Clever Teachers, Clever Sciences

Preparing Teachers for the Challenge of Teaching Science, Mathematics and Technology in 21st Century Australia

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Evaluations and Investigations Programme
Research Analysis and Evaluation Group
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Executive summary

This study was commissioned by the Department of Education, Training and Youth Affairs (DETYA) as an Evaluations and Investigations Programme (EIP) project. It examined current practices and innovations in initial teacher education for science, mathematics and technology, with a view to providing guidance for meeting the challenge of teaching in these fields in the 21st century. The research team comprised Professor Geoffrey Lawrance and Dr David Palmer, of the Faculties of Science & Mathematics and Education, respectively, at the University of Newcastle, supported by a research assistant and an advisory team. The study was conducted with the cooperation of academic staff in education and deans of science in thirty-six participating universities.

The study was influenced by the view that society of the 21st century will need not only people specifically trained for science- and technology-based industries, but will need all its members to have a reasonable grasp of science and technology to live in a technologically advanced world. Teachers skilled in the sciences and mathematics, and skilled in engaging students in learning in these fields, will become increasingly important in satisfying the nation’s need for a solid broad-based education inclusive of the sciences. Further, teacher preparation must address both specialist and generalist teaching of science, mathematics and technology in primary and secondary schools. Our teachers in 21st century Australia carry the weighty responsibility of delivering courses to sustain a technologically literate society.

With such a strong reliance placed on teachers for our future, it is necessary that education of those teachers be of the highest standard. The appropriate preparation of new science, mathematics and technology teachers is an essential element of the response to these challenges. Consequently, there is a need to understand what is happening in the current preparation of these teachers, as this information will assist in the development of policy and practice in these areas.

The project

This project explored the nature of university programs that prepare new teachers to teach science, mathematics and technology in both primary and secondary schools. It identified innovative practices in the preparation of these teachers. As an EIP project, it was primarily intended to be descriptive rather than highly analytical or judgmental. Its main intended outcome will be the sharing of information about innovative practice to inform the continuing development of teacher education programs.

To this end, the terms of reference of the project brief were to examine how teacher education programs deal with the following issues:

1. The nature and level of content studies undertaken.
2. Articulation between content studies and pedagogical studies in the preparation of these teachers.
3. The integration of teaching theory and practice.
4. Differences in teacher preparation between different types of programs.
5. Skilling teacher education students in practices to develop literacy and numeracy in school students in relation to these content areas.
6. The exposure of teacher education students to school projects and programs designed to improve student outcomes in their method area.
7. The links between the teacher education program and business/industry.

For the purposes of this study, technology was defined as ‘design and technology’ rather than information technology. Similarly, this project was intended to focus on initial teacher education at primary and secondary level, so honours programs, early childhood programs, postgraduate certificate programs, higher degree programs or retraining programs were not generally included. Further, it was decided to adopt a relatively loose definition of innovative practice, so as to be as inclusive as possible.

For the purposes of this study, innovations were considered to be changes that are designed to improve teaching and learning, and should be transferable to other institutions.

Methodology

This project was designed to employ a mixture of methods to provide a rich description of initial science, mathematics and technology teacher education. There were two main strands employed to provide information about current teacher education programs and innovation:

• A survey of teacher education programs across Australia was carried out by telephone interviews, employing a common structured set of questions, which was subject first to trial and refinement. A total of 119 participants, who were mostly university mathematics, science and technology education specialists and program coordinators, were interviewed. The major undergraduate and graduate programs in all Australian universities offering teacher education in science, mathematics and technology in 2001 have been described.

• Thirteen case studies of innovative practice were carried out, drawing on universities across Australia. Selection of case studies was performed with close reference to information from the telephone interviews, and with regard to the terms of reference, target student group, cohort size and location. These case studies usually involved on-site interviews with university staff and students, as well as teachers and industry representatives, as appropriate.

The identification of innovative practice was aided by information from two other sources:

• Two literature reviews were carried out. The first provided general background statistical and general information about the state of teacher education in Australia and overseas, based on university, state, national and international policy, curriculum and research information. The second was a focussed review of the education research literature that related directly to the terms of reference of the project.
Surveys of science deans and professional bodies were carried out by email, with 36 and 69 individuals or groups in each category, respectively, contacted. The purpose of this strand was to seek the views of other key non-education stakeholders, by asking them to comment on innovation in teacher education for the sciences, based on a common instrument in each case.

Approaches to teacher education

Of the thirty-nine universities offering undergraduate degree programs in Australia, only four do not offer some program of initial teacher training. Moreover, many of the universities offer degrees in education at several campuses. One tertiary college also provides teacher education degree programs, and another college offers diplomas. Overall, undergraduate degree programs in education offered in Australia now number over one hundred, and in addition there are a range of postgraduate teacher education diploma, degree and masters programs available. The diversity of programs and courses extant is commendable, providing students with a wide range of study options. The diversity of programs offered by individual providers may lead to student cohorts in discipline specialisations being small, introducing staffing and funding constraints.

Teaching qualifications are obtained usually through one of five distinct modes, via:

- four-year (full-time or equivalent part-time) single degrees;
- four-year (full-time or equivalent part-time) double degrees, with typically approximately 50 per cent education and 50 per cent other discipline content;
- one-year (full-time or equivalent part-time) graduate diploma of education following a minimum of a three-year degree in another approved field;
- one, one-and-a-half or two years (full-time or equivalent part-time) degree in teaching following a minimum of a three-year degree in another approved field;
- one-and-a-half or two year (full-time or equivalent part-time) coursework masters degree in teaching following a minimum of a three-year degree in another approved field.

The areas of specialisation for which teachers are prepared vary from university to university, with not all providers training teachers across the full spectrum of specialisations relevant to primary and secondary teaching.

It is in the preparation of pre-school, primary school and adult or vocational teachers that single degree programs are more often offered. Secondary school teacher training in a majority of states seems to be moving more towards double degree mode for student entry following acquisition of a higher school certificate (HSC) or equivalent qualification. Existing graduates seeking a teaching qualification take a second degree, graduate diploma or coursework masters pathway, with a minimum of one year and a maximum of two years of additional full-time study required. Postgraduate entrants to teacher education may still attain a teaching qualification in several states as a one-year full-time Diploma of Education, but there has been a clear shift towards progression to teaching through a second degree or even masters program in some states and institutions.
In cases where recognition of prior non-traditional learning is given, such as for special entry programs for retraining persons already in the workforce as teachers, the period of formal tertiary education is reduced.

**Primary teacher education programs**

In 2001, most of the primary undergraduate programs were of the four-year Bachelor of Education type, although there were some double degree programs. They all typically had large numbers of students. In about two thirds of these programs, the science faculty was directly involved by offering content subjects or mathematics/science electives, but in the other one-third of programs, all the units were Education offerings. In almost half the programs, the students had the opportunity to study up to a major or minor of general offerings of the science faculty, but very few students typically chose this option. Stand-alone technology subjects were relatively uncommon. The curriculum method subjects were all Education offerings, and typically contained science/mathematics/technology content as well as pedagogy. Most of the programs had two to four compulsory mathematics courses (one-semester units) over the four years, and two or three compulsory science/technology courses. Students typically had 18-22 weeks of practicum over the four years, and these usually contained dispersed days as well as blocks. Some of the programs also took students to centres of informal learning, such as science centres and museums, as well as involving them in school programs such as the Maths Challenge or the Science Talent Search. Most of the institutions also had graduate programs – 10 institutions had one-year graduate programs, and 18 had two-year programs.

Innovations in primary programs included:

- the integration of mathematics and science units (which provided a model for how to integrate, as well as increasing student contact with their mathematics/science lecturers);
- the integration of mathematics and science with other learning areas to form interdisciplinary or modular approaches (with a focus on authentic, real life issues or tasks);
- the use of problem-based learning either at course level or program level (which allowed students to drive the learning process themselves);
- the use of intensive mode (for example a trimester arrangement allowed students in two-year programs to finish in 18 months);
- the combining of content and pedagogy through a variety of innovative themes, such as science in popular movies, mathematics in the community, environmental tours and integrated science themes (which provided a model for how to present content in interesting and authentic ways);
- the creation of links between theory and practice, by the use of dispersed days (ie. individual days in schools side by side with days at university) or by each teaching practice having a focus on a particular learning area, or by having university staff permanently in each practicum school, or by presenting non-practicum components in school-based mode;
• a focus on the development of positive attitudes towards science and mathematics, to overcome students’ fear and dislike of these subjects, by emphasising the use of motivating hands-on activities and the investigation of real life examples and problems within a constructivist approach; and

• visits to schools as part of curriculum method subjects, which enabled students to practise innovative teaching techniques with small groups of children

Secondary science / mathematics teacher education programs

In these specialisations, most of the four-year undergraduate programs were of the double degree type, in which the content studies dominated the earlier years and the education studies dominated the later years (the ratio of content to education studies was typically about 50:50). However, there were typically very few students enrolled (half a dozen students in each year was fairly common). In all the undergraduate programs, the science/mathematics content was delivered by the science faculty/school and the units were standard B.Sc. offerings (or its equivalent). Students were typically required to complete a major and a minor from subjects such as physics, mathematics, biology, chemistry or Earth sciences. There was typically at least one curriculum method subject for junior high school level, and at least one other for the senior specialisations (these subjects contained some content as well as pedagogy). Most of the undergraduate programs included 16-20 weeks of practicum, much of which occurred in the latter half of the program, and which often included an internship in the fourth year.

Most institutions also had a graduate program of either one or two years (in Queensland and Tasmania, all the graduate programs were two years; there were no two-year programs in the Northern Territory or Western Australia; other states had some two-year programs). The graduate programs did not normally contain any content studies, and in most cases, were identical to the education component of the undergraduate program at the same institution. Interestingly, the one-year graduate programs often had higher enrolments than the undergraduate programs at the same institution. The two-year graduate programs typically included 16-20 weeks of practicum, but the one-year graduate programs normally had only 8-10 weeks.

Literacy and numeracy were included in nearly all of the programs, and were often located either in the general education courses and/or the curriculum methods courses. Some of the programs took students to centres of informal learning, such as science centres and museums, as well as involving them in school programs such as the Maths Challenge or the Science Talent Search.

Innovations in these secondary programs included:

• the tailoring of content studies to suit the needs of education students, by compiling a list of recommended units, or by allowing education students to modify their assignments to focus on the educational implications of the content;

• including two majors in discipline areas, rather than a major and a minor;

• the modelling of innovative teaching strategies in curriculum method courses (these particularly emphasised constructivist, student centred, hands-on and
motivational approaches using techniques such as role play, discrepant events, creative writing, drama, investigations and field studies visits);

- a school-based component in curriculum method courses (which allowed students to practise innovative teaching techniques with small groups of children);

- field experiences in primary schools, to expose students to the student-centred approaches of primary teachers;

- the use of dispersed days of practicum, which allowed students to have a more consistent presence in the school;

- practicum supervision by methods lecturers, so as to create close links between the methods subjects and the practicum;

- having a focus for each practicum (which allowed students to concentrate for example on either their major or minor teaching area);

- allowing students to choose the timing of their block practica;

- including experiences in professional industries such as research laboratories, mines or other science-related enterprises; and

- the integration of information technology into programs (e.g. web-based materials, chat/discussion facilities, electronic journals and CD-ROMs).

Secondary technology teacher education programs

Technology education programs were relatively uncommon, with only nine undergraduate programs identified (five were in NSW). Most of these were the Bachelor of Education type, for which non-education providers such as engineering faculties and TAFE offered the content studies. The content studies often comprised a design core (or design and technology major) and either one or two specialist areas to be chosen from (for example) agriculture, food technology, engineering studies, textiles and design and information technology. The arrangements for curriculum method studies and practicum were similar to those for the secondary mathematics/science education students. In addition, there were industry placement components in several of the programs. Seven one-year graduate programs and four two-year graduate programs were also identified, and many of these accepted students with industry experience rather than a university degree.

