathematics II. The participation rate of girls in traditional mathematics and science subjects had remained below that of boys.

2.1.1 Victorian Data: STEP: A Review 1975–79 (Secondary-Tertiary Education Planning)

The STEP study examined Higher School Certificate (HSC) subject participation patterns in Victoria.

The HSC science subjects available were: Agricultural Science, Biological Science, Chemistry, Geology, Physics, Science (general) and Environmental Science; and the mathematics subjects were: Pure Mathematics, Applied Mathematics and General Mathematics. Mathematics subjects could be selected in one of three combinations: Pure Mathematics and Applied Mathematics; Pure Mathematics only; General Mathematics only: alternatively, students need not study any mathematics at all. General Mathematics was a comparatively wide elementary course for students who did not intend to proceed to a tertiary institution or who intended to enter tertiary courses in areas such as the biological and social sciences, medicine and primary teaching. Its advantage was that it met the mathematics requirements for most tertiary courses.

The STEP report contained two main conclusions:

- that there had been a swing away from the two mathematics pattern to General Mathematics; and

- that, as a consequence, the choice of tertiary fields was considerably constrained, particularly for girls.

Findings which related specifically to science and mathematics were:

- that there was an absolute decrease in the number of students entering tertiary courses who had studied two mathematics subjects for their HSC;

- that there was an absolute decrease in the number of students who had studied two mathematics, Physics and Chemistry for their HSC and were qualified to enter tertiary courses in the physical sciences and engineering;

- that there was an absolute increase in the number of students who entered tertiary courses with General Mathematics; and

- that there was an absolute increase in the number of students who entered tertiary courses without HSC mathematics.

2.1.2 Australian Data Relating to Enrolment in Mathematics

Dekkers *et al* (1983) analysed mathematics enrolment patterns of Year 12 students in Australian secondary schools throughout the 1970s. They classified mathematics courses into three types. Type 1 courses were described as terminal courses. These were not designed to provide a foundation for any future tertiary studies involving mathematics. Type 2 courses involved a level of mathematical competence which provided a satisfactory background for tertiary studies in which the mathematics content was minimal, e.g. architecture, pharmacy or economics. Type 3 courses involved specialist mathematics leading to tertiary studies in which mathematics was an integral part of the discipline as in mathematics, physical science or engineering. Considerable overlaps between the three types of courses existed. For example, General Mathematics in Victoria was classified as both a Type 1 course and a Type 2 course; Mathematics I in Queensland was classified as both a Type 2 course and a Type 3 course.

The study found that there had been a marked increase in the number of Year 12 students who enrolled in Type 1 or terminal courses in mathematics throughout the 1970s. It also found that the male to female ratio in those courses had decreased as more females chose terminal mathematics courses. The enrolment patterns in Type 2 courses varied from state to state. The total number of students enrolled increased in the years from 1970 to 1979. Approximately equal numbers of the males and females were enrolled in Type 2 courses. A small increase in the number of students enrolled in Type 3 courses was found, with twice as many males as females enrolled in such courses.

The authors concluded that the figures reflected a nation-wide trend for girls to remain in school longer.

2.1.3 Queensland Data: Board of Secondary School Studies Information Bulletin

Students studying mathematics in Queensland's secondary schools are streamed, either at Year 9 level or at Year 10 level, into General Mathematics, Ordinary Mathematics or Advanced Mathematics. Science students are enrolled either in Science or in General Science. Enrolment trends in science and mathematics subjects for Queensland Years 9 and 10 students in the years 1981–84, the only years for which full details were available, are shown below.

Table 2.1: Enrolment Patterns in Years 9 and 10 Mathematics Courses in Queensland

Year 9

Subject	1981 N	1981 %	1982 N	1982 %	1983 N	1983 %	1984 N	1984 %
General Mathematics	3,848	10	3,711	9	3,079	7	3,606	8
Ordinary Mathematics	18,418	47	19,324	47	14,215	32	21,610	47
Advanced Mathematics	17,118	43	17,271	42	22,511	51	19,497	43
General Science	1,866	5	1,654	4	1,680	4	1,675	4
Science	33,108	84	37,008	90	39,706	90	41,470	91

Year 10

Subject	1981 N	1981 %	1982 N	1982 %	1983 N	1983 %	1984 N	1984 %
General Mathematics	4,374	12	4,453	11	4,775	11	4,840	11
Ordinary Mathematics	17,760	48	18,310	46	19,204	46	19,714	45
Advanced Mathematics	15,117	41	16,653	42	17,548	43	18,894	43
General Science	2,108	6	2,288	6	2,493	6	2,400	6
Science	29,064	78	32,133	81	34,836	84	37,158	85

The figures show that there was increase in the absolute number of students studying mathematics and science. At the Year 10 level the percentage studying each mathematics course remained relatively stable while there was a rise of 7% (from 84% in 1981 to 91% in 1984) in the proportion of Year 10 students who studied science.

The Year 9 mathematics figures were complicated by the introduction in many schools of a delay in specialisation until Year 10. Notwithstanding this difficulty in interpretation, it appears that, apart from 1983, the proportion of students studying Ordinary and Advanced Mathematics has remained relatively stable. The proportion of students studying Year 9 Science subject increased by 6% between 1981 and 1984.

Long-term trends in the participation rates for junior science and mathematics courses were gauged from the proportion of students who sat for the 1970 Junior examination (taken at the end of Year 10), although direct comparisons could not be made because of the different nature of subject organisation at that time. The 1970 Junior examination was the last such external examination held for Year 10 secondary students in Queensland. All Year 10 students studied Mathematics A, 64% studied Mathematics B, 70% studied Science A, and 74% studied Science B. Mathematics B could not be taken unless Mathematics A was also studied. For ease of comparison Mathematics B was regarded by the Working Party as being roughly equivalent to Advanced Mathematics and it was found that the proportion of students studying the advanced form of the subject decreased between 1970 and 1984. In 1970 two science subjects were offered. Science B was the more advanced and students who studied it were also required to study Science A. The Working Party was interested to note that the proportion of students who studied science had increased between 1970, when science was streamed, and 1984 when science was unstreamed.

More comprehensive data on enrolments at upper secondary school level was available to the Working Party. The mathematics subjects available in the senior school were Mathematics I, Mathematics II and Social Mathematics or Mathematics in Society. Social Mathematics was a terminal course which did not satisfy the mathematics pre-requisites of tertiary institutions. It had been designed to provide an extension of mathematical background for those students who did not intend to pursue a career in science and technology. Students could study Mathematics I only, Mathematics I and Mathematics II, or Social Mathematics only. Social Mathematics was therefore incompatible as a subject choice with Mathematics I or Mathematics II. The total number of students studying mathematics in Year 12 was determined by adding the number studying Mathematics I to the number studying Social Mathematics. Figures for the period 1973–84 are shown in Table 2.2.

The enrolment figures in the tables below were based on the numbers of students sitting for the ASAT examination in the various subject areas. The proportion of Year 12 students studying a particular subject was calculated as a percentage of the Year 12 English enrolment, since English is a subject virtually all students must study.

Table 2.2: Trends in Enrolment in Year 12 Mathematics I and Social Mathematics 1973–1984

	Number of Mathematics Students			As a Percentage of all Year 12 Students		
Year	Maths I	Soc. Maths	Total	Maths I	Soc Maths	Total
1973	7,606	306†	7,912	76	3	79
1974	7,719	325†	8,044	73	3	76
1975	7,462	416†	7,878	69	4	73
1976	8,186	917	9,103	67	7	74
1977	7,927	2,553	10,480	60	20	80
1978	8,332	3,294	11,626	59	24	83
1979	8,108	4,109	12,517	59	29	88
1980	8,560	4,770	13,330	60	33	93
1981	8,177	5,243	13,420	59	38	97
1982	8,748	5,962	14,710	59	40	99
1983	9,459	7,062*	16,521	58	42	100
1984	10,672	8,656*	19,328	55	45	100

† General Mathematics
* Includes students enrolled in Mathematics in Society.

Between 1973 and 1984 the total number and proportion of students studying mathematics in Year 12 increased. The substantial increase in the proportion taking Year 12 mathematics courses, from 79% in 1973 to 100% in 1984, has been attributed to a large increase in popularity of the Social Mathematics course, from 7% in 1976 when it was first introduced across the State to 45% in 1984. Over the same period, there was a marked decline in the proportion of students studying Mathematics I. The increased participation in Social Mathematics might partly reflect increased retention rates. For instance, the retention rate of students from Year 10 to Year 11 in 1976 was 49%, while in 1985 it was 63%. The proportion of upper secondary students who aspired to tertiary studies decreased with a concomitant increase in the proportion who opted for a terminal mathematics course.

The numbers and proportion of Year 12 students who studied Mathematics II are shown in Table 2.3.

Table 2.3: Trends in Enrolments in Year 12 Mathematics II 1973–1984

Year	N	%
1973	3,620	36
1974	3,470	33
1975	3,205	29
1976	3,158	26
1977	3,236	25
1978	3,425	24
1979	3,426	24
1980	3,588	25
1981	3,480	25
1982	3,679	25
1983	4,011	24
1984	4,304	23

The proportion of students who studied Mathematics II in Year 12 dropped from 36% in 1973 to 23% in 1984. It remained relatively stable from 1976 to 1984. There was a modest increase over the eleven-year period in the total number of students who studied Mathematics II.

Students chose their upper secondary school science subjects from Physics, Chemistry, Earth Science, Biological Science and Multistrand Science. Multistrand Science, like Social Mathematics, was generally not considered an appropriate preparation for those who wished to pursue tertiary studies in science. Students who studied Multistrand Science were not permitted to take Chemistry, Physics or Biological Science until 1983 when that constraint was removed

The numbers and proportion of students who studied Year 12 science subjects are shown below in Tables 2.4 to 2.6.

Table 2.4: Trends in Year 12 Enrolments in Physics and Chemistry, 1973–1984

	Physics		Chemistry	
Year	No. of Students	As % of all Year 12	No. of Students	As % of all Year 12
1973	4,121	41	4,591	46
1974	3,934	37	4,488	43
1975	3,816	35	4,340	40
1976	3,892	32	4,502	37
1977	4,097	31	4,740	36
1978	4,311	31	5,073	36
1979	4,287	30	5,182	36
1980	4,385	31	5,410	38
1981	4,243	30	5,281	38
1982	4,371	29	5,437	37
1983	4,659	28	5,946	36
1984	5,035	27	6,435	34

Table 2.5: Trends in Year 12 Enrolments in Biological Science and Earth Science, 1973–1984

	Biological Science		Earth Science	
Year	No. of Students	As % of all Year 12	No. of Students	As % of all Year 12
1973	3,789	38	–	–
1974	4,705	45	–	–
1975	5,424	50	21	*
1976	7,630	62	488	4
1977	8,482	65	656	5
1978	9,308	66	633	5
1979	9,597	67	590	4
1980	9,297	65	610	4
1981	8,842	63	606	4
1982	9,440	63	631	4
1983	10,097	62	741	5
1984	11,558	61	694	4

* Less than 1 per cent.

Table 2.6: Trends in Year 12 Enrolments in Multistrand Science, 1973–1984

Year	No. of Students	As % of all Year 12
1973	–	–
1974	–	–
1975	40	*
1976	214	2
1977	293	2
1978	464	3
1979	518	4
1980	630	4
1981	712	5
1982	764	5
1983	1,071	7
1984	1,349	7

* Less than 1 per cent.

The Working Party noted that the percentage of Year 12 students who had studied Physics and Chemistry had declined (from 41% in 1973 to 27% in 1984 for Physics and from 46% in 1973 to 34% in 1984 for Chemistry) despite an increase in absolute numbers of students who had studied those subjects. There was a huge upsurge in the popularity of Biological Science from 1973, when 38% of Year 12 students were enrolled, to 1984, when 61% were enrolled. That increase tended to level out from about 1976. The total number of students who studied Biological Science also rose enormously, from 3,789 in 1973 to 11,558 in 1984. The proportion of students who studied Earth Science remained steady at about 4% over that eleven-year period. Multistrand Science did not enjoy the same level of increased support as Social Mathematics. Indeed, only 7% of Year 12 students were enrolled in Multistrand Science in 1984 compared with 46% enrolled in Social Mathematics.

2.1.4 Sex Differences in Participation Rates

As well as looking at overall participation rates, the Working Party examined participation rates in mathematics and science subjects to determine whether any differences in participation rates existed between the sexes.

Table 2.7: **Percentages of Year 12 Boys and Year 12 Girls who studied Mathematics and Science Subjects – Selected Years**

	1973	1977	1981	1983	1984
Maths I					
Male	91	76	70	68	67
Female	58	44	48	48	47
Maths II					
Male	54	38	38	37	34
Female	16	11	13	13	12
Social Maths					
Male	–	19	32	36*	39
Female	–	20	43	49	53
Chemistry					
Male	61	50	48	46	44
Female	28	22	28	27	25
Physics					
Male	60	47	46	44	41
Female	20	14	16	14	13
Biological Science					
Male	31	54	51	50	51
Female	46	76	75	73	71

* Includes Mathematics in Society.

The data in Table 2.7 should be viewed in the light of the differential increase in retention rates between the sexes over that eleven-year period. In 1973, the retention rate for boys from Year 10 to Year 11 was 48%. It increased to 63% in 1984. The retention rate for girls rose from 42% to 67% over the same period.

Higher proportions of boys than girls studied Mathematics I and Mathematics II, while more girls than boys took Social Mathematics. The gap between the proportion of girls and proportion of boys taking the non-terminal mathematics courses narrowed over the eleven-year period.

A much greater proportion of boys than girls studied Physics and Chemistry in Year 12. In 1973, for example, more than three times as many boys as girls studied Physics but the differences in their participation rates narrowed over the years, owing mainly to a drop in the participation rates of boys, rather than an increase in the participation rates of girls. The proportion of girls enrolled in Biological Science was greater than the proportion of boys.

2.1.5 Factors which have Contributed to Lower Participation Rates in Traditional Mathematics and Science Subjects

The smaller percentage of the school population studying Mathematics I, Mathematics II, Physics or Chemistry has been attributed to a number of factors:

- the declining popularity of subjects reputed to be intellectually rigorous (STEP, 1980);

- the quest for relevance by students who saw their futures in Commerce or Technology (STEP, 1980);

- the question of electives and core. Students dropped or changed subjects at Years 11 and 12 without realising the impact such changes could have on future job opportunities (STEP, 1980);

- sex differentials in job opportunities for females. While more girls than boys satisfied tertiary entry requirements, girls tended to concentrate on subjects that were not technologically oriented: "More than 25% of boys satisfied tertiary entry requirements with two maths, Physics and Chemistry, but only about 6% of girls did so; about 45% of boys did so with at least General Mathematics compared with less than 20% of girls" (STEP, 1980);

- time spent on mathematics. Girls in Australia spent less time than boys learning mathematics. The introduction of time equivalence could lead to the disappearance of differences in achievement leve and perhaps to the development of attitudes which included seeing mathematics as a less threatening problem-solving activity (Moss, 1982);

- attitudinal factors differentiated between those students who continued into mathematics and science and those who did not. Leder (1977) showed that in Australia female students in particular needed to be made aware of the factors which contributed to mathematical reluctance and counselled towards more positive, confident, vocational orientations; and

- teaching methods in mathematics and the sciences which have been severely criticized for being too abstract, too remote from the experience of the learners, irrelevant, and not person oriented. Jones (1983) has argued the case for humanising mathematics teaching. Such an approach could enhance retention rates, particularly for girls.