Innovations identified in these programs included:

- the inclusion of content studies in some graduate programs, or the use of bridging courses as prerequisites;

- the offering of discipline studies by Education staff, who modelled the types of teaching behaviours appropriate to the content;

- the thoughtful integration of TAFE components with university studies, so that for example, students with a trade background could start their program at TAFE, where they were in a more familiar environment which could build their confidence for university studies;
studies which focussed on the nature of technology (which aimed at dispelling stereotypes of what technology and technology education are);

- the timing of practicum blocks by individual arrangement with each graduate student (to allow for their trade work commitments);

- a paid internship for students in schools where there were vacancies in technology;

- the use of innovative design projects which involved industry links.

Middle school teacher education programs
There were only six programs identified for middle school or K-12 teaching, although another will be introduced in 2002. Students in these programs were able to specialise in one or two secondary learning areas, as well as all the primary learning areas. The content studies were often science faculty offerings, but the amount varied considerably. The curriculum method studies were often identical to those taken by primary education students and secondary (junior high school) courses. There were typically 18-22 weeks of teaching practice, which often included components in both primary and secondary schools. Students in these programs typically enrolled in many of these same subjects as the mainstream primary or secondary students.

These programs were noteworthy because of their use of middle schooling philosophies such as integration, flexible learning pathways, authentic learning and assessment tasks and teamwork. One of the stated advantages of middle school programs was that they would help to ease the critical shortage of mathematics teachers in schools, by freeing up the teachers with full mathematics qualifications to teach at senior levels of high school.

Challenges, constraints and difficulties
The most common constraint or difficulty described by interviewees was lack of funding which caused pressure to, reduce contact hours with students, move towards mass lectures rather than tutorials, and reduce the in-school component of practicum.

The case studies
At least one case study of innovative practice was chosen for each of the terms of reference. They were also selected so as to provide examples across Australia, and a representative cross-section of primary, middle school and secondary. The focus of each of the case studies was as follows:

Case Study 1 was a primary education program which allowed students an option to specialise in technology; and it also integrated the mathematics and science components (Bachelor of Education [Junior Primary and Primary] at the Underdale campus of the University of South Australia).
Case Study 2 had a focus on the characteristics of high quality teaching of discipline/content studies for secondary education students (Bachelor of Arts [Education] / Bachelor of Science, at Edith Cowan University).

Case Study 3 described the development and philosophies of a fully integrated middle school program (Bachelor of Behavioural Studies / Bachelor of Education [Middle Years of Schooling] at the University of Queensland).

Case Study 4 was an example of attitude change towards science in a primary education program (Bachelor of Education [Primary] at Central Queensland University).

Case Study 5 described a school-based, problem-based program for primary education (Knowledge Building Community [KBC] program at the University of Wollongong).

Case Study 6 described a constructivist approach to primary practicum, in which students were required to choose practicum competencies themselves (Bachelor of Teaching [Primary] at Northern Territory University).

Case Study 7 was an example of secondary practicum supervision, in which the university supervisors were located on-site at each school, for the duration of the practicum (Bachelor of Science + Bachelor of Education [Secondary] at Murdoch University).

Case Study 8 described a masters program with a problem-based approach, for secondary education (Master of Teaching at the University of Sydney).

Case Study 9 described a non-education program, which allowed science students to have in-school experiences (Peer Tutor Program at Royal Melbourne Institute of Technology University).

Case Study 10 described an interdisciplinary numeracy course (subject) in which students conducted research in schools and the community ('Numeracy Across the Curriculum' course at Deakin University).

Case Study 11 described a project in which students used a website which linked to a local newspaper, then developed numeracy and literacy activities to be used in schools (Bachelor of Teaching [7-12] at the University of Tasmania).

Case Study 12 described how secondary students were involved in a Landcare project as an example of authentic learning involving a school project (Bachelor of Teaching [7-12] at the University of Tasmania).

Case Study 13 described the BHP retraining program as an example of an innovative link to a major industry and the use of Recognition of Prior Learning (Bachelor of Education [Design and Technology] at the University of Newcastle).

Conclusions and suggestions
The study was able to identify innovative practices extant across the nation, and at most of the institutions involved in teacher education. We stress that a program does not have to be innovative in order to be of high quality. However, the information in the program summaries and case studies should provide many innovative ideas to inform future development.
We identified two main types of innovations: innovations at the program level and innovations at the course (unit or subject) level. Innovations at the whole program level were relatively few, and included: the Bachelor of Behavioural Studies / Bachelor of Education [Middle Years of Schooling] at the University of Queensland; the Master of Teaching at the University of Sydney; the KBC program at the University of Wollongong; the Bachelor of Learning Management at Central Queensland University; and the Master of Teaching at Queensland University of Technology. The bulk of the innovations however, applied to particular courses within programs (e.g. an innovative mathematics unit or an innovative way of organising practice teaching) rather than to the whole program. Many of these appeared to be cases in which one or two highly motivated individuals had developed an innovative approach and were maintaining it largely by their own energy and enthusiasm.

We offer some suggestions for the directions that future innovation and research may take in the development of science, mathematics and technology initial teacher education:

1. At present, secondary science education students typically have content studies in only two sciences (a major and a minor). A step forward would be to develop patterns of discipline studies that will maintain a high professional standard, but include significant preparation in the full range of junior sciences.

2. Students in graduate programs are often strong in one science area, but deficient in others, so future programs should develop ways of including targeted science/mathematics content in graduate programs.

3. The huge breadth of the school curriculum in design and technology has created problems for technology teacher education programs, and some streamlining should be seriously considered.

4. At present, the ratio between content studies and education studies in secondary programs is normally 50:50, but whether this is the best ratio for a future teacher still needs to be established by future research.

5. According to interviewees, many teachers in schools are still using traditional ‘chalk and talk’ or textbook approaches, which are at odds with the strategies advocated at university. Innovative ways to ensure that the practicum reinforces what the students learn at university are still needed in all specialisations.

6. Double degree programs offer students the opportunity to complete two degrees in four years, but low enrolments show that they have not been a successful innovation for attracting students into mathematics and science teaching. Any future developments of this type of program, for mathematics and science at least, should take this factor into consideration.

7. Several institutions have non-Education based programs which give ‘mainstream’ mathematics and science students experiences in schools. The potential of these programs to be linked to existing education programs should be further explored.

One of the most useful and immediately practical things that this project can do will be to let teacher educators see what other people are doing in their programs. By creating an opportunity for teacher education providers to ‘peek over the fence’ it is hoped to encourage a cross-fertilisation of ideas and a dissemination of high quality practices.
Overall, initial teacher education in science, mathematics and technology is characterized by widespread innovation in course and program development. Overall, content providers and education providers were satisfied with the level of cooperation existing between them. The major quest for the short-term future remains, however, one of finding mechanisms that will bring good students of science, mathematics and technology into teaching. The programs we have examined are of high quality and appear to be good vehicles for effective teacher education; they would be all the better with stronger cohorts of strong students.
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1. Introduction

1.1 Setting the scene

The clever country, in a world of accelerating technological change, needs to become cleverer. Humanity is challenged by its ability to predict the future, but what seems certain in the future post-industrialized world is that the virtual will be more highly valued than the actual, and that tertiary products will be much more highly valued than primary products. This presents a challenge for a nation, reliant for much of its history on primary products for its wealth, to reinvent itself for the new century. This reinvention demands participation by a new generation skilled in and comfortable with the sciences and technology. It is already understood that science and mathematics underpin emerging technology to a significant extent, and that those who become the future technologists of each generation must be nurtured in our education system.

Australia has been well served as a nation by a vibrant, inventive and adaptable scientific community. This has been recognised recently by the Prime Minister, The Hon. John Howard, in his foreword to the recently published Commonwealth Government’s Innovation Report for 2001-2002, Backing Australia’s Ability.

Australia is a nation with a proud tradition of innovation and science. We have always been a resourceful people and, through our ingenuity and creativity, we have excelled in many fields of endeavour.

The Hon. John Howard (Backing Australia’s Ability 2001, p. iii)

Our leaders in science, mathematics and technology have been largely ‘home grown’, the products of a respected and strong education system. This was a system in which change was, until around the 1970s, slow and the product of much reflection and consideration. In parallel with the rapid acceleration of social and technological change, we have seen a parallel acceleration in change in our national education system throughout its various levels. Whatever the arguments for or against change, there is one certain fact; enrolments in science and mathematics at senior secondary school level have fallen significantly. Although our present society is founded on the achievements of science, fewer children see the sciences as a career path. The consequences of this for a nation set on a technologically advanced course for its future are of great concern.

The origins of change are complex and difficult to tease out. However, a clear concern is that students need to be engaged by the sciences and nurtured at an early age to permit the development of familiarity, skills and interests that may lead to a positive choice by students to pursue a science-centred future career. This task must be centred on teachers in primary and secondary schools, although there are clear opportunities for others, such as professional societies and industry, to participate.
The ‘knowledge society’ of the 21st century will need not only a strong supply of students trained in the sciences, but will need all its members to have a reasonable grasp of technology to live in a technologically advanced world. ‘Literacy’ in the later 21st century will evolve to naturally include scientific and mathematical concepts in its meaning. Teachers skilled in the sciences and mathematics and skilled in engaging students in learning in these fields, will become increasingly important in satisfying the nation’s need for a solid broad-based education inclusive of the sciences. Teacher preparation must address both specialist and generalist teaching of science, mathematics and technology in primary and secondary schools.

Our teachers in 21st century Australia carry the weighty responsibility of delivering courses to sustain a technologically highly literate society.

With such a strong reliance placed on teachers for our future, it is necessary that the training of those teachers be of the highest standard. Society, quite correctly, looks behind its concerns about education and teachers to question those teachers’ prior training. It also reads a number of warning signs: shortages of science, mathematics and technology teachers that may be approaching critical levels in some areas; teachers who are teaching subjects outside their range of expertise; low demand for teaching as a career; and concerns about the status of the teaching profession.

These high-profile issues mask what are key core issues in providing a sound basis for fundamental change, namely:

- What is best practice in the preparation of science, mathematics and technology teachers for our changing society?
- How are the providers of initial teacher education meeting the challenges and providing appropriate innovation in the preparation of teachers?
- What measures are being taken to expand participation in teacher education programs in science, mathematics and technology?

The decline in interest in science, mathematics and technology amongst the young has been startling and fairly rapid, as exemplified by a 40 per cent drop in Year 12 students studying advanced-level mathematics in only eight years. There has also been a sharp decline in enrolments in the enabling sciences of physics and chemistry. The study commissioned by the Australian Council of Deans of Science (Dobson and Calderon 1999) on Trends in Science Education between 1989 and 1997 identifies how, despite strong growth in science enrolments over this period, real growth in traditional enabling science disciplines has been at best modest. Fields like psychology, life sciences and computing science have been the sites of student interest.

While university-level enrolments in all courses in the broad field of science rose by 57.0 per cent between 1989 and 1997, it is notable that enrolments in education in this period fell by 1.5 per cent; of all fields of study, education performed the worst. The combination of decline in education enrolments generally and little or no growth in enabling sciences enrolments does not auger well for attracting teachers of the sciences. This is borne out by the statistics, with a 24.3 per cent decline in education students studying science from 1989 to 1997 when at the same time there was a 50.2 per cent increase in those taking some type of science major. In the physical sciences (chemistry, geology, physics) in particular the situation is worse, with a 54.1 per cent fall for education students studying in these fields against a
much smaller fall of 2.3 per cent in those taking science majors. The story in mathematics is very similar. Even in biological sciences, where a strong growth in science majors of 77.8 per cent was established, education students taking biology fell by 23.6 per cent. This makes for grim reading, but reflects the size of the challenge before us.

There is concern that science, mathematics and technology graduates do not look favourably on a career in teaching. For example, an Occasional Paper of the Prime Minister’s Science, Engineering and Innovation Council (1999) voiced concerns which are broadly based in the community about the decline in the number of teachers being adequately trained in the sciences and technology. This matches evidence from the Australian Council of Deans of Science (Dobson & Calderon 1999) that graduates in science, mathematics and technology disciplines have more professionally and financially attractive options available than becoming teachers. This situation is likely to become worse if it is not addressed properly. The Occasional Paper recommended:

*The Government ensure a career in science or technology teaching is an adequately attractive option for young people both during university training and later during their teaching career by ensuring that teachers of science and technology are appropriately rewarded and provided with opportunities for continuing training and development.*

Prime Minister’s Science, Engineering & Innovation Council (1999)

The growing under-supply of teachers in science, mathematics and technology is concerning to society. Firstly, the simple demand of placing teachers in front of classes leads to out-of-field teaching, where the lack of discipline skills and concomitant subject authority by teachers impinge on student satisfaction and performance, and contribute to decline in discipline enrolments. Secondly, where there is a shortage, the quality of teachers is less concerning to education authorities, which can lead to similar outcomes to those arising from out-of-field teaching. Thirdly, the decay in basic training in the enabling physical sciences and mathematics in particular has a follow-on effect on participation in the tertiary education system, further restricting the supply of qualified teachers in the future.

These concerns must also be placed in the context of separate calls for the acquisition of demanding high-level skills from teachers who graduate from teacher education programs. The Australian Science Teachers Association (Wright 1998), in its submission to the Senate Inquiry into the Status of Teachers, identified a need for ‘effective and appropriately qualified science teachers’, and suggested the tasks ahead were:

*to increase the status of science teachers and the profile of science education; to maintain a body of highly competent, well qualified science teachers committed to life long learning; to provide opportunities for professional development in science as science content increases and changes, enabling a teacher’s understanding to keep pace; and to attract able graduates to science teaching.*

Wright (1998)
The National Standards and Guidelines for Initial Teacher Education Project, *Preparing a Profession*, by Adey (1998) identified particular guidelines that are of relevance to teacher education. The report suggested that graduates should:

- have a broad general education as a framework for critically developing their understanding of their subject/learning areas, for developing understanding and capability in new areas, and for providing a basis for responding effectively to a range of issues which will arise in their professional work;

- have understanding, at a level appropriate to higher education, of the areas they are prepared to teach, and be able to engage in critical examination of those areas.

- have the deep understanding of content and pedagogy which enables them to transform (organise, adapt, present) content in ways which respond to the particular characteristics of learners, curricula and teaching environments.

Adey (1998)

To accommodate these type of demands there seems little option but to retain, rather than call for a diminution in, the current minimum of usually an overall four-years of full-time training for teachers at graduate and or postgraduate level. Thus potential teachers must enrol in a program of longer duration than some science degrees, with its subsequently higher personal support and HECS costs, to join a profession that has low public esteem and relatively low salaries compared with those achieved by even some three-year science or mathematics graduates. It is an unbalanced equation, and not conducive to attracting candidates.

The concerns about appropriate training relate, quite properly, to the concept of the teacher as the key vehicle for the promulgation of scientific literacy. However, the challenge to enhance public literacy in science, mathematics and technology does not lie fully with our education system and its teachers. There is growing recognition that government, professional societies and industry have important roles to play. Reform initiatives in the sciences and mathematics are driven by a growing awareness from both employers and accreditors of highly trained specialists that a nation’s position in a technological world is highly dependent on general scientific and mathematical literacy across society.

Thus the current scene in the education of teachers for science, mathematics and technology must be painted against a background of growing concern. Teacher educators are not immune from this social malaise, but have not removed themselves from their role of looking for new ways forward in initial teacher education for this demanding area. It is the status of this quest, in the contemporary context, which is at the core of this project.

### 1.2 Purpose and scope of this study

*Prior studies*

Studies of the status of and resources for science, mathematics and technology teacher education in Australia and have appeared over recent decades from a number of sources. An example of an early project of relevance conducted at the
start of the 1980s was the Australian Science Teacher Education Project (Fensham and Northfield 1983). The major prior examination of science and mathematics education commissioned by the Federal government remains the discipline review of teacher education in mathematics and science, which reported at the end of the 1980s (Speedy et al 1989). In 1988, the Teacher Education Mathematics Project report for the Committee to Review Australian Studies in Tertiary Education included material relevant to preserve teacher education. Slightly earlier, the National Committee of Technology Teacher Education forum produced a document on Strategies for change (Taylor & Middleton 1986). Recently, the National Standards and Guidelines for Initial Teacher Education Project, Preparing a Profession, by Adey (1998) was a more general review of teacher education promoted by the Australian deans of education. State-based government projects and reports also contribute effectively to the available information. The NSW-based report Quality Matters. Revitalizing teaching. Critical times, critical choices (Ramsay 2000) has wider implications for teacher education.

Studies of teacher education go on against a background of other debate, reports, investigations, agreements and initiatives in education generally. It is not our intent to list these exhaustively here, but rather to note a few. Of relevance in Australia is the national Common and Agreed National Goals for Schooling in the 21st Century (MCEETYA 1999), building on an earlier 1989 protocol. Reports such as those of the Australian Science and Technology Council (1987) on Education and national needs, of the Prime Minister’s Science Council (1990) on Science and mathematics in the formative years, and of the Australian Science, Technology and Engineering Council (1997) on Foundations for Australia’s future: Science and technology in primary schools, are of relevance. Recently, a Federal government Senate enquiry into the status of teachers completed its deliberations. Although broad-based, it did receive significant input from bodies with a personal focus in the sciences area, such as the Australian Science Teachers’ Association. Professional teachers associations have contributed frequently to the debate; a recent example is the Australian Association of Mathematics Teachers (2000) report Numeracy, a priority for all: Challenges for Australian schools. One example of a wide range of relevant state-based reports is the Monitoring Standards Project (1993) report from WA on Profiles of student achievements: Science in Western Australian government schools. In education for the sciences, international projects, particularly those in the United Kingdom and United States of America such as the UK’s Beyond 2000: Science Education for the Future and the USA’s National Science Education Standards, have also had an influence on developments in Australia.

The present study

This study has as its primary focus an examination of practices and innovations in the initial preparation of teachers for teaching science, mathematics and technology. This is particularly apposite at the current time, following a period of extensive curriculum review and revision within the school education systems across the nation. From an understanding of what is currently offered, as well as what is proposed, in initial teacher education for the sciences in Australia, both the training of teachers and development of relevant government policy and practice can be assisted.
This project also adopts the view that the preparation of science, mathematics and technology teachers is a partnership between those with expertise in education and those with expertise in the sciences. We have chosen to reflect this by employing co-directors who represent both sides of this partnership, and by seeking the views (about initial teacher education) of non-education stakeholders such as science faculty deans and professional bodies in the sciences.

Terms of reference

This project will explore the nature of university programs that prepare new teachers to teach science, mathematics and technology in both primary and secondary schools. It will target innovative practice in the preparation of teachers.

Throughout this report, ‘program’ is used to represent a complete degree program or course; further, ‘course’ is used to refer to individual component subjects or units within a program. This program/course nomenclature is used in several Australian universities, although it is by no means universal; hence it is appropriate to define the nomenclature initially.

As part of the exploration of university programs, the study will examine how these programs deal with the following issues:

1. The nature and level of content studies undertaken.
2. Articulation between content studies and pedagogical studies in the preparation of these teachers.
3. The integration of teaching theory and practice.
4. Differences in teacher preparation between different types of programs.
5. Skilling teacher education students in practices to develop literacy and numeracy in school students in relation to these content areas.
6. The exposure of teacher education students to school projects and programs designed to improve student outcomes in their method area.
7. The links between the teacher education program and business/industry.

Scope of the project

For the purposes of this study, technology will be defined as ‘design and technology’ rather than information technology. Design and technology is a broad area in the secondary school curriculum, and includes school subject areas such as computer studies, home science, agriculture, food technology, design and technology, textiles and design, graphics, and materials and technology.

Design and technology programs are often linked with vocational education programs; however, it was decided not to include the latter in this project.

Similarly, because this project was intended to focus on initial teacher education at primary and secondary level, it was decided to not include honours programs, early childhood programs, postgraduate certificate programs, higher degree programs or retraining programs (although there were a small number of exceptions to these).
Innovative practice

One of the thrusts of the project is identification of innovative practice in teacher education. Recently, Hannan, English and Silver (1999) studied innovations in higher education institutions. They described some qualities of innovative practice, in the following way:

*Innovation may be something new to a person, course, department, institution or higher education as a whole. An innovation in one situation may be something established elsewhere, but the implication of these assumptions is that it is a departure from what has been done before. … These were planned, rather than accidental changes, designed, but not guaranteed, to improve teaching and learning.*

Hannan, English and Silver (1999, p. 280)

Similarly, Ndahi (1999) supported the view that innovations should seem to offer a relative advantage, and should be transferable to other institutions.

For the purposes of the present project, we decided that a strict definition of innovation would not be appropriate, as we wanted to be as inclusive as possible. Consequently, it was decided to loosely adopt the views above as a base for informing our identification of innovative practice. However, we also recognised that the identification of innovation should involve a process of comparison. It was therefore decided that final decisions about innovative practice would only be made after we had finished collecting the information about programs from different institutions, and after we had been informed by both the education research literature and by various stakeholders.

One further issue was considered. Much of the discussion about innovation has focussed on the use of information technology to enhance or replace conventional teaching (Silver 1998) but our intention is to have a wider view, which includes any type of innovation relevant to the terms of reference of the project.

Outcomes of the project

As this is an Evaluations and Investigations Programme (EIP) project, it is primarily intended to be descriptive rather than analytical or judgmental. The main outcome is intended to be a description of current initial teacher education practices in the areas of science, mathematics and technology, with an added emphasis on innovative practice.

However, an equally important outcome will be the sharing of information about innovative practice to inform the continuing development of teacher education programs. One of the most useful things this project can do will be to let teacher educators see what other people are doing in their programs. By creating an opportunity for teacher education providers to ‘peek over the fence’, it is hoped to encourage a cross-fertilisation of ideas and a dissemination of high quality practices.
Structure of this report

The following is a brief rationale and description of the content of each of the following chapters in this report.

Chapter Two is a review of social, educational and political issues relevant to initial teacher education programs and of approaches adopted in other countries and in Australia. The purpose of this chapter is to provide general background information about teacher education, with a view to making the report more accessible to non-education stakeholders, such as science, mathematics and technology content providers in non-education faculties. Additional material relating to teacher education programs offered in 2002 appears in Appendix A.

Chapter Three is a description of the methodologies used in each phase of the project. It explains how teacher educators provided information about their programs, and how further information was provided by a literature review, and input from other stakeholders such as professional bodies and science deans. Additional material relating to the collection of information in the study appears in Appendices B and C.

Chapter Four is a focussed review of the education research literature that relates to the terms of reference of the project. The purpose of this review was to identify a range of high quality practices for teacher education programs. These findings were then used to help to inform the identification of innovative practice.

Chapter Five presents views, collected in this study, of professional bodies and science deans about innovation in initial teacher education. These views were then used to help inform the identification of innovative practices for case studies.