2.1.6 Recommendations which Arose from Examination of Data on Participation Rates

The Working Party was concerned that, by selecting Ordinary Mathematics in Year 9 or Year 10, students had closed doors to the study of Mathematics I and Mathematics II in the upper secondary school. Students who had limited their options for further secondary and tertiary study in mathematics at too early an age had contributed to the decrease which had been observed in the participation rates for Mathematics I and Mathematics II. The Working Party has therefore recommended, in Chapter 3, that the practice of streaming Year 9 and Year 10 mathematics classes into Advanced and Ordinary Mathematics be discontinued.

The Working Party considers that the reasons for subject choices in upper secondary school need to be examined in detail. Particular attention should be paid to sex differences affecting subject selection and it should be recognized that subject choice might be the result of beliefs and attitudes developed much earlier in a student's education. The Working Party recommends

R2.1 that a longitudinal research study be undertaken to determine reasons for subject choice, with particular reference to differences in subject selection between sexes.

2.2 Student Achievement and Attitudes in Science and Mathematics

2.2.1 Mathematics Achievement

Rosier (1980) examined changes in secondary school mathematics in Australia from 1964 to 1978. He paid particular attention to curriculum changes, time allocated to the study of mathematics and changes in achievement and attitudes at the beginning and end of the period.

Using the IEA (International Association for the Evaluation of Educational Achievement) Mathematics Test he found a slight overall decline between 1964 and 1978 in the mathematics achievement of 13 year old students in Australia but no evidence to support the view that there had been a serious or widespread decline in mathematics performance for that age group. The mean score in the test increased slightly in Western Australia and decreased in Queensland, Victoria, New South Wales and Tasmania. In the various sub-categories of achievement there was no evidence to indicate improvement at the higher levels of performance in application and comprehension, nor was there evidence of a marked decline in computation skills There was, however, a tendency for the percentage of students with lower scores to increase between 1964 and 1978 and for the percentage of students with higher scores to decrease, but this was less marked than at the lower end of the distribution.

The observed changes were attributed to curriculum changes over the period, sex differences and a change in time allocated to mathematics. The last factor was considered to be particularly important since there had been a substantial and consistent drop throughout the nation's schools in the time allocated to mathematics for the 13-year-old age group. Data which indicated that more time was spent in class or mathematics by male students than by female students was also noteworthy.

The situation for Year 12 students was found to be quite different. Year 12 enrolments throughout Australia doubled in the period 1964–1978, and the number of Year 12 mathematics students increased from 13% of the year cohort in 1964 to 21% in 1978. Rosier pointed out that in spite of the increased number of mathematics students, the state mean scores on the IEA Mathematics Test increased in the five states for which comparable data were available. In addition 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.

Thus, although the overall level of performance in mathematics was satisfactory the Working Party was concerned by evidence presented by Rosier, and earlier by Keeves (1977), that a small percentage, but nevertheless a large number, of school leavers was not achieving even the most rudimentary understanding of the subject. Keeves wrote:

"It is clear that the school leavers have handled these items competently. However, when 1% represents more than 60 students in the sample and thus more than 2,500 students in each age group in Australia, there are still numbers of 14 year old students who will probably leave school (approximately 10,000 each year) unable to subtract and multiply by means of basic number facts and twice as many who will be unable to perform division at this level."

2.2.2 Science Achievement

Studies relating to achievement in science of similar magnitude and extensiveness to the mathematics studies discussed above do not appear to have been carried out. Nevertheless, a number of studies have pointed to serious consequences.

Ives (1984) has drawn attention to the fact that both language and illustrations in science text books imply that boys do science while girls observe. Parker (1984) also noted that science teachers tended to pay more attention to boys than girls in science classes. Girls were therefore more likely to opt out of physical sciences in the upper secondary school and beyond and female school graduates suffered a serious labour market disadvantage because of the restricted nature of their science courses at school.

The Working Party identified the place of science in the curriculum as another more general factor that related to both achievement and participation. Since the majority of science instruction for most secondary students took place in the lower secondary school, classes at that level were more frequently exposed to teachers with the least adequate content preparation.

Wilson (1983) concluded, from meta-analysis of the relationship between science achievement and science attitude, that increased achievement was likely to improve interest in and attitudes towards science particularly at the primary and lower secondary levels. That finding ran contrary to the general view that increased achievement in science would result from improved interest in and attitudes towards science. The Working Party considers that raising science achievement, particularly at the primary and lower secondary levels, could increase participation, interest and attitudes at the senior level and beyond. More effective teaching of science in the earlier years could therefore improve the situation.

2.2.3 Attitudes in Mathematics

Rosier (1980) carried out a comprehensive study of changes in attitudes to mathematics which had occurred between 1964 and 1978.

He found that 13 year olds generally considered that knowledge of mathematics was rather important for employment or for an understanding of the environment, but that it was considered to be less important in 1978 than in 1964. There was little change in relative attitudes to the facility of mathematics between 1964 and 1978.

Despite findings that students generally enjoyed school less in 1978 than they did in 1964 there was no evidence amongst 13-year-old students of any general deterioration in their liking for mathematics. Moreover, only a fairly small percentage of students considered that their results in mathematics were worse than in other subjects, although the test data indicated a higher percentage of students with low scores in the 1978 than in the 1964 test.

Year 12 students perceived that their teachers emphasised an approach that was more problem solving in its orientation than was the case for the 13 year olds, but the Year 12 group had a more neutral feeling than the 13 year olds with respect to the importance of mathematics for employment and understanding of the environment. The Year 12 students also saw mathematics as being less important in 1978 than in 1964.

There was little change in relative attitudes of Year 12 students to the facility of mathematics between 1964 and 1978. Year 12 students did, however, perceive the subject to be more difficult than their 13-year-old counterparts.

Although there was no general deterioration in Year 12 students' liking for mathematics between 1964 and 1978, there was less polarization of attitudes in 1978. It should be noted that that change occurred within the general context of a lower level of enjoyment of school.

A number of studies on attitudes examined sex-related variables. Leder (1977) concluded that the perceived effect of their achievement on others as well as their academic performance determined girls' long-term career ambitions and the likelihood of those ambitions being realized. Such conclusions were supported by the overseas studies of Fennema and Sherman (1977).

Carss (1981) investigated the language of the mathematics classroom. Critical differences in language usage by both sexes indicated differing instructional needs and were related to the different ways in which boys and girls approached the learning of mathematics. Carss concluded that the tendency for most text books and many teachers to rely heavily on symbolic representation of mathematical ideas appeared to disadvantage girls. Also, the tendency of most text books to give instructions on "how to do a problem" rather than "why to do it that way" did not cater for the differing preferred mode of most girls. Barnes (1983) noted that recent research reviews had concluded that sex differences in mathematics achievement and attitudes persisted even when the data were corrected for the number of mathematics courses which had been taken. Such differences were not always found, but when they were, they indicated that boys performed better on higher cognitive tasks.

Despite a lack of research findings which related attitudes and mathematics achievement (Kulm 1980; Aiken 1970, 1976; Neal 1969), there was a consistent and prevailing view among educators that attitudes were important for both learning and continued involvement in the subject. There was also a high level of consensus that students, particularly female students, needed to be made aware of the factors which contributed to "mathematical reluctance" and counselled towards more positive orientations. Clearly it would also assist the entire cause if parents became highly involved and more aware of the potent role they played in influencing student attitudes towards mathematics.

2.2.4 Attitudes in Science

A distinction has been made between attitudes towards science (e.g. interests in science, attitudes towards scientists, attitudes towards social issues by scientists' and scientific attitudes (honesty, curiosity, suspension of judgments). Gardner ' reviewed student attitudes towards science and concluded:

- that correlations between attitudes to science and achievement were low across periods of compulsory schooling but tended to increase at the upper end of secondary schooling;

- that students favourably inclined to science tended to be serious, achievement oriented, realistic, conventional and conformist;
- that boys had a greater interest in science than girls;
- that attitudes to science related to teachers' use of discovery methods and group work;
- that a cluster of home background variables associated with parental interest in science affected the attitudes of young children towards science; and
- that most curriculum efforts to change attitudes were small, and they tended to be negative.

Research in physics education by Mackay (1971) supported the last point even in cases where non-traditional approaches to physics had been adopted.

Meta-analysis of research in science by Fleming and Malone (1983) revealed that the mean correlation between general ability and attitude to science ($r = 0.15$) was roughly one-third as large as mean correlations between general ability and science achievement ($r = 0.43$). Furthermore the result was consistent across grade levels although there was a marked increase in the tendency from lower-secondary to upper-secondary, consistent with Gardner's earlier finding.

Sex was found to be one of the most important variables related to pupils' attitudes to science and/or scientific attitudes. Gauld and Hukins (1980) reported that there were no significantly sex-related differences for curiosity, open-mindedness or objectivity. However, Fraser (1978) reported that males had higher scores than females on adoption of scientific attitudes, enjoyment of science lessons and interest in science outside of lessons. Females, on the other hand, had higher scores than males on the scale "normality" of scientists.

Lawrenz and Welch (1983) concluded that there was some evidence that students perceived that science classes taught by male teachers were different from those taught by female teachers. Classes taught by males were perceived to be more difficult while classes taught by females were perceived to be more formal, more goal directed, and more likely to involve instances of friction and favouritism. In a related study by the same authors, male science teachers were found to have greater knowledge of science than their female counterparts, while female science teachers scored higher on interest in science and receptivity to change.

Although these were mainly American studies, and perhaps not completely replicable in Australia, the extent to which science teachers served as role models for students considering alternative careers, including science or mathematics teaching, was clearly of great importance.

A Queensland study by Lucas and Tulip (1980) which employed Fraser's test of science-related attitudes, reported that mean scores on enjoyment of science, leisure interest in science, and career interest in science were neutral to slightly negative, with only small increases from Year 10 to Year 12. Those findings were supported by the observation of Hodson and Freeman (1983) that interest or indifference towards science developed at an early age and that students entered secondary school with that interest or indifference already developed.

Given the low retention rate in Australian secondary schools, one would expect a big increase in interest in the attitudes towards science for senior secondary students studying science. Sleet and Stern (1980) have provided a partial explanation for the fact that such an increase does not occur. They reported that, with the exception of students selecting Biology as their only science, Year 11 students were thinking of their careers rather than of their interest or ability in the subject when making their selection of science subjects in Years 11 and 12.

In order to improve achievement and attitudes to science and mathematics, the Working Party recommends:

R2.2 that longitudinal studies of achievement and attitudes in science and mathematics be undertaken to:

- identify achievement trends during primary and secondary schooling;
- identify attitude trends during primary and secondary schooling;
- determine factors which influence performance in science and mathematics at various stages of schooling; and
- determine factors which influence attitudes in science and mathematics at various stages of schooling;

R2.3 that research studies be undertaken to investigate the effect of sex-related variables on attitudes to science and mathematics at various stages of schooling; and

R2.4 that training packages be developed to enable students, particularly females, to become aware of the factors which contribute to negative attitudes towards science and mathematics and to counsel students towards more positive, confident, vocational orientations.

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CHAPTER 3

MATHEMATICS AND SCIENCE IN THE CURRICULUM

Abstract

The historical development of Queensland's mathematics and science curricula is outlined and the need for further updating and greater emphasis on concept acquisition, problem solving and process attainment is emphasized The introduction of mechanisms which allow syllabuses and their mode of implementation to be changed more rapidly is recommended.

3.1 An Historical Overview of the Science and Mathematics Curricula in Queensland: 1964–1984

The past twenty years have seen many changes in secondary education in Queensland, the most far-reaching being the introduction of the Radford system in 1970 when external examinations for full-time students were replaced by school assessment and moderation procedures. The Board of Secondary School Studies (BSSS) was set up as a statutory body with responsibilities which included the development of syllabuses for subjects accredited on the Junior and Senior certificates.

Prior to 1964 the junior science subjects studied were Physics, Chemistry, Physiology, and Biology while subjects at the senior level included Physics, Chemistry, Zoology and Geology. In 1964 Year 8 was incorporated into the high school for the first time and a more multi-disciplinary approach to science at the junior level emerged in the form of Science A and Science B. General Science was also introduced for Years 9 and 10 as part of a more general curriculum.

In mathematics prior to 1964 the two subjects studied at junior level were Mathematics A (algebra and arithmetic) and Mathematics B (geometry and trigonometry). At the senior level two subjects, Mathematics I (algebra, geometry, trigonometry and calculus) and Mathematics II (analytical geometry, calculus, solid geometry, and mechanics) were offered. After 1964 the mathematics curriculum provided a common program for all students in Year 8 which focused on three areas; arithmetic, algebra and geometry. In Years 9 and 10 of the junior secondary course, students could elect to take Mathematics A or Mathematics A and Mathematics B. Both subjects focused on the same topic areas, viz. arithmetic, mensuration, algebra, geometry and trigonometry; however, the depth of treatment and the expectations in terms of problem solving were greater in Mathematics B. General Mathematics was also introduced for Years 9 and 10 as an alternative program. Corresponding changes in senior mathematics occurred in 1967 with the introduction of Senior General Mathematics in addition to Mathematics I and Mathematics II. In 1967 syllabuses in Mathematics I and Mathematics II were largely a re-organization of content, but vectors, matrices and transformation geometry were introduced into Mathematics II for the first time.

The world-wide revolution in science and mathematics curricula during the 1960s led to the adaptation of the United States PSSC, Chem Study, and BSCS as the basis for the senior syllabuses in Physics, Chemistry and Biology. Biology was also introduced as an alternative to Zoology at the senior level.

In 1974 a further curriculum development resulted in a consolidated syllabus in science being trialled at the junior level. It was introduced across the State in 1975 and consisted of two junior science subjects and General Science, the latter being essentially the same as the 1966 General Science syllabus. In Years 11 and 12 the approach to science remained for the most part discipline oriented with separate offerings being available in Chemistry, Physics, Biology, and Earth Science. An exception to the discipline-oriented approach was the introduction of Multistrand Science, a less rigorous, multi-disciplined subject which has become increasingly popular with students in Years 11 and 12.

In 1978 the Scott Committee investigated the effects of the Radford system. As a result of its findings changes to assessment processes for all subjects were initiated. Further curriculum revision occurred as syllabuses were re-written in terms of the process, content and skill objectives which schools were then to pursue. The Parliamentary Select Committee on Education in Queensland had reported that action was taken regarding the Scott Committee's proposals. Each of the Radford Committee, the Parliamentary Select Committee and the Scott Committee – Review of School-Based Assessment (ROSBA) has affected the current curriculum approaches to objectives, content, teaching and assessment of science and mathematics in Queensland.

Science is now taught more systematically and extensively at the primary school level where the Primary Science Program is taught by the classroom teacher. That program was developed by the Curriculum Branch of the State Education Department and was introduced with attendant in-service courses conducted by advisory teachers. The scope of those in-service courses was extensive and provided opportunities for all primary school teachers from Year 1 to Year 7 to participate.