Chapter Six presents a summary of the information, collected in this study, and syntheses of the main findings about teacher education programs pertaining to science, mathematics and technology extant across Australia. Program descriptions of each of the individual teacher education programs surveyed, on which this chapter is based, appears separately in Appendices D–G.

Chapter Seven contains a series of case studies, which focus on innovative practices, selected following the wider study of existing programs.

Chapter Eight presents our conclusions and some suggestions for future directions.
2. Background and issues

2.1 Preamble
This project was initiated as a ‘cross-cultural’ exercise between education and science, with the two co-directors drawn one from each field. As a consequence, it was anticipated that the report would be of interest to the discipline experts in science, mathematics and technology in addition to those in education. The basic tasks of the project relate to an examination of initial teacher education programs, which has particular and direct relevance to those in education faculties charged with the primary responsibility for teacher education. However, the partnership role between the sciences and education is an important component of teacher education in science, mathematics and technology, and we wish to be inclusive in our report. Because of the disparate backgrounds of the partners, we saw it of relevance to provide a detailed overview of the background and pertinent issues against which the core of the project is reported. This may serve the sciences in particular, but may also add some perspective for those in education. This desire to inform and balance is the basis of this chapter.

2.2 Secondary and tertiary education in Australia
Education in Australia is of a high standard and, at all levels, is influenced by and contributes to international trends in education. The K–12 class system of primary and secondary school is used in other countries. The basic bachelors degree offered at University level has close analogies to those offered elsewhere, for example in Scotland and the USA. Coursework and research graduate diplomas, masters and doctoral degrees mirror international programs. Alternative tertiary training through a separate Technical and Further Education (TAFE) system is also a common trend internationally. Credit transfer for prior study at, and participation in aspects of teacher education programs through, TAFE is also relevant. While our education system is uniquely Australian, it reflects in part global trends.

2.2.1 Primary and secondary education
Primary and secondary education in Australia is state based, with each state operating autonomous departments of education under state-based legislation. Further, curricula in the various states are developed and their subsequent implementation in schools is monitored at state level, usually involving separate Boards of Studies or Curriculum Councils. Attempts to create a national curriculum over the past decade have not succeeded, although many of the components of that development have found their way into state curricula. Whereas national curricula now operate in countries such as the UK and NZ, state-based curricula operate in countries such as the USA and Germany. There is no ‘correct’ model. In Australia,
the interstate *Common and Agreed National Goals for Schooling in the 21st Century* (MCEETYA 1999) play a role in promoting common aims and outcomes.

State school curricula typically present a framework that is directed to the acquisition by students of a set of knowledge and understanding, skills, values, and attitudes. Expectations of students are described by a framework of standards and in terms of a series of defined, desired outcomes. Programs are operated in a number of key learning areas. For example, in Western Australian schools, the learning areas are:

- the Arts;
- English;
- Health and Physical Education;
- Languages other than English;
- Mathematics;
- Science;
- Society and Environment; and
- Technology and Enterprise.

All states operate division of this type, although the precise components may vary. In each learning area a set of overarching outcomes are defined. For example, nine learning outcomes for Science are identified in Western Australia, separated under:

- *working scientifically* (investigating, communicating scientifically, science in daily life, acting responsibly and science in society); and
- *understanding concepts* (earth and beyond, energy and change, life and living, natural and processed materials).

The desire to represent science in a social context is notable, although this approach is commonly met across all learning areas. Also notable is that science, mathematics and technology in Western Australia lie in separate learning areas. This is usually the case across Australia, and has implications for both teacher education and in classroom practice, since teachers often teach within a particular learning area. Given the intermixing of these fields of endeavour in the broader workplace, this level of compartmentalisation is somewhat limiting for teachers.

Teachers in state schools are required to obtain registered as teachers under state legislation, typically through a Board of Teacher Registration office. For example, the *Education Act 1958* under Victorian Consolidated Legislation requires, under Section 39, for Registration of Teachers the following:

1. *No person shall be registered as a teacher unless he produces evidence which satisfies the Board of his fitness to teach.*
2. *The Board may determine to register a teacher as a primary, secondary, special or technical teacher, or as a teacher of only one or more (not being all) of the subjects prescribed for the purposes of section 35.*

It is apparent that initial teacher training must address the preparation of persons suitably qualified for registration. More recent legislation is more explicit. For example, the *Education (Teachers Registration) Regulations 1996* under South Australian
Consolidated Regulations, prescribed qualifications and experience for registration as a teacher under the relevant Act to include:

(a) an approved teacher education degree, diploma or other qualification awarded on satisfactory completion of a tertiary course of pre-service teacher education in pre-primary, primary or secondary education that (i) is of at least three years’ full-time duration or part-time equivalent duration; and (ii) includes a practical student component; or

(b) (i) an approved non-teacher education degree, diploma or other qualification awarded on satisfactory completion of a tertiary course that is of at least three years’ full-time duration or part-time equivalent duration; and (ii) an approved postgraduate degree, diploma or other qualification awarded on satisfactory completion of a tertiary course of pre-service teacher education in pre-primary, primary or secondary education that (A) is of at least one years’ full-time duration or part-time equivalent duration; and (B) includes a practical student teaching component.

The approved awards must be from a ‘tertiary education institute that is a member of the Australian Vice-Chancellor’s Committee’; in other words, teacher training for state schools is defined under legislation as based only in mainstream Universities. This is a common feature in most states. However, the School Education Act 1999 in Western Australia (effective from the start of 2001) is more flexible, enabling a range of professionals and para-professionals to be considered provided they hold ‘a qualification recognised by the Chief Executive Officer as being an appropriate qualification’. Those with qualifications not recognised may apply for consideration of their qualification. This type of flexibility appears to relax the rigorous definitions present in acts such as the South Australian one discussed above, and may have further implications for teacher training in the future.

Also notable is the requirement for a ‘practical student teaching component’, the so-called ‘practicum’. It is common in most professions for relevant professional accreditation bodies to define minimum requirements for practical experience. This is effectively a legislative requirement for teacher registration, as it is for some other professions where direct involvement with the public is a key aspect of professional tasks, such as clinical psychology. Teacher training programs may include a defined or approved minimum amount of practical experience.

In addition to legislation for teacher status, school curricula are the subject of state legislation. For example, the Education (School Curriculum P-10) Act 1996 under Queensland Consolidated Acts lists current approved syllabuses. It also identifies that secondary syllabuses are to be maintained by a Board of Senior Secondary School Studies.

Further, non-government schools do not escape controls. They are usually registered under conditions defined in a separate Act, which include definition of the minimum curriculum that must be available for children.

Overall, it is apparent that primary and secondary education is heavily legislated and controlled in each state. Moreover, since approximately 70 per cent of children attend state-run schools, the state is in a very strong position to dictate policy pertaining to teacher education to nominally autonomous universities, as the major employer of teacher training graduates of those universities. At the same time, it is noted that universities are established under state legislation. It is not surprising, therefore, that
state departments of education play a strong role in the definition of curricula in teacher training programs, influencing institutes which obtain their funding to large extent from Federal government sources. Despite this, what is remarkable is the diversity of approaches to initial teacher training currently extant, as exemplified in this study of science, mathematics and technology initial teacher training.

### 2.2.2 Tertiary education

The commencement of tertiary education in Australia in the mid nineteenth century led to, by Federation, a number of well-established universities across the nation. Tertiary education in Australia, from these firm foundations, has continued to grow and be respected and recognised internationally. Our universities train graduates and postgraduates to globally recognised standards across the full range of disciplines. Graduates in education are no exception; placement of Australian graduates in English schools is an example of the portability of their qualifications.

For most of the last century, teacher education has been a formal, tertiary-level process. Prior to the development of teachers colleges in the first half of the 20th century, teacher education was more a process of apprenticeship. The teachers colleges and universities, which existed as separate entities, were the responsibility of the individual states before World War II. School systems and associated curricula also were state-centred. The universities evolved into being supported federally after the war, while teachers colleges remained in state hands.

Following the Martin Report (1964), the Commonwealth moved to funding teacher education in the colleges, which were converted into broader colleges of advanced education (CAEs). Mergers up to the 1980s were mainly directed to combining small institutions on adjacent sites or serving the same catchment, leading to larger, more comprehensive bodies. From 1974, tertiary education, in universities and CAEs, became the full responsibility of the Commonwealth.

The so-called binary system of tertiary education appeared to make the CAEs the minor partner, and created obvious tensions. For teacher education, with programs operating in both systems, the opportunity for tensions is apparent. The evolution of a unified tertiary education system from the end of the 1980s removed, in principle, these tensions, through the abolition of the CAEs and the creation of a suite of new universities. During 1981-1991, mergers driven by government policy involved over thirty institutes centred on teacher training merging with larger colleges or universities (Harman 2000).

The reliance of universities on the Commonwealth purse-strings has also changed since the amalgamation era. Funding of universities by direct grants from the Commonwealth has continued to diminish, following the introduction of undergraduate student Higher Education Contribution Scheme fees and growth in research and industry funding. Arguably, autonomy of universities is more readily guaranteed where there is more diverse funding options available. Of more concern is the way income is disbursed within institutions, with formula funding asserted to diminish the capacity of faculties of education to present their programs (Goodrum et al 2000). At the same time, science and technology faculties are equally concerned about the level of their funding. The funding of tertiary education is not at the core of this report; suffice to say that the comments herein assume adequate funding models operate or will be put in place.
2.3 Teacher education in Australia

2.3.1 Current teacher education programs

In an increasingly corporate tertiary education world, training in education is big business. Today, approximately one in nine of university students are enrolled in a degree in education, with the effective full-time student unit load (EFTSU) accounting for approximately one twelfth of all national enrolments. The total student load at the turn of the century, by broad categories, is shown in Table 2.1.

Table 2.1  Student load (EFTSU) for all university students by broad category in 2000.

<table>
<thead>
<tr>
<th>Category</th>
<th>EFTSU</th>
</tr>
</thead>
<tbody>
<tr>
<td>humanities</td>
<td>55 788</td>
</tr>
<tr>
<td>social studies</td>
<td>59 998</td>
</tr>
<tr>
<td>education</td>
<td>44 730</td>
</tr>
<tr>
<td>sciences</td>
<td>55 147</td>
</tr>
<tr>
<td>mathematics, computing</td>
<td>62 324</td>
</tr>
<tr>
<td>visual/performing arts</td>
<td>27 133</td>
</tr>
<tr>
<td>engineering, processing</td>
<td>32 248</td>
</tr>
<tr>
<td>health sciences</td>
<td>47 748</td>
</tr>
<tr>
<td>admin, business, economics, law</td>
<td>136 229</td>
</tr>
<tr>
<td>built environment</td>
<td>13 418</td>
</tr>
<tr>
<td>agriculture, renewable resources</td>
<td>7 481</td>
</tr>
</tbody>
</table>

One consequence of the number of education students is that almost all universities are currently participating in the training of teachers in some fashion. Given the number of students involved, it is not surprising from a purely corporate viewpoint that the large majority of universities in Australia offer degrees in education; it is a group of students that is too large to dismiss when building a university profile and footprint. At the same time, of course, there are state and regional issues involved in offering training. The universities involved in teacher education and the broad type of degrees or diplomas offered for initial teacher training of Australian citizens and residents, as indicated on their websites, appear in Table 2.2.