In Years 8, 9 and 10 Science is now taught as a single subject covering a range of areas over the three years. Participation data indicates that all Year 8 students study Science, that in approximately 83% of schools all Year 9 students study Science, and that in approximately 50% of schools all Year 10 students study Science. (Cooper, Byrne and Maynard 1983). The number of students studying Science at Year 9 and at Year 10 level is increasing. Science is recommended as a compulsory core subject within the Curriculum Guidelines for Queensland State Secondary Schools (Department of Education, Queensland 1982).

The worldwide revolution in science and mathematics curricula, the Radford Report, the Scott Report and the Report of Parliamentary Select Committee on Education in Queensland have similarly affected the mathematics curriculum. With the emergence of modern mathematics and the Radford system new syllabuses for Years 8–10 and 11–12 were introduced progressively from 1969. A common core program was retained for Year 8 while the students in Years 9 and 10 were streamed into Advanced Mathematics, Ordinary Mathematics or General Mathematics. For the first time in Queensland students at the junior level were able to take only one subject in mathematics. At the senior level 11 semester units in mathematics (preparatory mathematics, calculus I, algebra and calculus II, complex numbers, computer mathematics, financial mathematics, matrices and vectors, mechanics, probability and statistics, trigonometry and analytical geometry and modern algebra) were offered with students having the option of studying up to a maximum of 8 units over the four semesters of Years 11 and 12. In 1976 Social Mathematics was introduced as a less rigorous alternative to the 11-unit offering. It was later renamed Mathematics in Society.

With the evolution of changes following from the reports of Radford, Scott and Ahern, various organizational changes in the mathematics curriculum occurred. Mathematics to Year 10 is now compulsory in all Queensland schools. It is offered as a single subject to the end of Year 8 and at three levels in Year 10 – advanced, ordinary and general. Some schools also offer the three levels in Year 9 while others delay specialisation until Year 10. Approximately 42% of Year 10 students study at advanced level, 46% study at ordinary level and 11% study General Mathematics. (BSSS 1983).

At the senior level mathematics is now offered as Mathematics I, which consists of 4 revised units from the original 11 units, Mathematics II which consists of a further 4 units from the list of 11 units, and Mathematics in Society which was developed from Social Mathematics. Schools have some choice in the units which will comprise Mathematics I and Mathematics II. In the subject Mathematics in Society the scope and approach is seen to be less rigorous than in Mathematics I and Mathematics II. Transition courses and Participation and Equity programs often include some scientific and mathematical studies.

All assessment of students' achievement is now conducted within individual schools with the final results being moderated by the Board of Secondary School Studies.

3.2 Issues

3.2.1 Curriculum Design

At the junior high school level the Curriculum Guidelines for Queensland State Secondary Schools recommend that Science and Mathematics be compulsory core subjects for all students. The Board of Secondary School Studies requires 150 hours of timetabled teacher-student contact time. Many schools now follow the recommendation and offer Science as a core subject. All schools require students to study Mathematics to the end of Year 10.

Senior high school subjects are preferentially selected by students. The basis for selection ranges from tertiary entrance requirements to peer group influence. Students are not required to take either a science or a mathematics subject to obtain a Senior Certificate.

Transition and Participation and Equity programs have a more general structure but usually include some scientific and mathematical studies which are appropriate to the scope and focus of the course. Courses are designed by individual schools.

3.2.2 Syllabus – Junior High School

The Board of Secondary School Studies syllabus in Science requires that "the subject matter of Science should be chosen so as to facilitate the development of the individual student". It further states that a Junior Science program must make some contribution to students' life roles, as citizens, users of technology, consumers in society, persons, parents and earth inhabitants. The syllabus recognises other more traditional criteria for selection of subject matter for school-work programs but emphasises that "science teachers should be aware of the unique contribution that science knowledge, processes, skills and attitudes can make towards education for life roles".

It has been suggested that the life role emphasis in the Junior Science syllabus provides the greatest difficulty for teachers who have themselves been educated in the traditional disciplines with an emphasis on content and recall.

The Years 8–10 Mathematics syllabus which was implemented at the time of the Radford Report had two main features:

(i) Year 8 was to be a year of review and consolidation of Primary Mathematics, and

(ii) the Years 9 and 10 course was to be divided into three levels — advanced, ordinary and general.

The advanced course was seen as a preparation for further study of mathematics in Years 11 and 12 while Ordinary Mathematics was designed to equip students for societal needs when they left school at the end of year 10. General Mathematics was designed to cater for students with lower ability and involved fewer topics and more concrete learning experiences.

The streaming which took place at the end of Year 8 in order to meet syllabus requirements had serious implications for students' future careers. Decisions made at that point with respect to the particular level of mathematics were generally irreversible and resulted in students **closing doors** on future courses and careers.

All the syllabuses were written as broad frameworks, and at the time of their release interested parties were asked to present the BSSS with **guidelines to the syllabus**. Only one such guideline was foreshadowed for Advanced Mathematics and it presented a very formal theoretical interpretation of the syllabus. Unfortunately, it became accepted by many textbook writers and teachers as **the syllabus**. Hence the Advanced Mathematics course taught to many Queensland students in Years 9 and 10 in the following years included some very formal algebra at a very early stage. Research by Collis and Biggs (1979), Low (1977), and Collis (1975a, 1975b), has indicated that this was inappropriate for many Year 9 and Year 10 students. In England the Cockcroft Report (1982) also noted that formal algebra was a source of considerable confusion and negative attitudes towards mathematics amongst students in that age group.

The lack of relevance of the new mathematics syllabuses to the needs and interests of many 13 to 15 year olds probably led to the decline in student attitudes found by Rosier (1980). At the same time as the new syllabuses were introduced, the allocation of time for advanced mathematics was reduced without significant reduction in the content to be taught. This undoubtedly exacerbated problems relating to achievement and attitudes.

In summary, from the sixties to the eighties schools were confronted with the new mathematics, they were given less time in which to teach the subject, and student achievement and attitudes at the junior level declined.

3.2.3 Syllabus — Senior High School

Studies in science in the senior school have a traditional discipline orientation. All Senior science syllabuses state that those studies contribute to the education of young people through structured learning experiences which aim at further developing:

- knowledge and understanding of man, his planet, the universe and the relationships among them within the framework of formal sciences,
- knowledge and understanding of a number of aspects of science as an intellectual enterprise; and
- higher cognitive skills, manipulative skills and attitudes, through direct involvement in methods and procedures of science.

While the aims and approach to science at that level were seen to be commendable, the Working Party considered that the content of the syllabuses required examination. A major problem was that attempts by science teachers to cover the content at all costs even in Multistrand Science often led to a reduction of emphasis on process, skill and affective areas.

Multistrand Science was introduced in 1975 in an attempt to provide a broader education in science for those students not intending to pursue tertiary studies in science.

Under the Radford System the existing Mathematics I and II syllabuses were reorganised from two-year courses into discrete semester units. Some new topics were introduced and, in all, eleven units were prepared for use in schools, but the mathematical scope of the Years 11 and 12 mathematics syllabuses remained virtually unchanged.

About the same time there was a marked increase in the retention rate of students from Year 10 to Year 11. Rosier (1978) stated that the increase was largely due to an increase in the number of students with less ability and less interest in study, who came from homes rated at the lower levels of the socio-economic scale. It was found that the traditional mathematics subjects offered at Years 11 and 12 level were not suited to the abilities and interests of a large number of those students. Thus, in 1976, the Mathematics Advisory Committee of the Board of Secondary School Studies initiated a new subject which is now offered as Mathematics in Society. As it was not intended that that subject be studied by those who intended to pursue tertiary studies in science related areas, it was incompatible with Mathematics I and II. Since 1976 the numbers enrolled in Mathematics in Society have increased dramatically, from about 7% of the Year 12 population to about 46% in 1984.

Of the eleven units available to Mathematics I and II students, three particular units are required by tertiary institutions for entry to science-related courses of study. A further three are specified for entry to engineering studies. Those requirements have clearly restricted the freedom of schools to choose appropriate courses of study for their students. Schools were permitted to apply for approval to teach a flexible program in which the content of semester units could be spread across 2, 3 or 4 semesters, or in which they could seek approval to develop extra units. Those options were not widely taken up because of the tertiary institutions' pre-requisites.

The re-organization of Mathematics I and II into units to be taken over Years 11 and 12 has meant that mathematics was often seen by teachers and students as a collection of scarcely related topics rather than as a structured entity.

With the introduction of ROSBA (Scott, 1978) in 1982, the Board of Secondary School Studies stipulated there was to be no change to the process, content and skill objectives of the mathematics syllabuses. However, it soon became apparent that not all syllabus requirements were being met because of the lack of time available.

At the time of writing, a Department of Education committee has prepared a P–10 syllabus in Mathematics. This latest curriculum development in mathematics is occurring at a time when the Department of Education is carrying out a review of education in Queensland. The Department has already foreshadowed a preferred option for the organization of the curriculum program in Queensland schools.

The far-reaching nature of the changes now proposed suggests that it will be some time before a new syllabus in Mathematics is implemented at the secondary level. The likely delay was a matter of considerable concern to the Working Party. The present syllabus guidelines for mathematics in Years 8–10 have been in existence for 13 years and those for the Mathematics syllabus for Years 11–12 for 10 years. The Working Party received overwhelming evidence that the present syllabus is not appropriate for the current secondary population. It does not reflect trends in mathematics education that have occurred since its introduction.

With respect to science, the Working Party considered that the introduction of a P–10 curriculum could result in major advances. It was possible that the introduction of such a curriculum could lead to an integration of the sciences in the form of physical science and life science throughout the school system. In fact the present Primary Science program lends itself well to continued development into a junior high school life roles Science syllabus.

3.2.4 Transition and Participation and Equity Programs

Transition and Participation and Equity Programs are developed independently by schools and as a result depend upon the teachers in the school at a particular time. The continuity of such programs can be affected by the movement of teachers from one school to another. The success of the programs depends on the commitment of teachers in implementing an integrated approach to mathematics and science with sensitive recognition of the needs and abilities of students in the programs. Many teachers prefer not to become involved. Transition courses are, unfortunately, often seen by students, teachers and parents as lower-level courses and, therefore, not worthwhile.

3.2.5 Curriculum Methodology

Discipline oriented science courses are frequently interpreted as requiring formal presentation and acquisition of information by students whereas the life role scientific approach adopted in Junior courses aims at "assisting students to understand themselves and their environment and accordingly science is presented in a historical and cultural context and its social consequences are emphasised". (White and Tisher, in press 1985).

Many teachers aspire to the latter mode in Junior and Senior science courses but experience difficulty in sustaining that methodology and achieving its educational objectives. Moreover, teaching methods of student teachers and new teachers beginning their careers are directly affected by the way subjects are taught by more established teachers. The Working Party therefore considers it imperative that a wide variety of teaching methodologies are advocated, not only in pre-service programs but also in in-service courses, so that a more balanced approach is reflected in all aspects of teacher education.

In relation to mathematics teaching Jacobs (1982) proposed that "Teachers must pay more attention to motivation and less to structure in their efforts to convince students that mathematics is an important and enjoyable subject".

Bell (1982) also reported that surveys undertaken in the United States of America and in the United Kingdom indicated that most teaching in mathematics was directed narrowly towards the learning of particular techniques and concepts. The understanding needed to recognise potential areas of application and the ability to apply the concepts in a meaningful way was often lacking. From evidence presented to the Working Party it appeared that less of the mathematics teaching in classrooms in Queensland could be done via direct instruction, associated practice of large numbers of similar exercises, and the development of automatic associations and reactions. Greater emphasis was needed on the use of real mathematical activity to solve genuine real-life problems and on the development of problem-solving techniques. The point was also made that students often did not know "why" they were doing things.

It appears that insufficient emphasis has been given to relating the theory of teaching and learning to actual practices in mathematics classrooms. Low (1982) supports this:

> "The status of research on achievement in mathematics bears this out when it concludes that many of the concepts and operations in the curriculum are too difficult for the majority of children. Research on 'meaning' in particular indicates that one possible source of difficulty is that many concepts are introduced at a time or in a way which is unsuited to children's level of cognitive development."

3.2.6 Curriculum Resources

Science is a living, developing subject. There is a great need to go beyond textbooks which are often out of date and somewhat restrictive in their approach. Moreover it is often difficult to find textbooks which are suited to the emphasis of the syllabus, and at an appropriate **readability** level for the students.

In order for science teaching to grow and thrive, the Working Party considers that efforts must be made to identify and prepare resource packages which will encourage teachers to venture beyond tight discipline-oriented approaches in science to more global approaches manifesting scientific thought. Those responsible for school programs should recognize and accept that the boundaries between the various sciences are not sharply defined but overlap considerably. Unquestionably the resources of the community could be tapped more extensively to take scientific learning outside the four walls of the classroom into a more applied scientific environment which would allow greater examination of the social effects of scientific pursuits.

In a similar vein the Working Party considers that mathematics needs to incorporate a greater focus on genuine real-life problems. Such problems and activities could be located and developed for classroom use, especially if packages were to be prepared by a central source and transmitted to teachers through in-service and school-based workshops and projects.

In summary the Working Party considers that science and mathematics curricula and resources need to be presented in a more compelling, exciting and relevant context. While such an emphasis may be seen as a less rigorous approach to the disciplines, it should not devalue their significance or lower standards of achievement. In fact the Working Party is strongly of the opinion that a more student-centred, realistic focus would improve students' attitudes and achievement.

Consequently, in relation to the curricula in general, the Working Party recommends:

R3.1 that the procedures for developing and implementing syllabuses be examined with a view to creating mechanisms which will respond more rapidly to changes in education and society, particularly for those subjects which are affected by extensive technological change;

R3.2 that the examination of upper primary and lower secondary syllabuses in Science and Mathematics continue with a view to producing a P–10 curriculum which takes cognisance of integrating themes and key concepts in science and mathematics;

R3.3 that the syllabuses in Science and Mathematics be examined to determine if concepts are being introduced at points appropriate to children's level of development; and

R3.4 that the current form of certification adopted at the end of Year 10 be evaluated and consideration given to accrediting schools/courses at that level.

In relation to the science curricula the Working Party recommends:

R3.5 that more extensive in-service development programs for science teachers in secondary schools be provided to facilitate changes in science teaching methodologies foreshadowed in recent research and emerging curriculum programs;

R3.6 that the scope and content of science curricula at all levels of the secondary school be examined in order to determine whether there is a need to reduce the body of knowledge perceived to be required and to allow greater emphasis to be developed on concept acquisition, problem solving and process attainment;

R3.7 that those involved in ongoing curriculum development in science take account of differences in background knowledge and learning styles of females and males and that steps be taken within the organisation of science programs so that greater numbers of females may be attracted to study Senior Science;

R3.8 that, in keeping with trends both interstate and overseas, science be included as a core subject up to Year 10 in all secondary schools;

R3.9 that greater integration of key ideas be encouraged during teaching of science to Years 11 and 12 with an attendant reduction of the boundaries between science subjects in the senior school;

R3.10 that greater emphasis on the social effects of science and technology be incorporated into the Science curriculum at all levels;

R3.11 that resources for science teaching be improved through centrally co-ordinated developmental projects, so that key emphases in syllabuses are implemented; and

R3.12 that the development of a curriculum aimed at achieving a balanced and coherent P–10 Science program continue.

In relation to the mathematics curricula the Working Party recommends:

R3.13 that available mathematics textbooks be continually reviewed and evaluated with a view to providing advice on those that may best suit teachers and schools, keeping in mind their appeal and relevance to girls. Improved mechanisms are needed to evaluate and provide information to schools on textbooks so that those which are inert, out of date and alienating students will be discarded;

R3.14 that in ongoing curriculum development in mathematics, greater efforts be made to:

(i) ensure more appropriate selection and sequencing of learning in topics such as algebra, geometry, ratio and fractions;

(ii) encourage the use of meaningful learning experiences with calculators and computers;

(iii) eliminate unnecessary use of logarithm tables and trigonometric tables; and

(iv) de-emphasize the range of content and emphasize acquisition of concepts, applications, processes and problem solving;

R3.15 that the amount of content in Senior Mathematics units be reduced and in collaboration with tertiary institutions the Mathematics curriculum in Years 11 and 12 be reviewed in conjunction with the P–10 curriculum review;

R3.16 that the practice of streaming Year 9 and Year 10 mathematics classes into Advanced and Ordinary Mathematics be discontinued and that one mathematics subject be available for all students in Years 9 and 10;

R3.17 that all groups including administrators, subject masters and other teachers associated with the education of teachers of mathematics affirm the need for mathematics learning to take place in an active, exciting and caring environment characterised by a variety of approaches and organisational strategies;

R3.18 that resources for mathematics teaching be improved through centrally co-ordinated developmental projects, so that key emphases in syllabuses are implemented;

R3.19 that in view of the strong evidence that time is a significant variable in mathematics learning, more time be allocated to the teaching of mathematics and that mathematics teachers be better prepared to manage time more effectively in classroom learning experiences;

R3.20 that those involved in ongoing curriculum development in mathematics take account of the distinctive background knowledge and learning styles of females and that steps be taken within the organisation of mathematics to attract greater numbers of females to Senior Mathematics and place greater emphasis on the development of spatial abilities in female students;

R3.21 that all teachers be encouraged to place greater emphasis on diagnostic teaching strategies wherein specific emphasis is given to assisting students to recognise their own learning problems and to facilitate improved learning, by their own initiative; and

R3.22 that schools be encouraged to provide support mechanisms for inexperienced teachers of mathematics, particularly through organisational processes which would allow inexperienced teachers regularly to consult with and teach with highly competent colleagues.

An associated recommendation (listed in Chapter 5) is that employing authorities ensure that extensive and on-going in-service education support is provided to re-orientate teachers' understanding of how children learn science and mathematics given the continuing growth of knowledge in the field of cognitive learning.

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CHAPTER 4

THE EDUCATION OF SCIENCE AND MATHEMATICS TEACHERS

Abstract

The programs currently available in Queensland for the preparation of science and mathematics teachers are outlined and a review of the minimum qualification for entry into science and mathematics teaching is recommended. It is suggested that the possible introduction of a Master's degree course in Science Education at one of the colleges of advanced education be canvassed. Ways of attracting people to science and mathematics teaching as a career and of promoting desirable personal and professional qualities in teachers are described.

4.1 Desirable Characteristics of Science and Mathematics Teachers

In 1976 the Royal Society's British National Committee for Mathematics wrote: "Good teachers of mathematics are among the most valuable resources of an educational system." In arguing that position they took the view that mathematics was a vital part of the education of all young people. It was an essential requirement for everyday life in a modern society and was also a fascinating study which provided pupils with a means of better understanding their environment and developing their powers of problem-solving, reasoning and conceptualization. The importance of the availability of quality mathematics teachers is emphasized as follows: "All of this (vital education for young people) depends on the continuing supply of good teachers of mathematics, both specialist teachers of older pupils and generalist teachers in primary schools, who are responsible for the laying of mathematical foundations for all pupils."

The Working Party considered that the situation of science teachers and of science as a subject was similar to that described for mathematics and that the desirable characteristics of quality teachers of science and mathematics should be identified.

Such characteristics could be delineated into two categories – personal qualities and professional qualities. The former were common to teachers of all subjects and levels while the latter incorporated qualities specific to science and mathematics teachers.

The Working Party considered that the importance of personal qualities in science and mathematics teachers had generally been overlooked. Jones (1983) wrote of mathematics teachers:

> "Students are acutely conscious of their mathematics teachers as persons; not as impersonal purveyors of information and skills. They are more concerned with how interesting and sympathetic the teacher will be."
>
> Studies by Evans (1981) and Cooper and Petrosky (1976) concluded that mathematics teachers did not rate highly on variables such as personalised teaching, teacher warmth, respect for students built on understanding and humaneness and student autonomy. Jones (1983) commented on the implications of those findings for the personal relationship between teacher and pupil as follows:
>
>> "I believe that we cannot be too sanguine about the performance of mathematics teachers in relation to 'humanising' teaching environments."

The need for responsiveness to the social and natural world was considered to be another personal characteristic of growing importance for the teacher of science and mathematics. Reference has already been made, in Chapter 1, to the "hidden curriculum of daily experience" that children have gleaned from their encounters with computers, television and other technological aspects of the new culture. Teachers should be aware of those experiences so that they can be mutually shared. In essence teachers of science and mathematics have to facilitate a coherent partnership between formal and informal elements of the curriculum if their credibility with the children they teach is to be maintained.

4.1.1 Personal Qualities

As a guideline to those involved in the admission, pre-service education, employment and in-service education of teachers of science and mathematics, the Working Party noted the following personal qualities listed by Meade *et al* (1984) as highly valued in all teachers:

- personal autonomy, the quality of self direction;
- well educated, with a high value for excellence and scholarship;
- humane, with a genuine respect and liking for each individual and an ability to relate to and communicate with other persons;
- responsible, with a regard for the social and natural environment;
- resourceful and creative, with the flexibility to respond to changing situations;
- critical with the power to evaluate the relative merits of proposed changes; and
- industrious, with an awareness that effort is essential.

4.1.2 Professional Qualities

It is significant that the nature of the professional qualities of teachers of science and mathematics has been a growing area of interest for educators in the field of teacher education. Proposals and investigations of the professional qualities of teachers by Christiansen (1985), Howson (1985), Jones (1983/84), Cooney (1980), Otte (1979) have included a number of consensus qualities.

A. Teaching learning management

- understanding classroom dynamics and qualities;
- understanding the relations and relevant difficulties between theories of instruction and theories of learning;
- recognising the need for systematic observation of children at work and the importance of diagnosis and remediation of learning difficulties,
- adopting a problem-solving approach to teaching and learning which includes an understanding of the structures of scientific and mathematical tasks; and

- recognising the contribution of research and development so that the practitioner can operate simultaneously on the basis of comprehensive epistemological understanding (meta-knowledge) and also with specific and appropriate 'rule' knowledge.

B. Curriculum qualities

- understanding the structure of science and mathematics so that the curriculum emphasises 'relational' aspects of science and mathematics in the sense of Skemp (1976), and de-emphasises the current predisposition towards 'instrumental' aspects of science and mathematics;
- relating science and mathematics to other areas of the curriculum so as to enhance integration of key concepts and principles;
- understanding methods and techniques of evaluation so that there is a meaningful interplay between aims and attainment;
- developing curriculum experiences that are relevant for students and attuned to their cognitive and affective levels of development;
- understanding the value, function and limitations of resources, especially those originating from new technologies; and
- being aware of the relations between cognitive, affective and social activities as they occur in the context of the curriculum and the classroom.

C. Social qualities

- understanding the influence and impact of societal norms which includes the ability to respond constructively to such influences;
- recognising that the mental and emotional lives of the teachers inside and outside the classroom interact with their actions in the teaching process;
- understanding the importance of co-operation with professional colleagues, resource personnel and professional organisations;
- recognising the importance of their own commitment to life-long learning and scholarship so as to avoid 'freezing' of ideas and approaches; and
- developing powerful inner convictions that contemporary methods and new approaches to curriculum will be more successful and more rewarding for students than those often espoused within the community and given acquiescence by schools.

The Brisbane College of Advanced Education in its Rationale and Guidelines for Teacher Education Courses (1983) has described an approach to the education of teachers through which those qualities might be attained:

> "The preparation and in-service education of teachers must therefore provide learning experiences which initiate, support and enrich those (listed in 4.1.1 above) personal and professional qualities."

The Working Party considers that school leavers and other persons who may be interested in science and mathematics teaching should be made aware of the personal and professional qualities that are desirable in science and mathematics teachers. It recommends:

R4.1 that employing authorities and tertiary institutions involved in teacher education be encouraged to co-operate in the development of pamphlets and brochures which promote science and mathematics teaching and describe personal and professional characteristics of science and mathematics teachers;

R4.2 that actions be taken through in-service education to acquaint science and mathematics teachers with the importance of various aspects of their personal and professional roles.

4.2 Quality and Quantity of Entrants to Pre-service Courses

As stated earlier, difficulties have been encountered in attracting students of appropriate quality in sufficient numbers into courses of preparation for secondary science and mathematics teaching. The shortage of mathematics and science teachers is a world-wide phenomenon and has been exacerbated by the fact that it has existed for a protracted period.

In Queensland it has been particularly difficult to attract students into the State's only three-year Diploma of Teaching (Secondary) course at the Brisbane College of Advanced Education. For several years entry numbers have been well below quota and the quality of entrants, as measured by the median TE score and its range, has been a matter for concern. There is little evidence from participation trends in science and mathematics at Years 11 and 12 that the situation will be reversed, even though the overall school-leaver population has increased substantially in recent years.

The problem of attracting students into the Diploma of Teaching (Secondary) course has been heightened by the growing need in industry, particularly in technological areas, for qualified scientists and mathematicians. The Working Party was of the opinion that insufficient emphasis had been given to the encouragement of school leavers to enter science and mathematics teaching. There was also a need for the teaching profession to be made more attractive since teachers themselves played a significant role in maintaining the quality of their profession and in attracting young school leavers to enter teaching.

Accordingly the Working Party recommends:

R4.3 that science and mathematics teachers be made more aware of the importance of their role in attracting persons with high academic ability, especially school leavers, to enter science and mathematics teaching.

Data before the Working Party on graduates who entered the University of Queensland's Diploma in Education course and the Brisbane College of Advanced Education's Graduate Diploma in Teaching course indicated that larger numbers of higher quality entrants might be available. Unfortunately entry to the teaching profession via postgraduate study was being hampered by the fact that universities and colleges lacked the flexibility and the financial resources to respond quickly to changing patterns of graduate interest and employer needs. There was also evidence that appropriate graduates in the workforce could be attracted to pre-service graduate programs in teaching if these were available by various combinations of part-time and external modes. The matter of incentives, enhancements and financial support during training were other features that affected the attractiveness of teaching careers in science and mathematics for graduates in the workforce. The Working Party considers that the implementation of a number of recommendations that will be considered in Chapter 5 would facilitate the entry of graduates into courses of preparation for science and mathematics teaching.

4.3 Current Programs Available in Queensland for the Preparation of Science and Mathematics Teachers

The Working Party noted that there were four categories of pre-service programs currently available in Queensland for the preparation of secondary science and mathematics teachers.

- the three-year Diploma of Teaching course which incorporated studies in science and/or mathematics and professional studies in education, curriculum studies and field studies outlined in Appendix 4A;
- four-year programs which integrated undergraduate studies in science and mathematics with professional education studies outlined in Appendix 4B;
- one-year graduate programs in teacher education for students who already possessed a degree in science and mathematics outlined in Appendix 4C; and
- other programs which prepared secondary science and/or mathematics teachers outlined in Appendix 4D.

Unfortunately graduates were not always allocated a teaching timetable commensurate with the areas of specialisation in their teacher education. It was possible for a number of undesirable teaching combinations to occur: e.g. a teacher who had studied the principal teaching area/second teaching area (PTA/STA) subject combination of a PTA subject other than Mathematics or Science and a Mathematics or Science STA could be given Science or Mathematics classes at the Senior level; or teachers who had studied PTA Mathematics or Science and an STA subject other than Mathematics or Science could be expected to teach Science when it had been neither a PTA nor an STA study for them or they could be expected to teach Mathematics when it had been neither a PTA nor an STA study for them.

The Working Party was cognisant of developments in other states and overseas where a four-year degree in education/teaching was now the minimum requirement for entry into secondary science and mathematics teaching. Accordingly it recommends:

R4.4 that the raison d'etre for Diploma of Teaching courses as the minimum qualification for entering science and mathematics teaching be reviewed.

The Working Party noted that a wide variety of channels of entry into pre-service graduate teacher education programs had evolved in Queensland during the last decade and that those programs had had some impact in ameliorating the shortage of science and mathematics teachers. It was impressed by the fact that tertiary institutions had already adopted more flexible and varied entry requirements for their courses.

It was not part of the Working Party's mandate to examine the provision of master's degree courses in science and mathematics education, however, during its deliberations the Working Party had become aware that provisions for master's degree courses in science education were not as extensive as those in mathematics education. Both the universities and the Brisbane College of Advanced Education offered master's degree programs in mathematics education but only the universities offered master's programs in science education. A proposed course put forward in 1980 by one of the former colleges of advanced education in Brisbane was not supported. Given the major commitment of the advanced education sector in Queensland to the preparation of science teachers, the Working Party recommends:

R4.5 that further consideration be given to the need for a Masters degree course in Science Education at one of the colleges of advanced education.

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CHAPTER 5

FUTURE DIRECTIONS IN THE EDUCATION OF SCIENCE AND MATHEMATICS TEACHERS

Abstract

A number of actions to attract quality applicants into pre-service teacher education courses in mathematics and science are recommended, including greater publicity, offering scholarships, bursaries and special financial incentives; and implementation of mechanisms to ensure that qualified applicants are not turned away. Ways of attracting greater numbers of students into pre-service courses are outlined, including. alternative entry routes, part-time and external offerings; reduction in the number of areas of specialization required, and the promotion of a personalised approach to mathematics and science teaching.

Actions by employing authorities to enhance recruitment and employment are recommended, including. advertisement of positions in specific schools; offering permanent part-time employment, and provision of career paths which allow quality teachers to remain in classroom teaching positions. A number of measures to assist beginning teachers and encourage continuing teachers are recommended, including. extensive and on-going in-service education, and enhancement of classroom environments and resources. A number of ways in which public support for science and mathematics teachers and programs could be enhanced are suggested.

It is recommended that a group or person be appointed to oversee the implementation of the Working Party's recommendations.

Kilpatrick and Wilson (1983) speaking in the United States at a conference on the teacher shortage in science and mathematics stated

> "The current shortage of mathematics teachers reflects the negative attitudes of society and the educational community towards mathematics, its teaching and those who teach it. In fact, most people do not take the teaching of mathematics seriously."

Their statement is a forceful one and could be considered as an over-reaction to the situation. It does, however, reflect some of the gloom that the Working Party found in relation to the whole ambit of mathematics and its teaching. That same gloom does not appear to prevail as extensively in the case of science. Accordingly the Working Party considers that, if the situation is to be improved, steps must be taken to create a better image of science teaching and particularly of mathematics teaching and hence to encourage more able young people to consider mathematics and science teaching as a career. Ways to achieve that end are outlined in this chapter.