The size of education schools or departments varies greatly between universities. In initial teacher training, total number of students at individual universities range from approximately 90 to 2700 (DETYA 2001), with a mean size of 965 (standard deviation 707). There are many substantial schools. However, the operation over a number of campuses and the range of degrees offered mean that relatively small cohorts of students may be involved in a particular program at any one site in some cases. For science, mathematics and technology specialists particularly, where
### Table 2.2 Initial teacher education degree types offered in Australia

<table>
<thead>
<tr>
<th>University or College</th>
<th>Single Bachelor Degree</th>
<th>Double Bachelor Degree</th>
<th>Graduate Entry Masters Degree</th>
<th>Graduate Entry Bachelor Degree</th>
<th>Graduate Entry Diploma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian Catholic U.</td>
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<td>Avondale College</td>
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<td>Australian National U.</td>
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<td>Batchelor College</td>
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<td>Bond U.</td>
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<td>Central Queensland U.</td>
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<td>Charles Sturt U.</td>
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<tr>
<td>Curtin U.</td>
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(a) four years full time  
(b) four or five years full time  
(c) one-and-a-half to two years full time  
(d) one to two years full time  
(e) one year full time  
(f) offers undergraduate diplomas
enrolments represent around 15 per cent of total enrolments, the number of candidates at any particular campus may be small.

The character and geographical reach of universities varies considerably, from multi-state through multi-campus to single campus in character. The focus of universities from broad teaching and research through broad teaching and selected research to restricted teaching and research institutes is also variable. This is related, in part, to their origins; for example, as pre- or post-unified system in establishment. In education, teaching may be restricted to a single campus of multi-campus universities or else may be broadly based. Whereas most operate separate education, science and technology faculties, this is by no means exclusive, with a small minority presenting a less divided system; for some, education and science faculties do not even operate on the same campus. Thus there is a diversity in character which acts as a background to the way universities approach their teacher education programs.

Usually, teacher training programs require from four to five years of full-time equivalent study. This may occur in a single four-year bachelors degree; in a four-year double degree program; in a one-year postgraduate diploma following prior completion of a three year non-education degree; or, in a postgraduate education component of from one to two years following a first non-education and leading to a second degree or masters in teaching.

The fields of specialisation offered in each type of degree differ with degree type and with institution. It is apparent that institutions with overlapping regional footprints may feature different program specialisations compared with their academic neighbours, as part of both competitive reality and a desire to create a distinctive character for their institutions. However, overall specialisations offered are designed to match the requirements of employers, in particularly the relevant state education department. Some programs have a broad common character across the nation. For example, the vast majority of teachers training as pre-school teachers will be doing so in a single four-year degree program. This is also the case, but less so, in primary teacher training, whereas secondary teacher training exhibits the broadest variety of training modes. Of course, this is a broad generalisation, which does not recognise the diversity of educational philosophies that drive what appear at first sight to be similar courses. What is apparent is that a combination of state-based education priorities, market forces, overarching university corporate policy and the dominant local educational philosophy contribute to a diversity of teaching approaches that are not immediately apparent. This is reflected in this project.

Teacher education in Australia has traditionally been a tertiary college or university based activity. These institutes have enjoyed a monopoly in teacher training essentially throughout the 20th century. Whether this continues to be the case in the 21st century is an issue that remains to be resolved (Jones 2001). There are some who see value in school-based or even private provider-based training. Concerns that current initial teacher training may lag behind international developments, with teacher educators slow to adopt new teaching and learning strategies, are extant in the community. The validity of this view can be challenged. Faculties of Education in Australia are clearly productive in terms of their research output, ranking fifth in the world. Moreover, the recent DETYA report on The Impact of Educational Research (2000) concluded that a good deal of the research had practical application for teaching and policy development. The inference is that university-based educational research in Australia is of international standard, is aligned with debate and
developments across the world, and contributes to the evolution of teacher training programs in Australia.

What is evident from the above is the high level of participation by universities in initial teacher education, and the range of degree and diploma programs which have been developed to prepare teachers for our nation’s schools. A full list of undergraduate degrees offered for 2002 entry, as listed in state university admission guides (except for Tasmania and the Northern Territory, where information is based on web pages), has been included in Appendix A. This list does not include most postgraduate entry programs. That a number of new degree programs is listed compared with 2001 is indicative of continuing change in the teacher education system. We presume these changes reflect contemporary philosophy and on-going research in teacher education.

Another concern for current teacher education programs is their capacity to attract academically gifted students. It is relevant to examine the University Admission Index (UAI) scores for various degree programs, although they represent only the lower limits and do not inform on spread of entering student scores. The data for entry to initial undergraduate degrees in NSW universities in 2001, as presented in the NSW 2002 UAC guide, is summarised in Table 2.3

Table 2.3. Comparison of UAI scores required for entry to selected education and non-education degree programs in NSW in 2001

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<thead>
<tr>
<th>Program</th>
<th>UAI Entry Scores</th>
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<tr>
<td></td>
<td>Average</td>
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<tr>
<td>Education – Arts</td>
<td>71.9</td>
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<td>Education – Early Childhood</td>
<td>71.3</td>
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<td>Education – Physical Education</td>
<td>76.0</td>
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<td>Education – Primary</td>
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<td>Education – Science/Mathematics</td>
<td>73.4</td>
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<td>Education – Technology</td>
<td>70.2</td>
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<td>Arts a</td>
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<td>Commerce a</td>
<td>79.3</td>
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<tr>
<td>Engineering a</td>
<td>83.0</td>
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<tr>
<td>Law b</td>
<td>92.1</td>
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<td>Medical Science c</td>
<td>90.5</td>
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<tr>
<td>Nursing a</td>
<td>68.5</td>
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<tr>
<td>Psychology a</td>
<td>83.4</td>
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<td>Science a</td>
<td>69.8</td>
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(a) general, base-level single degree; usually available with higher UAI entry score as special, advanced or double degree
(b) entry generally available only as a double degree
(c) pre-medical degree only
The table is informative in several ways. First, the average UAI entry requirements for all education programs are reasonably consistent and on only one occasion was a minimum over 80 applied. Secondly, these entry scores compare favourably with generalist degrees in arts and science.

However, specialist degrees, with the exception of nursing, had UAI cut-off scores above or even well above teaching, and ranging up to UAI's of greater than 90. Since these UAI scores reflect in part student demand, the inference is that teaching is not a high demand specialisation. The academic abilities of students entering teacher education programs as measured by higher school certificate examination results, while not necessarily indicative of performance in university courses or practical teaching ability, are likely nevertheless to have some impact on the character of the programs and curricula that are offered.

2.3.2 Initial teacher education curricula in Australia
With current initial teacher training supplied by universities or tertiary colleges, and with reasonably common legislative and department of education expectations across states, there is a reasonable expectation of sameness in curricula across the nation. This is only partly true. First, current initial teacher training employs a number of pathways to the achievement of teacher accreditation, as outlined earlier in section 2.3.1. Second, there are different educational philosophies extant, which are reflected in variations within teaching programs. Third, physical aspects such as the size of a particular student cohort, student-staff ratios, staff profile, available infrastructure and the type of partner schools involved in teaching practice play a role in influencing programs. These, in combination, lead to a level of diversity within a general framework, which may not be obvious at a superficial level.

Initial teacher training is involved with the preparation of teachers for a number of defined areas. Students may choose to train as pre-school, primary school, middle school or secondary school teachers, as well as in areas like special, adult and vocational education. This choice defines in what area they will receive registration to practise. Each field of study operates separate curricula, although there are invariably some common subjects in all universities where students from different areas may come together. The range of discipline areas taught within any degree program varies depending on universities, but all are seeking to satisfy the requirements of the major employers in the particular state in which they operate.

Some background to the range of teacher education programs across universities is provided below, gleaned from website and other published information.

Double degree programs
Double (or combined) degree programs are the predominant mode of preparation of secondary school teachers entering university without any prior degree, particularly those having completed a higher school certificate or its equivalent. The use of the double degree for educating primary school teachers is also increasing. The range of broad discipline fields in which this type of training is offered currently is presented in Table 2.4. The double degree model is growing in popularity, with some additional programs being established for 2002, and included in Appendix A.
Table 2.4  Fields of major study in companion degrees to B.Ed., B.Teach. or B.A.(Educ.) degrees offered in double/combined degree initial teaching programs

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<th>Design &amp; Technology</th>
<th>Information Technology</th>
<th>Business / Economics</th>
<th>Arts / Languages / Soc Sci</th>
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Since all the universities listed in the table offer some form of teacher education, absences of an entry against a particular university means that it does not currently offer this type of program (but does offer some alternate program). This also applies to other similar tables following. These absences may reflect in part state-specific factors. What is notable from Tables 2.4 and others is that both science education and mathematics education are common areas of specialisation, whereas technology education is less commonly offered. In the design and technology area, this is in part related to the lack of facilities for teaching the program, although the reasons are complex. That the great majority of universities offer degree studies in science and mathematics also contributes to parallel education courses including the specialisations.

The typical double degree, for example Bachelor of Science/Bachelor of Teaching, takes four years of full-time study and assigns approximately half of formal credit to education subjects and half to science or other discipline subjects. Discipline subjects are generally taught by the relevant discipline, with education students usually joining classes along with students taking other degrees. The emphasis with regard to fields of study in the program at four different institutes (not identified here) appears in Table 2.5.

Table 2.5 Formal credit assigned to various fields as a percentage of total load for four example double degree programs for science teachers

<table>
<thead>
<tr>
<th>Component</th>
<th>A</th>
<th>B</th>
<th>C</th>
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Required subjects typically include professional knowledge such as basic psychology, information technology and communication skills. Most students complete an approved level of training in two science disciplines and in some cases three. The theoretical basis of child development, learning theories, educational philosophy, curriculum theory, evaluation of learning, pedagogy and educational practice form a significant part (around 25 to 30 per cent) of training, whereas practicum occupies much less than half of that in credit terms.

Single degree programs

Single degree programs are offered across a range of specialisations (Table 2.6), and are at present the predominant mode of preparation of preschool and primary teachers, as well as vocational and adult education teachers. However, some
Table 2.6  Areas of specialisation offered in four-year single degree teacher education programs

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</table>
secondary school teachers are prepared by this type of program. These programs involve four years of educational training in all but two cases (Northern Territory and Wollongong, where a three-year program operates as well as four-year programs).

Typically, the science, mathematics and technology content for each primary education program is presented in courses specifically designed for these students. These reflect the different requirements for teaching at this level compared with secondary school. Generally, these courses are compulsory in the teacher education curriculum. Other required subjects typically include areas such as basic psychology, information technology and communication skills. Education-focussed courses in child development, learning theories, educational philosophy, curriculum theory, evaluation of learning, pedagogy and educational practice form a significant part of training. Practicum in primary school classrooms occupies a small component of the overall course. Teaching practice in this degree occupies effectively the same credit and the same period of time is allocated as in the double degree programs. The credit allocations for various broad fields of four selected programs (locations not defined) appear in Table 2.7.

### Table 2.7 Formal credit assigned to various fields as a percentage of total load for four example single degree programs for primary teachers

<table>
<thead>
<tr>
<th>Component</th>
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</table>

The science, mathematics and technology component of primary teacher single degree education programs is smaller than that found in double degree programs, unless the key learning area elected by the student is in one of these fields. The minimum amount of science, mathematics and technology topics a student teacher must take is only around 10 per cent of most programs.

### Postgraduate diploma programs

The one year full-time postgraduate diploma remains a popular minimal level of training for teachers in several states. In some states, the graduate diploma has been supplanted by, or is offered as well as, longer graduate degree programs, which better satisfy recent state government requirements. The diploma programs assume appropriate content knowledge and focus on education studies, curriculum method and practicum.

Students may choose to train for teaching in a range of specialisations (Table 2.8).
### Table 2.8 Fields of discipline specialisation provided for in one-year postgraduate Diploma of Education programs

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<th>Design &amp; Technology</th>
<th>Information Technology</th>
<th>Business / Economics</th>
<th>Arts / Languages / Soc Sci</th>
<th>Music / Drama / Dance</th>
<th>Vs. / Fine / Creative Art</th>
<th>Health / Physical Educ.</th>
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Occasionally, students may be required to take additional science, mathematics or technology content subjects to provide a relevant major and minor to satisfy the relevant state education department’s requirements for teacher registration.