5.1 Encouragement of Quality Applicants into Pre-service Teacher Education Courses in Science and Mathematics

Kilpatrick and Wilson touched a sensitive nerve when they commented on the negative attitudes of society and the educational community towards mathematics. The Working Party considers that such negative attitudes, often reinforced by the media, professionals, and teachers themselves, can deter able school leavers from entering programs in science and mathematics teaching.

Accordingly it recommends:

R5 1 that the Ministe. release further press statements drawing attention to the current shortage of mathematics and science teachers and stressing within a period of rapid technological change the importance of sound teaching in mathematics and science for all pupils and encouraging school leavers, new graduates in mathematics and science and other suitably qualified persons in the community to enter appropriate courses with a view to becoming teachers of mathematics and science; and

R5.2 that tertiary institutions, employing authorities and schools adopt a more active role in encouraging suitably qualified people to enter courses in science and mathematics teaching and in raising the image of science and mathematics teaching as a career.

Incentives were discussed extensively by the Working Party and were the subject of numerous communications to the Working Party. Higher salaries for science and mathematics teachers had been the subject of considerable discussion in the United States of America and the United Kingdom and were regarded favourably by the Working Party as a means of alleviating the teacher shortage in those areas. Such a solution would, however, raise the problem of finding money to increase salaries and the problems associated with providing differential pay for a particular group of teachers. While the Working Party would support additional salary scales as a means of keeping high quality and experienced teachers in the classroom, whatever their teaching area, it is not in favour of differential pay scales for science and mathematics teachers.

On the other hand, additional financial incentives to encourage students into teacher education courses in mathematics and science (or other areas of teacher shortage) do not present the same degree of difficulty as differential salary scales. The Working Party therefore recommends:

R5.3 that, while the shortage of mathematics and science teachers continues –

(i) the number of scholarships and bursaries offered by government authorities for pre-service teacher education courses in mathematics and science be substantially increased;

(ii) that such bursaries be offered during the first year of study as an added incentive for students to undertake mathematics and science teacher education courses;

(iii) that bursaries also be made available in the final year of a Bachelor's degree to students who intend to undertake a Graduate Diploma course in Teaching or a Diploma in Education course leading to a career as a mathematics or science teacher.

Similarly additional incentives might appropriately be offered to allow persons who already possess qualifications in mathematics and science to transfer into teaching without undue financial penalty. It is recommended:

R5.4 that, while the shortage of mathematics and science teachers continues, persons with suitable qualifications in mathematics or science and appropriate experience be encouraged to undertake a graduate diploma in teaching or diploma in education by means of special financial incentives including:

(i) living allowances and other financial support to enable them to engage in full-time study;

(ii) modification of the conditions on TEAS which prevent students from supplementing their income; and

(iii) recognition of all or some of any prior industrial experience they may have in determining commencing salaries within the appropriate scale.

The Working Party also considers that more tertiary science and mathematics students might be encouraged to proceed to postgraduate teacher education courses if they were aware early in their initial degree courses of the pre-requisites for those postgraduate courses, particularly the requirements relevant to the selection of subjects in their undergraduate courses. Briefings in these matters would also help to avoid the occasional instances of undergraduate students who intend to undertake teacher education rendering themselves ineligible through inappropriate subject choice.

It is recommended:

R5.5 that institutions publicize to undergraduate students in mathematics and science courses the requirements and procedures pertaining to entry to pre-service postgraduate teacher education courses.

As there have been instances in recent years of suitably qualified candidates not being accepted into mathematics and science teacher education courses, the Working Party believes that more effective policies need to be adopted by all concerned to respond more quickly to shortages or potential shortages.

The Working Party notes with pleasure that the Board of Advanced Education has reconvened its Committee to Advise on Numbers of Entrants Required for Pre-service Courses of Teacher Education to review the teacher supply and demand position in Queensland in the light of the actual intakes and increases in State teaching service staff ceilings. While the recommendations of this committee can assist teacher education institutions to prepare for longer term changes in intakes, there is a need for flexibility within institutions to respond during the enrolment period to unexpected surges in the numbers of candidates presenting for entry to courses in areas of teacher shortage. Accordingly, the Working Party makes the following recommendations:

R5.6 that universities and colleges closely monitor the offering of places in pre-service secondary teacher education courses through the Queensland Tertiary Admissions Centre with a view to ensuring that all suitable applicants wishing to become mathematics and science teachers are admitted;

R5.7 that additional resources be provided for tertiary institutions to allow the intake of science and mathematics teacher education students to be increased at short notice, particularly in the Graduate Diploma in Teaching and the Diploma in Education;

R5.8 that tertiary institutions consider the need for greater flexibility in staffing through the use of secondments, the employment of part-time staff and other means so that they can respond quickly to the availability of extra students in areas of teacher shortage; and

R5 9 that all employing authorities be encouraged to continue to second suitably qualified teachers to tertiary institutions to provide additional teaching resources to accommodate extra student numbers.

In discussing the difficulties experienced by tertiary institutions in accommodating unexpected increases in numbers of suitably qualified entrants in areas of shortages, the Working Party noted that flexibility in staffing had become increasingly difficult over the past decade. In volume 2 of its Report for 1979–81 Triennium, the Commonwealth Tertiary Education Commission (CTEC) foreshadowed reductions in funding for facilities and schools of education because of an alleged oversupply of teachers. The Commission indicated in paragraph 3.27, that:

"universities and colleges should fill vacancies in teaching staff in education only when the filling of such a vacancy is essential to the oroper provision of an existing course and then with temporary appointments; only in the most exceptional cases should a position be filled on a permanent basis."

This directive appeared not to have been withdrawn and was thought to be a major cause of the lack of flexibility in staffing for teacher education.

It was clear to the Working Party that the supposed general oversupply of teachers, which had prompted the CTEC's embargo on additional staff appointment, no longer applied in Queensland, if indeed it ever did apply, and there was no evidence that any significant numbers of "surplus" teachers from other states were moving to Queensland to meet increasing needs. The Working Party therefore recommends:

R5.10 that, in view of the restructuring and reallocation of higher education resources which has taken place over the 1982–84 triennium and having regard to the current shortage of teachers in areas such as mathematics and science, the Commonwealth Tertiary Education Commission be requested formally to withdraw its policy on the filling of vacancies in teaching staff in faculties and schools of education by universities and colleges.

5.2 Pre-service Teacher Education Courses

The Working Party did not attempt to evaluate the substantive content and objectives of pre-service teacher education programs. That was seen as the prerogative of tertiary institutions and accrediting authorities. It did, however, examine the structure and modes of operation of courses and the paths by which students entered pre-service teacher education courses.

The Working Party does not support any easing of the entry requirements for pre-service teacher education courses. Such action could lead to a lessening of teacher quality and would therefore be a short-term solution at best. It was considered sufficient that tertiary institutions were already experimenting with alternative admission procedures in order to enhance the selection process and to address the Commonwealth Government's Participation and Equity policy. The Working Party has, however, formulated a number of recommendations relating to alternative entry paths to courses and reinforcing actions that tertiary institutions have foreshadowed. It therefore recommends:

R5.11 that tertiary institutions consider amending their admission requirements and course structures to provide an alternative pre-service science and mathematics teacher education course for able students who lack the presently required entry subjects in those areas.

Implementation of the above recommendation would enable institutions to tap a pool of able students who lacked the necessary background requirements in science and/or mathematics, but had the potential, commitment, and achievement in other areas to succeed as science or mathematics teachers. Tertiary institutions might consider stretching the present course to include background units in the needed area so that students could successfully complete the necessary teacher education course – albeit in a longer time period.

The Working Party also endorsed the offering of bridging courses which would allow students who lacked the normal entry requirements in mathematics and science to qualify for entry to pre service programs for the preparation of mathematics and science teachers. It noted that such a course had been proposed by the Advanced Education Council in 1981. Bridging courses could become the initial tier of a two tier course, or UG3 courses, or could be similar to the stretch courses referred to previously.

Accordingly, the Working Party recommends:

R5.12 that consideration be given to the possibility of offering suitable bridging courses in science and mathematics for underqualified school leavers seeking entry to teacher education courses in those fields.

The Working Party also noted that in Queensland pre-service courses were offered only by full-time study. While that approach was clearly desirable from the point of view of practical teaching studies, it restricted the entry of a number of well qualified and experienced graduates whose financial commitments required them to remain in full-time employment. The approach could also be restrictive from a geographical point of view. The Working Party realised that a restructuring of the modes of operation of courses might present some difficulties but nevertheless recommends:

R5.13 that early consideration be given to the offering of pre-service graduate diploma courses in science and mathematics teaching by part-time evening or external study.

The Working Party considers that close co-operation between employing authorities and tertiary institutions in relation to the development of pre-service teacher education course structures is vitally important. The concurrence of employing authorities is necessary if desirable developments such as greater flexibility in course structures are to be implemented by tertiary institutions. In particular the Working Party considers that the general requirement for mathematics and science teachers to be capable of teaching at least two subject areas to Year 12 level and both mathematics and science to Year 10 level places unrealistic demands on pre-service courses. The Working Party considers that mathematics and science teachers could be much better prepared if they were able to concentrate on either mathematics or science throughout the secondary school or on both mathematics and science at the junior secondary level. Again, while many beginning teachers were both highly competent and confident in teaching subjects of their principal teaching areas, there were numerous instances of their being asked to teach subject areas in which they lacked competence.

The Working Party therefore recommends:

R5.14 that employing requirements for mathematics and science teachers be reviewed with a view to reducing either the range of content areas or year levels of the school curriculum which teachers are required to teach;

R5.15 that provision be made for a limited number of students to undertake secondary teacher education courses specializing in only one teaching area, mathematics or science;

R5.16 that, wherever possible, teachers not be required to teach in areas of mathematics and science for which they have had not received an adequate professional preparation.

Research evidence considered by the Working Party suggested that mathematics teachers and to a lesser extent science teachers need to be more cognisant of the effects of sex-related factors on the teaching/learning process and to be aware of the importance of a personalised approach in teaching. In fact the evidence collected suggests that mathematics teachers rate poorly in areas such as teacher warmth, personalised teaching, and respect for students built on understanding and humaneness. Consequently the Working Party recommends:

R5.17 that tertiary institutions include in their pre-service teacher education courses in science and mathematics studies that make students more aware of the importance of sex-related factors in the teaching/learning process and stress the importance of a personalised approach in teaching mathematics and science.

5.3 Recruitment and Employment

The current shortage of science and mathematics teachers inevitably places pressures on employing authorities to seek alternative means of meeting school needs for teachers in these areas. In its deliberations the Working Party noted policies and proposals relating to recruitment and employment which are being used overseas and in other parts of Australia. Those policies included the advertising of vacancies in particular schools, rather than on a system-wide level only, the use of part-time teachers, and the provision of salary and status rewards which do not require high quality teachers to withdraw from classroom teaching. The Working Party believes that these have potential for Queensland employing authorities at this time and accordingly recommends:

R5.18 that employing authorities be encouraged to advertise through local and State newspapers positions in science and mathematics teaching associated with particular schools;

R5.19 that the establishment of permanent part-time positions for science and mathematics teachers be encouraged; and

R5.20 that further consideration be given to the possibility of providing status and salary rewards for high quality teachers in science and mathematics which do not require them to withdraw from classroom teaching.

5.4 Beginning Teachers

Even after an ideal pre-service education the needs of beginning teachers in science and mathematics during their first years will be significant. Moreover, in their early years beginning teachers start to shape their own teaching styles and methods and their attitudes to the teaching and learning of science and mathematics and the entire educative process. Accordingly the Working Party recommends to school authorities:

R5.21 that close attention be given by principals and subject masters/mistresses to the provision of an effective and sympathetic induction to the teaching profession for beginning teachers, particularly in science and mathematics;

R5 22 that beginning teachers of mathematics and science not be given full and immediate responsibility for teaching classes where students experience substantial learning difficulties,

R5.23 that beginning teachers be given realistic and carefully considered teaching loads. Too little variety such as the teaching of science or mathematics to multiple classes at one year level only could be just as detrimental as too much variety; and

R5 24 that subject masters/mistresses, advisory teachers and consultants consider further ways of assisting beginning teachers to overcome problems of class management, classroom and laboratory organization, assessment, and lack of student motivation in learning that are so characteristic of the early teaching years

The Working Party also recommends:

R5.25 that employing authorities be encouraged to assist beginning teachers by providing greater numbers of advisory and consultant teachers, both in schools and via telecommunication links; and

R5.26 that subject associations in science and mathematics be encouraged to place greater emphasis on the needs of beginning teachers and to identify among their members teachers who could organize in-service and continuing education programs especially for beginning teachers.

5.5 In-service Teacher Education

The Cockcroft Committee (1982) believed that the need for in-service support was self-evident. Their argument was as follows:

> "Even if greatly increased numbers of teachers who are well equipped to teach mathematics were to enter teaching in primary and secondary schools in the next few years, it would take many years to have a significant effect on the overall quality of the mathematics teaching force. It follows that any improvement in the standards of mathematics in schools must come largely as a result of the efforts of those teachers who are already in post; they must, therefore, receive all possible support to enable them to improve the effectiveness of their teaching."

The Working Party found the situation in Queensland to be similar to that in the United Kingdom and the Cockcroft argument to be valid here also. Cockcroft identified a number of forms of in-service support; viz. school based support, meetings with other teachers, visits to other schools, involvement of professional associations, the use of mathematics advisory staff, contributions from higher education, in-service and continuing education courses, use of radio, television and teleconferencing programs, and the provision of information on science and mathematics teaching and learning drawn from centres for research. All of those forms of in-service support have been used to varying degrees in Queensland during recent years and will continue to be used in the future. The Working Party wishes, however, to make a number of specific proposals in relation to in-service support for science and mathematics teachers. It therefore recommends:

R5.27 that in-service training be provided by appropriate bodies to enable teachers to keep up to date with multistrand and life-role approaches to science teaching as well as advances in their discipline areas;

R5.28 that extensive and on-going in-service education support be provided to re-orientate teachers' understanding of how children learn science and mathematics, given the continuing growth of knowledge in the field of cognitive learning;

R5.29 that employing authorities take steps to expand both school-based and systemic in-service teacher education programs in the areas of science and mathematics as a matter of urgency;

R5.30 that science and mathematics teachers be encouraged to collaborate and engage in discussions with other staff in schools in the areas of curriculum development and implementation.

In addition to in-service education for current teachers of mathematics and science, the Working Party believes that there is scope for courses for primary teachers or secondary teachers of other subjects who may have some background in mathematics and science to become teachers of mathematics or science at the junior secondary level. Such courses may allow some teachers who may not currently be teaching to return to teaching on a full-time or part-time basis to help alleviate the shortage of mathematics and science teachers, at least at the junior secondary level. They might also allow more flexibility for movement of teachers between the upper primary and lower secondary levels.

At the suggestion of the Working Party, a survey was undertaken of registered teachers not currently teaching to gain an indication of the number who might be willing to undertake further studies to prepare them for mathematics and science teaching. The results of the survey suggest that courses of this nature could make a useful contribution to reducing the teacher shortage. The Working Party therefore recommends:

R5.31 that tertiary institutions be encouraged to mount non-award continuing education courses in junior secondary mathematics and science teaching and that the support of employing authorities and teachers' unions in giving such programs high recognition be sought.

In summary the Working Party believes that expenditure to achieve an expansion of in-service training is a necessary investment in the future quality of the teaching force, especially at this time when all indications are that such expansion is essential for children's survival in a scientific and technological age.

Similarly, to enhance the quality of teaching in mathematics and science, the Working Party believes that every effort should be made to ensure that teachers have the facilities and resources to make mathematics and science classrooms exciting and stimulating for young people.

The Working Party recommends:

R5.32 that, within existing resources, school authorities, principals, subject masters/mistresses and teachers explore ways of making the typical mathematics or science classroom a more attrative place in which to work;

R5.33 (a) that additional staffing and financial provisions be made by employing authorities for the assessment of available resource materials for the teaching of mathematics and science, for the production of additional resources and for the necessary in-service programs to enable teachers to use such resources effectively in their classrooms

(b) that, in particular, resources be supplied to encourage and support initiatives in mathematics teaching.

5.6 Public Support for Mathematics and Science Teaching

To sum up the burden of this report, the Working Party would identify the root problem underlying the present shortage of mathematics and science teachers as a critically low level of public support for mathematics and science teaching The Working Party believes that this level of support must be significantly enhanced if the teaching and learning of science and mathematics are to be improved.

The United States Agenda for Action (1981) underlines concern there as follows:

> "Few school systems have truly adequate supervisory and material support for the teachers in the maintenance and improvement of the instructional environment. More and more, teachers feel the lack of parental understanding of the complexity of their task and the lack of parental co-operation and support in their efforts to instruct children. Furthermore governmental support for improving the quality of mathematics teaching has dwindled."

The Agenda for Action Report also states:

> "At present, there are too many unnecessary obstacles to the effective functioning of teacher and student in a true teaching/learning interaction. These include more and more time required for unproductive record keeping; many unmotivated, undisciplined students; a lack of parental support; ambivalence and vacillation in government regulations; shifting societal priorities; and the lack of home and school agreement on out-of-school study assignments."

The Working Party considers that those sentiments mirror opinion in Queensland and in the rest of Australia. Such impediments to children's learning in science and mathematics need to be removed. In this report, numerous ways have been suggested for increasing public support for mathematics and science teaching and for removing impediments to effective teaching and learning. In commending these recommendations to all those concerned, the Working Party would make a general appeal for public support for mathematics and science education by recommending:

R5.34 that Government and private funding agencies collaborate more widely with science and mathematics educators in relation to needed research into science and mathematics teaching and learning;

R5.35 that additional funds be made available for research and development in science and mathematics education;

R5.36 that community organizations and the media be encouraged to be supportive of science and mathematics teachers so that the attractiveness of the profession will be enhanced;

R5.37 that parents, teachers, and school administrators establish new and higher standards of co-operation and teamwork in the interests of attaining the common goal of educating students to their highest potential in science and mathematics; and

R5.38 that governments at all levels facilitate the attainment of goals in science and mathematics agreed upon co-operatively by parents, mathematics and science teachers, teacher educators, professional mathematicans and scientists and other interested and involved parties.

In particular, in relation to its recommendations the Working Party would also recommend.

R5.39 that the Board of Teacher Education consider appointing an independent group to monitor the implementation of the recommendations in this report

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Appendix 1

LIST OF RECOMMENDATIONS

R1.1 that annual reviews of teacher supply and demand in Queensland be conducted during the first half of each year.

R2.1 that a longitudinal research study be undertaken to determine reasons for subject choice, with particular reference to differences in subject selection between the sexes;

R2.2 that longitudinal studies of achievement and attitudes in science and mathematics be undertaken to:

- identify achievement trends during primary and secondary schooling;
- identify attitude trends during primary and secondary schooling;
- determine factors which influence performance in science and mathematics at various stages of schooling; and
- determine factors which influence attitudes in science and mathematics at various stages of schooling;

R2.3 that research studies be undertaken to investigate the effect of sex-related variables on attitudes to science and mathematics at various stages of schooling; and

R2 4 that training packages be developed to enable students, particularly females, to become aware of the factors which contribute to negative attitudes towards science and mathematics and to counsel students towards more positive, confident vocational orientations.

R3.1 that the procedures for developing and implementing syllabuses be examined with a view to creating mechanisms which will respond more rapidly to changes in education and society, particularly for those subjects which are affected by extensive technological change;

R3.2 that the examination of upper primary and lower secondary syllabuses in Science and Mathematics continue with a view to producing a P—10 curriculum which takes cognisance of integrating themes and key concepts in science and mathematics;

R3 3 that the syllabuses in Science and Mathematics be examined to determine if concepts are being introduced at points appropriate to children's level of development;

R3 4 that the current form of certification adopted at the end of Year 10 be evaluated and consideration given to accrediting schools' courses at that level;

R3 5 that more extensive in-service development programs for science teachers in secondary schools be provided to facilitate changes in science teaching methodologies foreshadowed in recent research and emerging curriculum programs;

R3.6 that the scope and content of science curricula at all levels of the secondary school be examined in order to determine whether there is a need to reduce the body of knowledge perceived to be required and to allow greater emphasis to be developed on concept acquisition, problem solving and process attainment;

R3.7 that those involved in ongoing curriculum development in science take account of differences in background knowledge and learning styles of females and males and that steps be taken within the organisation of science programs so that greater numbers of females may be attracted to study Senior Science;

R3.8 that, in keeping with trends both interstate and overseas, science be included as a core subject up to Year 10 in all secondary schools;

R3.9 that greater integration of key ideas be encouraged during teaching of science to Years 11 and 12 with an attendant reduction of the boundaries between science subjects in the senior school;

R3.10 that greater emphasis on the social effects of science and technology be incorporated into the Science curriculum at all levels;

R3.11 that resources for science teaching be improved through centrally co-ordinated developmental projects, so that key emphases in syllabuses are implemented;

R3.12 that the development of a curriculum aimed at achieving a balanced and coherent P–10 Science program continue;

R3.13 that available mathematics textbooks be continually reviewed and evaluated with a view to providing advice on those that may best suit teachers and schools, keeping in mind their appeal and relevance to girls. Improved mechanisms are needed to evaluate and provide information to schools on textbooks so that those which are inert, out of date and alienating students will be discarded;

R3.14 that in ongoing curriculum development in mathematics, greater efforts be made to:

(i) ensure more appropriate selection and sequencing of learning in topics such as algebra, geometry, ratio and fractions;

(ii) encourage the use of meaningful learning experiences with calculators and computers;

(iii) eliminate unnecessary use of logarithm tables and trigonometric tables; and

(iv) de-emphasise the range of content and emphasize acquisition of concepts, applications, processes and problem-solving;

R3.15 that the amount of content in Senior Mathematics units be reduced and in collaboration with tertiary institutions the Mathematics curriculum in Years 11 and 12 be reviewed in conjunction with the P–10 curriculum review;

R3.16 that the practice of streaming Year 9 and Year 10 mathematics classes into Advanced and Ordinary Mathematics be discontinued and that one mathematics subject be available for all students in Years 9 and 10;

R3.17 that all groups including administrators, subject masters and other teachers associated with the education of teachers of mathematics affirm the need for mathematics learning to take place in an active, exciting and caring environment characterised by a variety of approaches and organisational strategies;

R3.18 that resources for mathematics teaching be improved through centrally co-ordinated developmental projects, so that key emphases in syllabuses are implemented, R3.19 that in view of the strong evidence that time is a significant variable in mathematics learning, more time be allocated to the teaching of mathematics and that mathematics teachers be better prepared to manage time more effectively in classroom learning experiences;

R3.20 that those involved in ongoing curriculum development in mathematics take account of the distinctive background knowledge and learning styles of females and that steps be taken within the organisation of mathematics to attract greater numbers of females to Senior Mathematics and place greater emphasis on the development of spatial abilities in female students;

R3.21 that all teachers be encouraged to place greater emphasis on diagnostic teaching strategies wherein specific emphasis is given to assisting students to recognise their own learning problems and to facilitate improved learning, by their own initiative;

R3.22 that schools be encouraged to provide support mechanisms for inexperienced teachers of mathematics, particularly through organisational processes which would allow inexperienced teachers regularly to consult with and teach with highly competent colleagues.

R4.1 that employing authorities and tertiary institutions involved in teacher education be encouraged to co-operate in the development of pamphlets and brochures which promote science and mathematics teaching and describe personal and professional characteristics of science and mathematics teachers;

R4 2 that actions be taken through in-service education to acquaint science and mathematics teachers with the importance of various aspects of their personal and professional roles;

R4.3 that science and mathematics teachers be made more aware of the importance of their role in attracting persons with high academic ability, especially school leavers, to enter science and mathematics teaching;

R4.4 that the raison d'etre for Diploma of Teaching courses as the minimum qualification for entering science and mathematics teaching be reviewed;

R4.5 that further consideration be given to the need for a Masters degree course in Science Education at one of the colleges of advanced education.

R5 1 that the Minister release further press statements drawing attention to the current shortage of mathematics and science teachers and stressing within a period of rapid technological change the importance of sound teaching in mathematics and science for all pupils and encouraging school leavers, new graduates in mathematics and science and other suitably qualified persons in the community to enter appropriate courses with a view to becoming teachers of mathematics and science;

R5 2 that tertiary institutions, employing authorities and schools adopt a more active role in encouraging suitably qualified people to enter courses in science and mathematics teaching and in raising the image of science and mathematics teaching as a career;

R5 3 that, while the shortage of mathematics and science teachers continues —

(i) the number of scholarships and bursaries offered by employing authorities for pre-service teacher education courses in mathematics and science be substantially increased;

(ii) that such bursaries be offered during the first year of study as an added incentive for students to undertake mathematics and science teacher education courses;

(iii) that bursaries also be made available in the final year of a Bachelor's degree to students who intend to undertake a Graduate Diploma course in Teaching or a Diploma in Education course leading to a career as a mathematics or science teacher;

R5.4 that, while the shortage of mathematics and science teachers continues, persons with suitable qualifications in mathematics or science and appropriate experience be encouraged to undertake a graduate diploma in teaching or diploma in education by means of special financial incentives including:

(i) living allowances and other financial support to enable them to engage in full-time study;

(ii) modification of the conditions on TEAS which prevent students from supplementing their income; and

(iii) recognition of all or some of any prior industrial experience they may have in determining commencing salaries within the appropriate scale;

R5.5 that institutions publicize to undergraduate students in mathematics and science courses the requirements and procedures pertaining to entry to pre-service post-graduate teacher education courses;

R5.6 that universities and colleges closely monitor the offering of places in pre-service secondary teacher education courses through the Queensland Tertiary Admissions Centre with a view to ensuring that all suitable applicants wishing to become mathematics and science teachers are admitted;

R5.7 that additional resources be provided for tertiary institutions to allow the intake of science and mathematics teacher education students to be increased at short notice, particularly in the Graduate Diploma in Teaching and the Diploma in Education;

R5.8 that tertiary institutions consider the need for greater flexibility in staffing through the use of secondments, the employment of part-time staff and other means so that they can respond quickly to the availability of extra students in areas of teacher shortage;

R5.9 that all employing a horities be encouraged to continue to second suitably qualified teachers to tertiary institutions to provide additional teaching resources to accommodate extra student numbers;

R5 10 that, in view of the restructuring and reallocation of higher education resources which has taken place over the 1982–84 triennium and having regard to the current shortage of teachers in areas such as mathematics and science, the Commonwealth Tertiary Education Commission be requested formally to withdraw its policy on the filling of vacancies in teaching staff in faculties and schools of education by universities and colleges;

R5.11 that tertiary institutions consider amending their admission requirements and course structures to provide an alternative pre-service science and mathematics teacher education course for able students who lack the presently required entry subjects in those areas, R5.12 that consideration be given to the possibility of offering suitable bridging courses in science and mathematics for underqualified school leavers seeking entry to teacher education courses in those fields;

R5.13 that early consideration be given to the offering of pre-service graduate diploma courses in science and mathematics teaching by part-time evening or external study;

R5.14 that employment requirements for mathematics and science teachers be reviewed with a view to reducing either the range of content areas or year levels of the school curriculum which teachers are required to teach;

R5.15 that provision be made for a limited number of students to undertake secondary teacher education courses specializing in only one teaching area, mathematics or science;

R5.16 that, wherever possible, teachers not be required to teach in areas of mathematics and science for which they have had not received an adequate professional preparation;

R5.17 that tertiary institutions include in their pre-service teacher education courses in science and mathematics studies that make students more aware of the importance of sex-related factors in the teaching/learning process and stress the importance of a personalised approach in teaching mathematics and science;

R5.18 that employing authorities be encouraged to advertise through local and State newspapers positions in science and mathematics teaching associated with particular schools;

R5.19 that the establishment of permanent part-time positions for science and mathematics teachers be encouraged;

R5.20 that further consideration be given to the possibility of providing status and salary rewards for high quality teachers in science and mathematics which do not require them to withdraw from classroom teaching;

R5.21 that close attention be given by principals and subject masters/mistresses to the provision of an effective and sympathetic induction to the teaching profession for beginning teachers, particularly in science and mathematics;

R5.22 that beginning teachers of mathematics and science not be given full and immediate responsibility for teaching classes where students experience substantial learning difficulties;

R5.23 that beginning teachers be given realistic and carefully considered teaching loads. Too little variety such as the teaching of science or mathematics to multiple classes at one vear level only could be just as detrimental as too much variety;

R5.24 that subject masters/mistresses, advisory teachers and consultants consider further ways of assisting beginning teachers to overcome problems of class management, classroom and laboratory organization, assessment, and lack of student motivation in learning that are so characteristic of the early teaching years;

R5.25 that employing authorities be encouraged to assist beginning teachers by providing greater numbers of advisory and consultant teachers, both in schools and via telecommunication links;

R5.26 that subject associations in science and mathematics be encouraged to place greater emphasis on the needs of beginning teachers and to identify among their members teachers who could organize in-service and continuing education programs especially for beginning teachers;

R5.27 that in-service training be provided by appropriate bodies to enable teachers to keep up to date with multistrand and life-role approaches to science teaching as well as advances in their discipline areas;

R5.28 that extensive and ongoing in-service education support be provided to re-orientate teachers' understanding of how children learn science and mathematics, given the continuing growth of knowledge in the field of cognitive learning;

R5.29 that employing authorities take steps to expand both school-based and systemic in-service teacher education programs in the areas of science and mathematics as a matter of urgency;

R5.30 that science and mathematics teachers be encouraged to collaborate and engage in discussions with other staff in schools in the areas of curriculum development ' .d implementation;

R5.31 that tertiary institutions be encouraged to mount non-award continuing education courses in junior secondary mathematics and science teaching and that the support of employing authorities and teachers' unions in giving such programs high recognition be sought;

R5.32 that, within existing resources, school authorities, principals, subject masters/mistresses and teachers explore ways of making the typical mathematics or science classroom a more attractive place in which to work;

R5.33 (a) that additional staffing and financial provisions be made by employing authorities for the assessment of available resource materials for the teaching of mathematics and science, for the production of additional resources and for the necessary in-service programs to enable teachers to use such resources effectively in their classrooms

(b) that, in particular, resources be supplied to encourage and support initiatives in mathematics teaching;

R5.34 that Government and private funding agencies collaborate more widely with science and mathematics educators in relation to needed research into science and mathematics teaching and learning,

R5.35 that additional funds be made available for research and development in science and mathematics education;

R5.36 that community organizations and the media be encouraged to be supportive of science and mathematics teachers so that the attractiveness of the profession will be enhanced;

R5 37 that parents, teachers, and school administrators establish new and higher standards of co-operation and teamwork in the interests of attaining the common goal of educating students to their highest potential in science and mathematics;

R5.38 that governments at all levels facilitate the attainment of goals in science and mathematics agreed upon co-operatively by parents, mathematics and science teachers, teacher educators, professional mathematicans and scientists and other interested and involved parties;

R5.39 that the Board of Teacher Education consider appointing an independent group to monitor the implementation of the recommendations in this report.