The amount of practicum taken by students in the diploma programs is usually less but not greatly different from that taken by students in some four-year programs. As a consequence, it represents a larger percentage of the program than it does in the full degree programs. The amount of schoolroom practice is nevertheless the minimum considered appropriate by education departments. However, in a crowded curriculum of only two semesters, there is limited room for maneuvering compared with the longer multi-year programs.

Second degree or postgraduate coursework Masters degree programs

For graduates who have already completed an applicable first degree and are seeking training as a teacher, the alternative to the diploma of education is to complete a second undergraduate degree in education or else a postgraduate coursework masters degree in education. These de-emphasise content knowledge and focus on education studies, curriculum method and practicum. This is because of assumptions about relevant discipline knowledge having been achieved in the prior degree. However, where insufficient appropriate subjects (i.e. relevant to disciplines taught in the school environment) have been studied in the prior degree, students may be required to take additional science, mathematics or technology subjects to satisfy the relevant state education department.

These programs run for from one to two years full-time or equivalent. Two-year full-time programs are dominant, and lead to a coursework masters degree or a bachelor of education or teaching degree qualification. For eight universities, one-and-a-half or even one-year bachelor of education or teaching programs exist. Typically the amount of practicum usually equates with that operated in the four-year single or double degree programs, but represents a higher percentage of the second degree programs simply because they run for a lesser total period of time. Some programs, such as the masters program operated at the University of Sydney, offer exit after one and a half years with a bachelors degree, or participation in an additional internship in a school to complete the masters. The latter option provides for, obviously, a much higher amount of practical in-class teaching experience. Semester- or term-long internships are popular in two-year programs.

Connections between teacher education curricula and school curricula

The primary task of teacher education programs is not only to prepare classroom teachers, but also to prepare them for teaching the approved school curriculum in their expertise areas. In designing curricula for teacher education, a university must ensure that requirements of the state department of education are met through the programs offered. This is addressed through appropriate consultation. For example, secondary science teachers are usually required to complete at university a science major and minor in two disciplines also taught in the school curriculum. The school subject curriculum is addressed in the university curriculum method subjects, and student teachers are prepared for the tasks they will meet in practice teaching.
Consequently, the university discipline study and teaching method curricula are matched to satisfy ‘customer’ requirements.

For example, outcomes based education where the acquisition of knowledge and skills by students can be represented by the acquisition of key competencies is an approach which was not in place some decades ago. Seven key competencies have been defined in the Monash KC Project (2000): collecting, analysing and organising information; communicating ideas and information; planning and organising activities; working with others and in teams; using mathematical ideas and techniques; solving problems; and using technology. For attainment by students of these competencies, teachers need to have the capacity to lead their development. Subsequently, one would anticipate some matching of appropriate training against these competencies in current teacher training curriculum.

Although school-based curricula change and are developed independent of the university sector, it must be recognised that there is articulation. As in any professional training, the course of education offered by the university must satisfy the employers’ needs. For science, mathematics and technology teachers there is no particular difference in this respect to any other field. A dilemma for teacher educators is how to achieve a balance between what they consider as essential from an education disciplinarian viewpoint and what the schools sees as essential from an education practitioner viewpoint. Possibly, this remains the key issue in initial teacher education.

2.3.3 The demand for science, mathematics and technology teachers

That there is a shortage of teachers nationally in science, mathematics and technology has been widely reported recently. There are two consequences for schools: experienced, highly qualified teachers in these disciplines are in demand and may tend to move to selective state and private schools; and, classes may be taught by teachers without strong formal training in the discipline subject they are required to teach. One response to the teacher shortfall has been the introduction of programs of teacher training which draw on mature people with appropriate workplace experiences or else apply retraining of qualified teachers from other fields, where significant over-supply exists, in the sciences and mathematics. The former program has attracted a reasonable level of support from the professional bodies, but the Australian Council of Deans of Science does not consider the latter program appropriate. The President, Professor W. R. MacGillivray, has said that:

> While we acknowledge that retraining of personnel with current teaching qualifications is an innovative approach to solving the shortage problem, the Board wishes to express considerable concern at what can be achieved in one semester. … To attain the necessary science content required for teaching physics, chemistry or any of the sciences usually involves students undertaking in excess of four semesters of study in the appropriate science faculty. So our concern is that the shortage of qualified teachers of physics and chemistry will be exacerbated by the current proposal.

These are reasonable concerns, but do not (and, of course, were not intended to) offer a solution. The problem for the government is, of course, complex; put simply, is any teacher better than no teacher? An even deeper problem with teacher
training is that, even when a student chooses to study education, participants in the program also have fixed perceptions about what type of teacher they wish to become. This is exemplified with enrollments from just one university over the past three years (Table 2.9), which appears to be fairly representative of national trends. It is clear that science and technology are not popular even amongst teacher trainees. Presumably, this reflects, dominantly, views about science amidst teacher trainees more than it does career prospects, given that they would eventually work in the same system with a common remuneration structure. In fact, despite obvious over-supply in some key learning areas, students still choose such areas.

If traditional or standard entry routes are not supplying sufficient number of science, mathematics and technology teachers, alternative entry schemes may deliver suitably trained teachers. However, the demand amidst the public for retraining as teachers is still not large, and is unlikely to grow much without special scholarship support for students who likely have existing financial and family commitments, which impinge significantly on their ability to study.

Table 2.9 | Enrolments (EFTSU) in undergraduate double degree teacher education programs at one university between 1999 – 2001

<table>
<thead>
<tr>
<th>Degree</th>
<th>1999</th>
<th>2000</th>
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<tbody>
<tr>
<td>B. Teach. / B. Arts</td>
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<td>1091</td>
<td>1096</td>
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<td>B. Teach. / B. Social Science</td>
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<td>307</td>
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<td>B. Teach. / B. Music</td>
<td>59</td>
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<td>B. Teach. / B. Fine Art</td>
<td>88</td>
<td>91</td>
<td>86</td>
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<tr>
<td>B. Teach. / B. Science</td>
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<td>82</td>
<td>79</td>
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<tr>
<td>B. Teach. / B. Health &amp; Physical Education</td>
<td>257</td>
<td>298</td>
<td>298</td>
</tr>
<tr>
<td>B. Teach. / B. Design &amp; Technology</td>
<td>32</td>
<td>48</td>
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</table>

In the recent Australian Council of Deans of Science commissioned national study of employment outcomes for science graduates between 1990–2000, What Did You Do With Your Science Degree? (McInnes, Hartley & Anderson 2001), it was noted that a basic pass degree provided an effective entry into employment for the large majority of graduates. Of respondants in their first job, 89 per cent said it was either a desired career position or a stepping stone to the same. Moreover, the employment of science graduates overall did not feature science education highly. In fact, graduates who listed science education as their field of employment were effectively zero for computer science, only approximately 2 per cent for mathematics graduates, and from 4–7 per cent for life and physical science graduates. Further study of those in the workforce was most likely to be taken in business or information technology. Education as a career for science graduates did not feature highly in the last decade.

Retraining programs, which focus on non-science graduates and persons without a degree but with some relevant experience, offer an alternative approach to meeting demand for teachers in the sciences and technology. The University of Newcastle is the biggest retrainer for the teaching service in New South Wales, through their
'Newcastle Program', directed towards curriculum areas with acute teacher shortages. This uses the principle of industry recognition of prior learning to give applicants advanced standing for the content side of their teacher qualification when placing them into a mainstream teacher education program. It requires:

- a minimum attainment of the level of Certificate 3 trade qualification;
- extensive expertise in industry which is relevant to their prospective teaching area; and
- a capacity and continued ability for life long learning.

The retraining of BHP workers who studied part-time under an arrangement negotiated with the company prior to the closure of their Newcastle operations represent perhaps the best known group who have completed this scheme. All graduates of the first cohort have now been placed as Technology and Applied Studies technology teachers in schools. Despite their non-standard entry into teaching, anecdotal evidence suggests that they have been accepted by their peers and in the classroom. The use of such non-standard entry schemes, with their intake of mature students with developed workplace and social skills, represents an avenue for providing teachers with relevant qualifications for our schools. There is the prospect that these mature, more worldly graduates will cope well in the classroom environment, and enhance public perception of teachers.

2.4 Teacher education methods in other countries

Having reviewed teacher education approaches in Australia, particularly with reference to science, mathematics and technology education, it may be informative to briefly examine how some other developed countries approach their teacher education. Teacher training in most countries falls into two broad categories, being either centralised in a national system or decentralised into state or regional systems. The state-based system in Australia has close parallels in countries such as the USA and Germany. Centralised systems are found, not surprisingly, in most small countries such as New Zealand (Bell et al 1995), but also in larger countries such as the UK and France. Further, the mechanisms of teacher training varies from country to country, from being based in special tertiary education colleges, in broad-spectrum universities, to being potentially entirely school-based. There is no clear ownership of wisdom in initial teacher training, although in almost all developed countries teaching is now a graduate profession. Further, there has been an increasing emphasis on assessment of teacher competency and quality assessment. In addition, the globalisation of approaches to teacher training is accelerating, with the first international conference for heads of teacher training institutes, held in 2000, calling for global networks.

Of particular note is that significant reforms of teacher education have occurred in many countries in the 1990s, following a period of reasonable stability, often lasting for decades. That initial teacher education has been swept up in the wider reforms of education was inevitable, but this has not limited the uncertainty and controversy associated with change. Of changes in countries such as France and England, it is the increased role of schools in teacher education and a deeper emphasis on the practice of teaching that is notable (Asher & Malet 1999).
Brief overviews of programs in four major western countries appear below. Those chosen were the USA and Germany (state or district systems), and the UK and France (national systems). These provide an opportunity to see how other countries are changing their initial teacher education.

UK

In England and Wales, the overwhelming majority of secondary school teachers are graduates who are trained via the Postgraduate Certificate of Education (PGCE), a one-year full-time course. This course is dominated by time spent in schools; 24 of the 36 weeks of the course are spent in schools, and only the remainder in a higher education institute. The government agency, the Teacher Training Agency (TTA) funds initial teacher training and is responsible for recruitment to the teaching profession. Provided trainee teachers meet the standards set by the TTA, they can attain Qualified Teacher Status (QTS). This is a challenging exercise, which requires them to attain appropriate standards in teaching and classroom management, assessment, planning, recording, reporting, accounting, and professional responsibilities. The pressures created by the government’s skills tests have been implicated with the loss of good student teachers from the system in a recent press report (Thornton 2001). Training institutes are subject to regular outcomes-based external evaluation by the Office for Standards in Education. These training providers are under great pressure in terms of meeting enrolment targets and compliance, since failure in these areas severely influences funding.

Despite, or perhaps because of, the rigorous professional program, recruitment has proved difficult in science, mathematics and design and technology in England and Wales. Some critics have suggested that there is a crisis in teacher recruitment. Further, there is evidence that trainee students may withdraw from teacher training because of financial problems or the perceived poor image of the profession (Chambers & Roper 2000). Certainly, the number of entrants to initial teacher training was 24 per cent below target in 1998-99, with shortfalls in design and technology (46 per cent), mathematics (47 per cent) and information technology (44 per cent) particularly severe. Several schemes, lately the Secondary Shortage Subject Scheme, have been used to address these problems over the years. It has been suggested that financial incentives alone are insufficient (Whitehead & Postlethwaite 2000).