Appendix 2

INTERIM REPORT OF THE WORKING PARTY – DECEMBER 1983

The Working Party recognised that its terms of reference were far reaching in scope and would involve not only an investigation of teacher supply and quality in the areas of mathematics and science but also consideration of various aspects of the school mathematics and science curriculum. Accordingly, while it has not yet been able to address all aspects of its terms of reference in detail, the Working Party has agreed upon a set of interim recommendations which it believes may assist in alleviating the current difficulties.

1. Teacher Supply

Information that we have received from the major employing authority, the Queensland Department of Education, indicates that the present shortage in supply of secondary mathematics and science teachers is real, extensive and likely to be protracted. The most recent report of the committee convened by the Board of Advanced Education on the "Review of Teacher Supply and Demand in Queensland" (1982) reflects this critical situation in its provision for significant increases in quotas for all pre-service courses in secondary mathematics and science teaching at least until 1988.

The Working Party is further aware that the 1983 entry quotas were not met in mathematics and science teacher education. For example, in the Brisbane College of Advanced Education, Diploma of Teaching (Secondary : Mathematics/Science) a quota of 195 was proposed but only 80 students were enrolled. The universities report similar difficulties in filling quotas for mathematics and science teacher education courses. Both colleges and universities have expressed disappointment that the students seeking entry to these courses did not include many with the highest entry scores. Indeed, experience would suggest that some of those admitted may be expected to experience difficulty in completing the course.

The situation in Queensland is reflected in other states in Australia and is, in fact, indicative of the world-wide shortage of quality teachers in mathematics and science. (Cockcroft 1982, Report of the Commission on the Teaching of Mathematics, Science and Technology at Pre-college Level, National Science Board, U.S.A., 1983).

In order that the situation in Queensland can be continually and sensitively monitored, the Working Party recommends:

1.1 that the Board of Advanced Education reconvene the Special Committee to Advise on Entrants Required to Pre-service Courses of Teacher Education as soon as practicable to review the teacher supply and demand position in Queensland in the light of the actual intakes in 1983 and of the recently-announced increases in State teaching service staff ceilings.

At the same time, however, given the present evidence of critical shortage in the supply of mathematics and science teachers for Queensland secondary schools, the Working Party believes that immediate action should be taken to encourage more, and more able, students to enter mathematics and science teacher education courses and to develop a broader range of courses in this area.

Firstly, we believe that much more needs to be done to improve the public image of teaching in general and of mathematics and science teaching in particular.

Accordingly, we recommend:

1.2 that the Minister release press statements stressing the importance of sound teaching in mathematics and science for all pupils and encouraging school-leavers, new graduates in mathematics and science and other suitably qualified persons in the community to enter appropriate courses with a view to becoming teachers of mathematics and science;

1.3 that school authorities review their present facilities and conditions for mathematics and science teaching and give consideration to the provision of additional resources with a view to making the typical school mathematics or science classroom a more attractive place in which to work.

The Working Party noted that there was some evidence that the number of applicants for entry to pre-service mathematics and science courses in 1984 might be somewhat higher than in recent years although still below the projected entry levels suggested in the 1982 Review of Teacher Supply and Demand in Queensland. It was suggested that, as resources may have been allocated within institutions on the basis of entry levels predicted from previous years' intakes, there may be some difficulty in accommodating all eligible applicants.

The Working Party would therefore recommend:

1.4 that the Board of Advanced Education and the Brisbane College of Advanced Education closely monitor the offering of places in pre-service secondary teacher education courses through Queensland Tertiary Admissions Centre in 1983–84 with a view to ensuring that all suitably qualified applicants for the mathematics and science strand are admitted.

Despite the somewhat hopeful indications of an increase in the numbers seeking entry to these courses, the Working Party still believes that the intakes will fall short of needs for a number of years to come. Therefore, in order to encourage more school-leavers and new graduates to enter pre-service mathematics and science teacher education courses the Working Party further recommends:

1.5 that, while the shortage of mathematics and science teachers continues, the number of scholarships and bursaries offered for pre-service teacher education courses in mathematics and science be substantially increased.

The Working Party also has reason to believe that there may be a significant number of persons in the community who possess suitable qualifications and experience in mathematics and science who may be attracted into teaching if the transition could be achieved without undue financial penalty. To top this additional source of supply, we recommend:

1.6 that, while the shortage of mathematics and science teachers continues, special financial incentives be offered for persons with suitable qualifications in mathematics or science and appropriate experience to undertake a graduate diploma in teaching or diploma of education, including –

(i) living allowances and other financial support to enable them to engage in full-time study; and

(ii) recognition of all or some of any prior industrial experience they may have in determining commencing salaries within the appropriate scale.

Again, persons already employed in other areas may be interested in undertaking teacher education on a part-time basis if suitable courses were available. Arrangements could be made for them to undertake school experience during periods of leave from their regular employment. To enable this possibility to be explored, we recommend:

1.7 that the Board of Advanced Education, the Brisbane College of Advanced Education and the universities give early consideration to the offering of graduate courses in mathematics and science teaching by part-time evening or external study.

It is noted that the availability of such part-time courses would also enable teachers without recent teaching experience to re-enter teaching better prepared to meet the needs of today's secondary school students. In addition, it would become possible for teachers of other subjects to move into mathematics or science teaching.

The Working Party is aware that some graduates who, in their first degrees, have specialised in mathematics or a single area of science, are presently ineligible for entry into postgraduate teacher education courses or are dissuaded from undertaking such courses because of the requirement that they prepare for teaching in two subject areas.

Similarly, the Working Party noted the heavy workload in the Diploma of Teaching (Secondary) for mathematics and science students brought about by the need to cover a very broad area of content in order to meet the requirements of two subject areas. It was suggested that this heavy workload might deter school-leavers from applying to enter the course and many contribute to the withdrawal of some students from the course.

The requirement noted above stems from the policy of the major employing authority to employ for service in secondary schools only teachers who are prepared to teach in two subject areas where science and mathematics are each regarded as one subject area only. The Working Party had before it, however, the results of a survey which suggested that, once employed, the great majority of beginning mathematics and science teachers were rarely required to teach in their second teaching area. It was further noted that non-government schools are prepared to employ teachers who have a single teaching specialisation in mathematics or science or, indeed in a single area within the scientific field such as biology, chemistry or physics. In the light of these considerations, the Working Party recommends:

1.8 that the major employing authorities review their employment requirements for mathematics and science teachers with a view to reducing the range of content areas and year levels of the school curriculum for which they are required to be prepared to teach; and

1.9 that secondary teacher education institutions make provision for a limited number of students to undertake teacher education courses specialising in either mathematics or science.

A related difficulty noted by the Working Party was the tendency of employing authorities to assume that teachers who have any science or mathematics teacher preparation are able to teach any science or mathematics throughout the secondary school. Thus teachers who have mathematics and one senior science, say physics, as their teaching areas are expected to be able to teach junior science including aspects of chemistry, biology, earth science and astronomy. Similarly, teachers who have one or two senior science subjects together with junior science or multistrand science as teaching areas may be assumed to be able to teach mathematics.

Finally, we are aware that some teachers with no background in either mathematics or science are required to teach these subjects at the junior secondary level.

The Working Party is concerned that the detrimental effects of mathematics and science teachers being required to teach in these areas may be one of the factors which is contributing to the current lack of enthusiasm on the part of secondary school students for mathematics and science and to their consequent lack of interest in mathematics and science teaching as a career.

We are also concerned that some admirable teachers of senior science and mathematics subjects may be lost to the service as a consequence of their having been required to teach in areas for which they do not feel adequately prepared.

While recognising the special problems of staffing small secondary schools and secondary departments in primary schools, members of the Working Party felt that it must **recommend**:

1.10 that every effort be made by employing authorities to avoid requiring teachers to teach in areas of mathematics or science for which they have not received an adequate professional preparation.

On a more positive note, the Working Party would expect that some of the teachers who lack formal qualifications in mathematics and science who are currently teaching these subjects would be willing to undertake in-service non-award or continuing education courses which might provide them with a more adequate background for teaching junior mathematics or science, for remedial teaching in mathematics or for teaching basic mathematics in transition programs.

Similarly, there may be secondary teachers in other subject areas or primary-trained teachers who have some background in mathematics or science who might be prepared to undertake an in-service course of this kind in order to transfer into junior secondary mathematics or science teaching. Accordingly, the Working Party **recommends**:

1.11 that universities and colleges be encouraged to mount non-award continuing education courses in junior secondary mathematics and science teaching.

The offering of courses such as those proposed above might also prove attractive to teachers not currently teaching who might see their chances of regaining employment enhanced by gaining qualifications to teach in an area of high demand. Some of these teachers, and others already qualified in mathematics and science, may not be able to return to full-time teaching, but may be prepared to teach on a part-time basis. We feel that this possibility should be further explored and **recommend**:

1.12 that employing authorities give consideration to the increased use of suitably qualified part-time teachers to help overcome the current shortage of mathematics and science teachers; and

1.13 that the Board of Teacher Education consider undertaking a survey of registered teachers who are not currently teaching to ascertain the numbers of such teachers who are qualified mathematics and science teachers who might be prepared to return to teaching on a full-time or part-time basis and the numbers who might be willing to undertake a "conversion" course to prepare them for mathematics or science teaching.

A number of overseas reports noted by the Working Party indicate that numerous excellent teachers of mathematics and science move out of the classroom to gain higher status and salary. We believe that a similar situation exists in Queensland. It seems to us ironic that to gain the greatest recognition or reward for excellence in classroom teaching, teachers must move out of the classroom, particularly when there is a shortage of suitably qualified replacements. While recognising the difficulties involved in implementation of such a proposal, the Working Party recommends:

1.14 that employing authorities give further consideration to the possibility of providing status and salary rewards for high quality teachers who do not require them to withdraw from classroom teaching.

2. Routes of Entry and Courses Available for the Education and Training of Mathematics and Science Teachers

The Working Party is aware that a number of able students in mathematics and science have closed doors to areas of tertiary study as a result of their selection of subjects of their educational experience in secondary schools.

In 1981, the Advanced Education Council proposed a one-year bridging course in mathematics and science for school-leavers who are interested in these fields but did not qualify for college or university programs. In our view such a course of action is most timely and we believe that preference should be given to school-leavers who are desirous of entering a teaching course in mathematics and/or science following such a bridging course. The use of packages such as SPIM or Polymath in these bridging courses would appear to have high potential for success.

Similar opportunities might be provided to allow school-leavers with the appropriate tertiary entrance score who lack the required entry subjects in mathematics and science, to undertake teaching courses in these areas by taking bridging units as part of an extended diploma course or an alternative diploma course which prepares them for teaching junior secondary mathematics and science subjects.

There are also students whose achievement in mathematics and/or science in Years 11 and 12 has been quite acceptable, but who have failed to gain a sufficiently high T.E. score to meet entry requirements. It is the Working Party's belief that more flexible entry requirements should be applied to enable students in this category to enter a teaching course in mathematics and/or science. The development of alternative forms of the T.E. score, e.g. a T.E. score based on a science-mathematics cluster, would appear to be helpful in assisting colleges and universities to develop more flexible admission criteria.

We therefore recommend:

2.1 that tertiary institutions pursue the possibility of offering bridging courses in mathematics and science for school-leavers seeking entry to teacher education courses in these fields who lack the formal tertiary entry levels in these subjects; and

2.2 that colleges consider amending their admission requirements and course structure to provide an alternative pre-service mathematics and science teacher education course for able students who lack the presently-required entry subjects in these areas.

3. Additional Provisions for Mathematics and Science Teachers in their Early Years of Teaching

The Working Party is concerned that a number of newly employed teachers of mathematics and science give up the profession early or do not reach their full potential because of inadequate support in their initial teaching experiences. Several reports read by the Working Party made reference to the difficulties young teachers experience during their early years of teaching. This is often exacerbated by the fact that they are given immediate and full responsibility for teaching classes where students experience substantial learning difficulties in mathematics. In other cases, beginning teachers have been given teaching loads which lack variety, such as the teaching of mathematics to multiple classes at one year level only.

The Working Party endorses the Board of Teacher Education's policies on the induction of beginning teachers and we believe that much more can be done by schools to assist young teachers of science and mathematics. Team teaching with highly competent teachers and more appropriate timetables for young teachers were two suggestions identified by the Working Party.

Accordingly, we **recommend**:

3.1 that particular attention be given by school authorities, principals and subject masters to the provision of an effective and sympathetic induction to the teaching profession for beginning teachers, particularly in mathematics and science.

In this context, comment was also made by members of the Working Party concerning the need for a greater variety of resource materials for secondary mathematics teaching such as RIME. Although the Working Party has not pursued this matter to any depth at this stage, we feel it appropriate to **recommend**:

3.2 that additional provision be made for the assessment of available resource materials for the teaching of mathematics and science, for the production of additional resources where appropriate and for the purchase of such resources by schools.

Appendix 3

CLASS TEACHER QUALIFICATIONS BY CATEGORY*, REGION, YEAR AND SUBJECTS

*Each class in the sample was categorized as follows:

Group 1: Those classes taught by teachers whose qualifications had been obtained by major curriculum studies and major content studies in that subject. Classes whose teachers had completed a Diploma in Education, Graduate Diploma in Teaching, Diploma of Teaching or a Bachelor of Education course with a **principal** teaching area in the subject under consideration formed the major part of this group.

Group 2: Those classes taught by teachers whose qualifications had been obtained through minor curriculum studies and minor content studies in that subject. For the most part teachers of classes in this group were graduates of a Diploma of Teaching or a Bachelor of Education course with a **second** teaching area in the subject under consideration

Group 3: Those classes taught by teachers whose qualifications included substantial content studies but no curriculum studies in the class subject.

Group 4: Those classes taught by teachers whose qualifications comprised minimal or no content studies and no curriculum studies in the class subject In essence this group contained classes which could not be categorised under Groups 1 through 3.

BRISBANE NOR H REGION

Subject	Sample Size	Group 1	(%)	Group 2	(%)	Group 3	(%)	Group 4	(%)
Year 8	13	4	(31)	6	(46)	2	(15)	1	(8)
Year 9, 10 Maths	24	10	(42)	6	(25)	1	(4)	7	(29)
Senior Maths	17	14	(82)	2	(12)	0		1	(6)
Junior Science	29	20	(69)	4	(14)	2	(7)	3	(10)
Biological Science	8	5	(63)	1	(13)	1	(13)	1	(13)
Multistrand Science	2	0		2	(100)	0		0	
Chemistry	3	3	(100)	0		0		0	
Physics	3	1	(33)	0		1	(33)	1	(33)

BRISBANE SOUTH REGION

Subject	Sample Size	Group 1	(%)	Group 2	(%)	Group 3	(%)	Group 4	(%)
Year 8 Maths	14	6	(43)	3	(21)	0		5	(36)
Years 9, 10 Maths	30	10	(33)	7	(23)	2	(7)	11	(37)
Senior Maths	21	12	(57)	4	(19)	3	(14)	2	(10
Junior Science	39	25	(64)	6	(15)	1	(3)	7	(18)
Multistrand	2	2	(100)	0		0		0	
Biological Science	9	8	(89)	1	(11)	0		0	
Chemistry	4	2	(50)	2	(50)	0		0	
Physics	4	2	(50)	0		0		2	(50)

BRISBANE WEST REGION

Subject	Sample Size	Group 1	(%)	Group 2	(%)	Group 3	(%)	Group 4	(%)
Year 8 Maths	7	3	(43)	1	(14)	2	(29)	1	(14)
Year 9 10 Maths	16	7	(44)	1	(6)	2	(13)	6	(38)
Senior Maths	10	6	(60)	1	(10)	2	(20)	1	(10)
Junior Science	23	14	(61)	5	(22)	0		4	(17)
Earth Science	1	0		1	(100)	0		0	
Biological Science	6	6	(100)	0		0		0	
Multistrand Science	2	0		2	(100)	0		0	
Chemistry	4	3	(75)	1	(25)	0		0	
Physics	3	3	(100)	0		0		0	

CENTRAL REGION

Subject	Sample Size	Group 1	(%)	Group 2	(%)	Group 3	(%)	Group 4	(%)
Year 8 Maths	9	5	(56)	3	(33)	1	(11)	0	
Years 9, 10 Maths	16	7	(44)	4	(25)	0		5	(31)
Senior Maths	9	8	(89)	1	(11)	0		0	
Junior Science	23	20	(87)	3	(13)	0		0	
Biological Science	5	4	(80)	0		0		1	(20)
Multistrand Science	2	0		2	(100)	0		0	
Chemistry	2	1	(50)	0		0		1	(50)
Physics	3	2	(67)	0		0		1	(33)

DARLING DOWNS REGION

Subject	Sample Size	Group 1	(%)	Group 2	(%)	Group 3	(%)	Group 4	(%)
Year 8 Maths	4	1	(25)	0		0		3	(75)
Year 9, 10 Maths	11	3	(27)	1	(9)	1	(9)	6	(55)
Senior Maths	6	5	(83)	1	(17)	0		0	
Junior Science	13	7	(54)	3	(23)	0		3	(23)
Biological Science	2	1	(50)	1	(50)	0		0	
Chemistry	2	2	(100)	0		0		0	
Physics	1	0		1	(100)	0		0	

NORTHERN REGION

Subject	Sample Size	Group 1	(%)	Group 2	(%)	Group 3	(%)	Group 4	(%)
Year 8 Maths	9	4	(44)	1	(11)	1	(11)	3	(33)
Years 9, 10 Maths	19	8	(42)	4	(21)	1	(5)	6	(32)
Senior Maths	13	8	(62)	3	(23)	0		2	(15)
Junior Science	24	19	(79)	3	(13)	0		2	(8)
Biological Science	6	5	(83)	1	(17)	0		0	
Multistrand Science	1	1	(100)	0		0		0	
Chemistry	4	3	(75)	1	(25)	0		0	
Physics	3	2	(67)	1	(33)	0		0	

NORTH-WESTERN REGION

Subject	Sample Size	Group 1	(%)	Group 2	(%)	Group 3	(%)	Group 4	(%)
Year 8 Maths	2	0		0		0		2	(100)
Years 9, 10 Maths	3	2	(67)	0		0		1	(33)
Senior Maths	2	0		1	(50)	0		1	(50)
Junior Science	5	3	(60)	1	(20)	0		1	(20)
Biological Science	1	1	(100)	0		0		0	

SOUTHWEST REGION

Subject	Sample Size	Group 1	(%)	Group 2	(%)	Group 3	(%)	Group 4	(%)
Year 8 Maths	2	1	(50)	1	(50)	0		0	
Years 9, 10 Maths	4	4	(100)	0		0		0	
Senior Maths	2	0		2	(100)	0		0	
Junior Science	5	1	(20)	3	(60)	0		1	(20)
Biological Science	1	1	(100)	0		0		0	

WIDE BAY REGION

Subject	Sample Size	Group 1	(%)	Group 2	(%)	Group 3	(%)	Group 4	(%)
Year 8 Maths	5	1	(20)	3	(60)	0		1	(20)
Year 9 10 Maths	14	5	(36)	3	(21)	1	(7)	5	(36)
Senior Maths	7	5	(71)	2	(29)	0		0	
Junior Science	16	9	(56)	5	(31)	0		2	(13)
Earth Science	1	1	(100)	0		0		0	
Biological Science	4	4	(100)	0		0		0	
Chemistry	3	1	(33)	1	(33)	0		1	(33)
Physics	2	0		2	(100)	0		0	

Appendix 4

CURRENT PROGRAMS AVAILABLE IN QUEENSLAND FOR THE PREPARATION OF SCIENCE AND MATHEMATICS TEACHERS

A. Diploma of Teaching (Secondary) – Brisbane College of Advanced Education (Kelvin Grove Campus)

The Diploma of Teaching (Secondary) course offered by the Brisbane College of Advanced Education was the only program of its type currently available in Queensland. Between 90 and 100 students were enrolled annually. The major characteristics of the course are summarised in Table A.

Table A: Characteristics of the Diploma of Teaching (Secondary) Course in Science and Mathematics

Characteristics	Outline	
Level	UG2	
Length (years)	3	
Entry Requirements	Entry is based on TE score and a general requirement of 4 semesters in English with a minimum of sound achievement (16 points) Specific requirements for Science include 4 semesters of at least one science with a minimum of sound achievement (16 points); preference is given to students who have studied more than one science. In Mathematics 4 semesters of mathematics (including preparatory mathematics, algebra and calculus I and geometry and calculus II) with minimum of sound achievement (16 points). Some students may be accepted with less than the minimum specific subject requirements providing their TE scores are sufficiently high	
Course Requirements as to Teaching Areas	One principal teaching area (PTA), one second teaching area (STA).	
Science and Mathematics Curriculum Studies (Teaching Areas Available)	As PTA : Mathematics or Science As STA : Mathematics, Science or Science Studies Science covers a range of areas including Junior Science, Multi-strand Science and a Senior science. STA Science Studies is available only to students whose PTA is Science. It extends the students' course to include two Senior Sciences	
Course Pattern of Studies		Credit Points
Strands and Credit Points	Studies in Teaching/Learning Process	30
	Studies in Education	60
	Curriculum and Discipline Studies	
	(a) PTA	120
	(b) STA	70
	Liberal Studies	20
	Field Studies	65
		365

The Working Party noted that there were a number of principal teaching area/second teaching area (PTA/STA) combinations which led to science and/or mathematics teaching.

(a) PTA : Science or Mathematics
STA : Mathematics or Science

(b) PTA : Science or Mathematics
STA : Subject area other than Science or Mathematics

(c) PTA : Subject area other than Science or Mathematics
STA : Science or Mathematics

(d) PTA : Science
STA : Science Studies.

Combination (a) was designed to provide a science teacher (with a specialization in biology, chemistry, physics or earth science) who could teach science at the senior level of the school and both science and mathematics at the junior level or a mathematics teacher who could teach mathematics at the senior level of the school and both mathematics and science at the junior level.

Combination (b) was similar to (a) except that the science teacher would have a second teaching area other than mathematics at the junior level and the mathematics teacher would have a second teaching area other than science at the junior level.

Combination (c) was designed to provide a teacher who could teach either science or mathematics at the junior level and a subject other than science or mathematics across all years of the secondary curriculum.

Combination (d) was designed to provide a science teacher (with a specialization in two of biology, chemistry, physics and earth science) who could teach science across all years of the secondary curriculum.

B. **Four-year Programs which Integrate Undergraduate Studies in Science and Mathematics with Professional Education Studies**

Two four-year programs which integrated undergraduate studies in science and mathematics with professional education studies were available. James Cook University offered a four-year Bachelor of Education degree and Brisbane College of Advanced Education (Kelvin Grove Campus) and Griffith University offered a joint program which led to a bachelor's degree and a Graduate Diploma in Teaching. The major characteristics of those courses are summarised in Table B.

Table B: Characteristics of the Four-year Programs Integrating Undergraduate Studies in Science and Mathematics with Professional Education Studies

Institution	James Cook University	Brisbane CAE – Griffith University
Program	Bachelor of Education	Bachelor's degree + Graduate Diploma in Teaching
Length	4	4 (2 years) (GU) + 1 year KG) + 1 Year (GU and KG)
Entry Requirements	Appropriate TE score and a general requirement of 4 semesters in English with a minimum of 12 points.	Satisfactory completion of the first two years of a bachelor's degree at Griffith University provided that the student's Griffith University program includes sufficient units in each of two curriculum areas: Science (Junior)· Mathematics and Science (Senior) Science (Senior) could include Agriculture, Biology, Chemistry, Earth Science or Physics.
Course Requirements as to Teaching Areas	Three teaching areas (one studied to third year level, two or three to second year level, three at first year level).	Sufficient background in each of two years normally consists of a minimum of one-fourth of the total course and not less than one-sixth of the total course in these studies should be at second and/or third year level.
Science and Mathematics Studies (Teaching Areas Available)	Mathematics, Chemistry, Physics, Botany/Zoology, Geology and Biochemistry.	Mathematics; Junior Science*; Senior Science (Agriculture, Biology, Chemistry, Physics and Earth Science). *Junior Science must be studied if Science is chosen, and special provisions are made for those, who do not select Senior Science as one of their two areas, to take elective workshops in Senior Science over two semesters.
Pattern of Studies (Credit Points)	Education Studies: Foundations – 540 Curriculum – 210 Non Education Studies – 690 Plus Field Studies	Griffith University Studies: Plus Education Studies 40 Studies in Teaching 10 Curriculum Studies 40 Elective Studies 10 Field Studies 40 140

The Queensland Education Department has informed institutions that students undertaking those courses might restrict their employment opportunities significantly if their academic background was confined to biology and chemistry. It has also advised that geology and mineralogy was not an advisable subject to study at an advanced level.

C. One-year Graduate Programs in Teacher Education for Students who already Possess a Degree in Science and Mathematics

The Working Party noted that one-year programs in teacher education for students who already possessed a degree in science and mathematics were currently available. The University of Queensland offered a Diploma in Education course while Brisbane College of Advanced Education (Kelvin Grove Campus) and McAuley College each offered a Graduate Diploma in Teaching (Secondary) course. The characteristics of those courses are outlined in Table C.

Table C: Characteristics of One-year End-on Graduate Programs in Secondary Teacher Education

Institution	University of Queensland	Brisbane CAE (Kelvin Grove Campus)	McAuley College
Program	Diploma in Education	Graduate Diploma in Teaching (Secondary)	Graduate Diploma in Teaching (Secondary)
Length (years)	1	1	1
Entry Requirements	Completion of a recognised degree with studies in depth in at least two different teaching areas (i.e. about one-sixth of the entire degree course should be devoted to studies at a level above first year in each of the areas).	Possession of a degree or equivalent and adequate academic background to enable the student to undertake two curriculum studies from: Science (Junior), Mathematics and Science (Senior). Science (Senior) could include Agriculture, Biology, Chemistry, Earth Science or Physics.	An appropriate Bachelor's degree or a Diploma and a strong sequence of studies in two curriculum areas. The curriculum areas include Mathematics and Science. Students are also required to have completed some study of Theology at a post-secondary level.
Course Requirements as to Teaching Areas	Two teaching areas.	Two teaching areas.	Two teaching areas and the teaching of Religion
Mathematics and Science Curriculum Studies (Teaching Areas Available)	Mathematics, Logic, Chemistry, Phyiscs, Biological Science, Multistrand Science.	Mathematics, Junior Science*, Senior Science, (Agriculture, Biological Science, Chemistry, Physics and Earth Science) * Junior Science must be studied if a Senior Science is chosen, and special provisions are made for those students who do not select a Senior science as one of their two areas, to take elective workshops in Senior Science over two semesters.	Mathematics and Science which includes General Science in the junior secondary school as well as a specialist area in Biology, Chemistry, or Physics.

Institution	University of Queensland		Brisbane CAE (Kelvin Grove Campus)		McAuley College
Pattern of Studies/ Credit Points	Foundation Studies Curriculum Studies	56 44 100	Studies in Education Studies in Teaching Curriculum Studies Elective Studies Practice Teaching	40 10 40 10 40 140	The program is "school based" with three dominant learning modes. , the intensive presentation mode at college; b) the college- school learning mode; and c) the school observation and block practice teaching. Contact Hours Religion Studies 72 Foundation Studies 97 Curriculum Studies 339 General School Experience 374

The Queensland Education Department's advice outlined in Section B in relation to the Biology-Chemistry combination and advanced level studies in Geology and Mineralogy was equally applicable here. The University of Queensland had recommended that prospective BA students take majors in at least two different subjects from a list which included mathematics and a science subject (not Geology), and that prospective BSc students take about 60 credit points in each of three of the following areas: Biology, Chemistry, Geology and Mineralogy, Mathematics, Physics and Earth Science if they intended to enrol in the Diploma in Education.

D. Other Programs which Prepare Secondary Science and Mathematics Teachers in Queensland

Other programs which prepared secondary science and mathematics teachers in Queensland included the University of Queensland's Bachelor of Agriculture (Teaching Stream) and the James Cook University's two-year postgraduate Bachelor of Education. Those programs are described briefly in Table D.

Table D: Characteristics of Other Relevant Teacher Education Programs

Institution	University of Queensland	James Cook University
Program	Bachelor of Agriculture (Teaching Stream) (1)	Bachelor of Education (Post-graduate)
PG/UG	UG	PG
Length (years)	4	2
Entry Requirements	. Appropriate TE Score . English . Mathematics . Chemistry and Physics or one of these plus another subject from Agriculture, Biological Science, Earth Science/ Geology, Mathematics.	Possession of a degree of a university, CAE or Institute of Technology with at least a major and a sub-major in separate subjects taught in the secondary school. Priority is given to students with majors in Science, Mathematics or languages.
Program Description	All students do a common course of study in the first two years and have a choice of specialisation in the 3rd and 4th years. Each of the seven specialist streams (one of which is denoted "teacher training") contains certain prescribed subjects as well as a selection from a range of recommended subjects. For the teaching stream, the prescribed education subjects are the two first level B.Ed.St. subjects (2), two second level B.Ed.St. subjects (3), and a Dip.Ed. foundation studies subject (4). Teaching stream students are also required to take two other second level B.Ed.St. subjects (chosen from a list of four) (5) and two Dip.Ed. curriculum subjects (chosen from a list of four) (Biol.Sc, Chem., Multi strand Sc., Economics).	Students complete the Education Studies section of the 4-year B Ed. course which includes 540 points of field studies and 210 points of curriculum studies.