Teacher training in England and Wales has become homogeneous in the wake of a National Curriculum. The role of teachers in the partner schools working with higher education institutes in postgraduate initial teacher training has increased in importance. In fact, schools in England are permitted to form consortia to fully provide initial teacher training, challenging the traditional role of tertiary colleges. Both the School Centred Initial Teacher Training and Graduate Teacher Scheme do not require higher education institute involvement in the training program. The existence of a continuing valid role for higher education institutes in training has been probed (Williams & Soares 2000). They concluded that the expertise of higher education institutes in research and their associated broad overview of latest thinking in education represent the most important contribution they bring to the training partnership. Earlier studies have pointed to a stronger and critically important role for higher education, particularly with regard to elevating the status of teachers (Edwards 1992).
Concern about the consistency and standard of school-based mentor training, including the rate of mentor turnover and high costs, exists. There is a view that, since the main purpose of schools is not initial teacher training, their priorities may not be conducive to teacher training. Learning how to teach is not simply copying a role model, and some preparatory work is necessary, which best resides with a tertiary institute. Support for a partnership between schools and tertiary institutes in initial teacher training attracts strong support from most interested parties, since there is recognition of their capacity to make effective complementary contributions. That papers by those in higher education institutes point to a crucial role for their institutes in teacher training could be cynically dismissed as self-serving. However, this not only reflects unfairly on the integrity of the researchers, but ignores parallel opinion beyond the tertiary environment.

USA

Education in the USA is state or district based. However, both school and teacher education programs are influenced by some overarching national policies and organisations. One such body is the National Board for Professional Teaching Standards.

Most teacher education is via four-year degrees offered at state universities or four-year colleges. Teacher education institutions usually obtain program accreditation from the state in which they reside. Local two-year community and technical colleges may offer shorter certificate or associate degree programs in education, although the field of education represents only ~1 per cent of the total curriculum delivered through these colleges across the nation. Credit transfer from these shorter programs towards a four-year degree in a university or four-year college can usually be arranged.

Teacher education graduates usually require certification as a teacher from their state authority. Their registration requires that they have completed an approved teacher education program at an accredited four-year institution. Classroom practice teaching forms a part of the curriculum in all university programs, but is typically for a total of from only eight to twelve weeks.

As an example, the Western Washington University offers two programs leading to teacher certification in the state of Washington, the higher of which is a Masters in Teaching. Endorsable major areas of study are approved by the state, with certain minimum requirements of credit, knowledge and skills set. The program of study includes a full semester internship in a school. In Georgia, certification of graduates who complete approved programs at universities is governed by the Georgia Professional Standards Commission (Hart, 1997). Despite these quality control measures, a significant number of teachers are working without full credentials; this is estimated to be as high as ~14 per cent in California, mostly in urban areas.

There are concerns in the USA about a growing shortage of qualified elementary and secondary school teachers, as expressed by Secretary of Education, Richard Riley (1999). Further, the preparedness of new teachers for teaching, with over 60 per cent of graduates in one survey feeling they were not well prepared to implement state or district curricula. Partly, this relates to high percentages not having academic majors appropriate to their teaching tasks. These issues appear in a report from the National Center for Education Statistics, *Teacher Quality: A Report on*
the Preparation and Qualifications of Public School Teachers, summarised by Barlow (1999). One proposed solution has been a call for an expanded role for community colleges in teacher training and recruitment (Gerdeman 2001), through better articulation agreements and partnerships with four-year institutions. State authorities now encourage articulation arrangements. One example of current developments is the University of Illinois at Chicago – Community College Collaborative for Excellence in Teacher Preparation. This interaction of UIC with six local community colleges is funded under a National Science Foundation grant, with its purpose being to increase mathematics and science teacher candidates.

Changes to the education of teachers in the universities are also starting to appear (Darling-Hammond 1999). Over three hundred have created new programs that extend beyond the traditional four-year degree. These new programs also include stronger partnerships with local schools. Some of these new programs are graduate entry programs for those with a prior discipline degree, and offer one or two years of teacher education. Others are five-year undergraduate entry programs that allow for a year-long school-based internship at the end of the program. Professional development programs devoted to formalising and monitoring the classroom work of novice teachers, established with the assistance of local school districts, have also gained a foothold.

Germany

Each state in the German Federation has a large measure of autonomy in terms of arranging its school system and teacher education programs. There are over-arching directives from the federal department of education (Kultusministerium), and an assembly of state ministers of education and cultural affairs (Standige Konferenz der Kultusminister der Lander) serves to assure a reasonable degree of commonality while permitting a level of diversity.

Schools, both public and private, are under state supervision. At secondary level, there are three distinctive levels of schooling: Hauptschule (with a practical vocational orientation), Realschule (technical vocational orientation), and the Gymnasium (academic orientation). The latter provides the major route for university entrance. This tripartite system naturally involves a high level of stranding of students, and some states provide additional comprehensive schools as an option. However, the belief in differentiation and specialisation in secondary education is dominant, and this is reflected in a parallel segregation of teacher training.

In the tripartite system, each type of school is staffed with teachers trained especially for that school (Jones 2000). Teachers undertake university education followed by a period of practical training (up to two years) and assessment in a teacher training college (Lehrerseminar), or else take their full training program at the college over a longer period. The period of education is longer for Realschule and Gymnasium teachers (4–6 years) compared to Hauptschule teachers (3–4 years). The distinctive training and qualifications for the different programs is reflected in different salaries, teaching hours and status. Trainee teachers receive a salary, and when they become teachers are usually appointed as civil servants.

The teacher training institutes in Germany operate practically and administratively separate from the general university system, under the control of the state.
department of education. The Kultusministerium is responsible for establishing the centralised curriculum framework, while the Lehrerseminar are responsible for program delivery and assessment. Training occurs in partnership with schools (Seminarschulen), in which full-time teachers act as mentors.

All three streams of teacher education involve an induction and orientation stage initially, followed by broader professional development. Trainee teachers are selected for training on the basis of their subject knowledge, and teacher training concentrates on teaching methodology and practice. Approximately half their time is spent in classrooms in the early stages, extending to up to four days a week. Trainee teachers usually spend their time in just one host school. The partnership between school and college is well developed.

Despite a growing public unease with the school system and growing criticism of teachers, graduates are still opting to become teachers. Germany is one of very few countries where there is at present a surplus of science teachers.

France

There has been a profound change in teacher education in France, as in England. However, the direction of the change has differed substantially. Major reform commenced in France in 1991. It was directed first towards degree-level training for both primary and secondary teachers, closing an existing gap. Secondly, it sought to strenghten links between theory and practice in initial teacher training (Bonnet 1996). To lead these changes, old-style training institutes were replaced with new institutes known as Institut Universitaire de Formation des Maitres (IUFM), public institutes under the control of the Minister for Higher Education, with a clearer and stronger focus on classroom practice.

Teacher education in France is at postgraduate level. Entry requires a degree or three years of equivalent study subsequent to the baccalaureat, and is achieved through application to the IUFM for a place. For secondary teachers, it is a two-year program of full-time study. The first year is dominantly academic study, with a single week of classroom observation. If successful, students move to the second year, which comprises classroom placement for six hours per week, with associated coursework in pedagogy and teaching methodology. Classroom practice involves a school-based mentor and some observation by an institute-based tutor. There is a greater emphasis on academic training over professional training in France compared with England (Foster 2000). Qualified teacher status (titularisation) involves assessment by a committee including national inspectors, school teachers and university academics. All qualified teachers are civil servants and state employees.

France is facing a severe teaching shortage, which has produced efforts to attract new graduates to the profession (Marshall 2000). Teacher education in France faces further reform (Marshall 2001), relating to an effort to enhance subject knowledge and provide for more classroom experience before teachers enter their profession. Most students in the present system have been pointing to insufficient development of classroom skills. Further, the need for ongoing professional skills training of teachers new to teaching is being recognised. These changes were introduced in the last quarter of 2001.
2.5 Roles for the community and the professions

2.5.1 Stakeholders
The education of teachers is carried out against a rich background of interested parties or stakeholders. In the sciences and technology in particular, the existence of strong and active professional bodies and employer bodies who see they have a role in science and technology education enhances the stakeholder cohort. The interplay of influences on science, mathematics and technology teacher education and the school environment is shown in Figure 2.1. From this diversity of direction, input and concern, it would appear that teacher education is constantly under the public microscope.

Figure 2.1 Stakeholders in teacher education and teaching for science, mathematics and technology.

Teachers in the sciences are entrusted with the multiple roles of first developing general mathematical, scientific and technological literacy in students, and next developing and preparing some students for careers in these fields. The two are linked but not completely overlapping fields. For example, senior school advanced mathematics is obviously a key for those intending to be mathematicians and engineers, but has little direct application for most students. The teaching of such a subject is then a specialised field, which requires a limited number of very able teachers. For the teacher educator, providing for this group in addition to the teacher of junior secondary mathematics teacher is a challenge not easily met; and yet the learned societies, who see in students taking these courses their future members, the importance is clearly high. This is the general problem with
stakeholders and interest groups – they have, naturally, a focus of interest that does not necessarily include the full picture. It is against this background of such quite legitimate but disparate sets of concerns that teacher preparation must perform.

2.5.2 Professional support

Professional societies and industry, key stakeholders in education through their obvious involvement with the ‘end products’ of our education system, have been developing independently their personal contributions as concerned stakeholders in recent decades. An example of an ambitious long-term project directed towards dealing with the issue of scientific literacy is the American Association for the Advancement of Science’s Project 2061. This project began its work in 1985, when Halley’s comet last was visible on earth, and is planning to be in action until the return of the comet in 2061. Scientific and technological change in this period will be profound; in some ways, it is already. The project’s first major task was the publication of the definitive *Science for All Americans* (1989), which contained recommendations for what students should know and be able to perform through to the end of high school. From this foundation grew the *Benchmarks for Science Literacy* (1993), the translation into learning goals and standards for grades K–12, from which states in the USA have drawn for their own standards documents. More recently, they have published *Atlas of Science Literacy* and *Designs for Science Literacy*. What is clear about this project is that it is influencing the way both educators and the public think about teaching and learning priorities in science, and to an extent mathematics and technology, education. The way groups beyond the formal education sphere can influence both policy and public perceptions is notable. Participation of bodies who are not core educators has for a long time had a well-established place in science, mathematics and technology education, and is an important piece of the fuller picture.

Science, mathematics and technology teachers in Australia are well served by a number of initiatives based in universities, government, industry and their own Australian Science Teachers Association (ASTA) and its state branches. The level of support of science, mathematics and technology education is broad and diverse, and is a characteristic of these fields of education. These initiatives appear to have a variety of driving forces, including a desire to retain a strong and vibrant profession (the learned societies), a desire to promote their industry and its functions (industry bodies), and a desire to attract high quality students (university-based bodies). While not purely altruistic, there is across all supporters of science education a basic belief in the place science and technology should hold in modern society, which prompts their participation. This body of support is of assistance to teachers commencing their careers, and developing knowledge of the various schemes and, where relevant, associated web sites should form part of initial teacher training.

The ASTA booklet *Science and Technology 2001* (ASTA Secretariat 2001) lists a large number of programs and activities available to school children and teachers of science. It is appropriate to list some of the activities (Table 2.10) as an indication of the breadth of support; the list is my no means exhaustive. It is noted that these programs encompass both primary and secondary level, but those available for secondary school level dominate.
**Table 2.10  A selection of activities and awards available to school students and teachers by other providers**

<table>
<thead>
<tr>
<th>National</th>
<th>State or Regional</th>
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<tr>
<td>Australian Biology Olympiad</td>
<td>ACT Science Fair (ACT)</td>
</tr>
<tr>
<td>ASTA/Minerals Council of Australia Teacher Awards</td>
<td>ACT Science Fair (ACT)</td>
</tr>
<tr>
<td>Australian Academy of Science Foundation for Young Australians Award for Biology Teachers</td>
<td>Intel Young Scientist 2001 (NSW)</td>
</tr>
<tr>
<td>Australian Geological Survey Earth Science Education Centre</td>
<td>Murder under the Microscope (NSW)</td>
</tr>
<tr>
<td>Australian Chemistry Olympiad</td>
<td>NSW Water Bug Survey (NSW)</td>
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<tr>
<td>Australian Informatics Competition</td>
<td>RACI Nyholm Youth Lectures (NSW)</td>
</tr>
<tr>
<td>Australian National Chemistry Quiz</td>
<td>SMART (Science, Mathematics and Real Technology) Program (NSW)</td>
</tr>
<tr>
<td>Australian Mathematics Competition</td>
<td>&quot;On the Spot!&quot; The 2001 Physics Competition (NSW)</td>
</tr>
<tr>
<td>Australian Physics Olympiad</td>
<td>Science in the City (NSW)</td>
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<td>Australian Schools Science Competition</td>
<td>Science and Technology Challenge (NSW)</td>
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<td>Australian Student Mineral Venture</td>
<td>STANT Science Competitions (NT)</td>
</tr>
<tr>
<td>BHP Science Teacher Awards and Student Awards</td>
<td>CSIROSEC Vacation Program (NT, TAS)</td>
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<tr>
<td>CREST – Creativity in Science and Technology</td>
<td>‘Brainwaves’ Science Festival (QLD)</td>
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<tr>
<td>CSIRO Student Research Scheme</td>
<td>Pacific Coal/QAMT Yr 8 Maths Quiz (QLD)</td>
</tr>
<tr>
<td>CSIRO Double Helix Science Club</td>
<td>Quasar Club (QLD)</td>
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<td>Eureka Schools Prizes</td>
<td>Queensland Science Contest (QLD)</td>
</tr>
<tr>
<td>Kistler Space Endeavour Competition</td>
<td>RACI Crystal Growing Competition (QLD)</td>
</tr>
<tr>
<td>Mathematics Challenge for Young Australians</td>
<td>Oliphant Science Awards (SA)</td>
</tr>
<tr>
<td>Microscopes on the Move</td>
<td>Model Solar Electric Challenge (SA)</td>
</tr>
<tr>
<td>Mt Stromlo Astronomy Summer School</td>
<td>Living in a Biodiverse World – Science and Engineering Expo (TAS)</td>
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<tr>
<td>National Chemistry Scavenger Hunt</td>
<td>Sleek Geek Week 2 (TAS)</td>
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<tr>
<td>National Science Week</td>
<td>Tasmanian Science Talent Search (TAS)</td>
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<tr>
<td>National Youth Science Forum</td>
<td>Great Australian Science Show (VIC)</td>
</tr>
<tr>
<td>RACI National Chemistry Analysis Competition</td>
<td>EPA Victoria &amp; AirWatch ‘Clean Air’ Poster Competition (VIC)</td>
</tr>
<tr>
<td>ScienceNOW!</td>
<td>Physics Gymnasium (VIC)</td>
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<tr>
<td>Smogbusters</td>
<td>Science Talent Search (VIC, WA)</td>
</tr>
<tr>
<td>SPECTRA Awards</td>
<td>School Community Opportunity for Real Experiments in Science on the Road (VIC)</td>
</tr>
<tr>
<td>Prof Harry Messel International Science School</td>
<td>Chemistry Magic Show (WA)</td>
</tr>
<tr>
<td>Waterwatch</td>
<td>Science for Students Science Fairs 2001 (WA)</td>
</tr>
</tbody>
</table>
UniServe Science is a clearinghouse for information about using technology in science teaching and learning, funded by the University of Sydney. They maintain a comprehensive website <http://science.uniserve.edu.au> with links to discipline-specific education resource material and sites, and a searchable database of science software for teaching use, and also publish a regular newsletter. Although initially established in 1994 to support tertiary science teaching, the service is now available to secondary school teachers.

The Australian Academy of Science and the Australian Academy of Technological Sciences are active in science and technology support for schools. This is exemplified by the former’s Primary Investigations program, a science, technology and environment program developed for primary schools.

2.6 Quality of initial teacher education programs

2.6.1 Quality assurance

For teacher education, assurance of quality in programs and outcomes is clearly of great concern. The nation is clearly not well served by inefficient and ineffective teacher training. Fortunately, tertiary education has developed over recent years highly effective and regularly employed mechanisms for course and program review. Both internal and external reviews form part of the structure of all Australian universities. This is matched by national exit surveys and other program assessment and review mechanisms operated by DETYA. Thus, if there is one ‘industry’ that has effective quality assurance processes, it is the tertiary education sector.

The importance of effective quality assurance cannot be underestimated. Both students and the public need the reassurance that programs of teacher education are monitored and meet current best practice standards. The recent establishment of the Australian Universities Quality Agency (AUQA), which commences its work in selected universities in 2002, will ensure that universities remain highly sensitive to and effective in quality assurance. This is relevant to teacher education in the sense that it is not apparent that there is any effective alternative mode of quality assured training mechanism extant.

For the sciences and technology, a parallel concern is the existence of effective occupational health and safety processes in their programs. Again, the tertiary system has well-developed protocols – after all, they are also often in the business of teaching this field in other programs in their institutions.

There are public concerns for the quality of teacher education, which found voice in the 1998 Senate Inquiry into the Status of the Teaching Profession, *A Class Act*. The enquiry concluded, reasonably, that:

> If we are serious about enhancing the status of teachers we must ensure that new teachers are adequately prepared for the complex and demanding task ahead of them. High quality, appropriate pre-service training is essential.

However, beyond this recognition came witness claims that universities were unwilling to commit funding beyond standard formula funding to ensure highest
quality programs of teacher education. Tying funding to quality is a contentious issue, so assertions that teacher training may otherwise deteriorate are concerning, but may not be viewed as authoritative.

Concern about the quality of initial teacher preparation again surfaced in the Ramsey report on teacher education in New South Wales (Ramsey, 2000). This set out to address four key issues:

- the quality of teachers and teaching;
- the implications for teaching of new technology;
- behaviour management in the school environment;
- student teacher practical classroom training.

The review noted, amongst a range of findings, how both employers and parents want assurance that teachers are well trained and able to teach the curriculum professionally and well. For the tertiary educators, there is cold comfort in the report:

> In many cases teacher educators appear to be driven by an interest in the academic discipline of Education or by passing on their own philosophies, rather than giving priority to preparing their students to be excellent teachers.

This, along with a call for

> the provision of teacher education in the State to be sought from a range of institutions which are prepared to meet pre-determined requirements and have a strong commitment to provision

infers that the monopoly on teacher education was not considered sacrosanct. There are already, albeit unregistered and modest, independent teacher training programs established in Australia. For example, the Rudolf Steiner education approach, which operates through a number of private schools across Australia, is served in part by the Melbourne Rudolf Steiner Teacher Training Seminar Ltd.

For science, mathematics and technology teacher training, it can be argued that a key factor to the training of teachers with professional discipline skills is exposure to the technologically rich environments of the university. Training in science and technology is demanding in terms of infrastructure as well as personnel expertise, and it is unlikely that effective scientific training can be achieved outside the tertiary institution environment. This view infers parallel training in discipline and education; where initial teacher training follows separately after a primary discipline-based degree, this view may not be so relevant.

The DETYA course experience surveys of graduates in education is revealing in terms of participant opinion in teacher training in universities. Graduates agreeing that their degree programs provided good teaching varies with university from 69 per cent to 94 per cent, whereas those expressing good overall satisfaction varies from 71 per cent to 100 per cent with the vast majority over 85 per cent. Evidently, students of education complete their course reasonably satisfied.
2.6.2 Seeking best practice initial teacher education

Efforts to identify the characteristics of ‘best practice’ programs are broadly based and widely reported. For a contemporary view, we note that the recent related DETYA study by Goodrum et al. (2000) have drawn attention to key characteristics of exemplary teacher education programs as defined earlier by Darling-Hammond (1997). These involved:

- a common, clear vision of good teaching that is apparent in all coursework and clinical experiences;
- a curriculum grounded in substantial knowledge of child and adolescent development, learning theory, cognition, motivation, and subject matter pedagogy, taught in the context of practice;
- extended clinical experiences (at least 30 weeks) which are carefully chosen to support the ideas and practices presented in simultaneous, closely woven coursework;
- well-defined standards of practice and performance that are used to guide and evaluate coursework and clinical work;
- strong relationships, common knowledge, and shared beliefs among school- and university-based faculty;
- extensive use of case study methods, teacher research, performance assessments, and portfolio evaluation to ensure that learning is applied to real problems of practice.

These characteristics exemplify the dilemma in planning for teacher education. They represent albeit well studied opinion, but are not natural physical rules. They can be added to, challenged, overturned, even replaced by others, and pragmatic realities can dilute them without clear evidence of serious effect. A common model program of teacher education may simply not exist; it is a creature of its time, including fashion in educational philosophy, and hence will evolve as society and knowledge changes. Indeed, the very innovations identified in the present report exemplify the processes of change around us.

Of fundamental importance in developing a model initial teacher preparation program is exactly what are teachers expected to do in the school environment, since this must have a major impact on the education they receive in order to be able to perform their role effectively. Meeting the education needs and priorities for 21st century teaching is a challenge on several fronts. New teachers should not be entering the workplace with deep anxiety about whether they are prepared for the schoolroom; they should have appropriate breadth and depth of preparation that sets them on their course with a positive attitude. For science, mathematics and technology in particular, where there are deep and continuously changing intellectual challenges from the subject bases, the concern regarding preparation is heightened (Dooley & Lucas, 1981; Biddulph 1999).

Fundamentally, we need teachers who champion scientific literacy and numeracy, not solely as necessary preparation for further education of a minority of interested and or gifted students, but as a basic tool for life in a technologically advanced society. We need teachers who can ensure students enter adulthood with at least an interest in and understanding of their world; a capacity to examine, draw
conclusions and question issues pertaining to science and technology; and an ability to make informed decisions involving their environment and personal well-being.

We can learn much from programs extant in the international community. For example, the National Commission on Mathematics and Science Teaching for the 21st Century (the so-called Glenn Commission) in the USA established three key goals to address mathematical and scientific literacy, enhance students’ potential for personal success, and drive secure economic development. These are teacher-focussed goals (Lewis 2000), namely:

- to establish an ongoing processes for grades K-12 to improve the quality of math and science teaching;
- to improve the quality of preparation for mathematics and science teachers while increasing their numbers, including identifying exemplary models of teacher education;
- to improve the working environment for teachers, including better induction programs and school/industry partnerships to support teachers.

These are appropriate targets, and reflect the need to link teacher training to curricula, to the school environment, and to social expectations. The value of a link from training to practice through appropriate mentoring is notable. Placing teacher quality at the heart of the developments is particularly apposite.

Key issues of current concern internationally in initial teacher education programs include:

- achieving the correct balance between academic and professional training;
- the importance placed on teaching practice, and its position within overall training programs;
- the appropriate sites for carrying out teacher education;
- responsibility for program development;
- responsibility for program delivery;
- modes of assessment; and,
- assignment of teaching competence to graduates.

In developing a model teacher education program, the aspects discussed above should be addressed. Further, the core of any program is participation. The shortages of teachers in the enabling sciences, in mathematics, and in technology are not well served by programs that do not attract candidates. In the end, this is the test of a model program; if it is not inclusive of and attractive to students, then it is, well, merely academic.

The pre-service education of teachers is a major undertaking for all developed countries, and present approaches are exemplified in the next section. It is not surprising, given the participation levels, to find that research on teacher preparation is a lively field. The development of teacher education research has been examined by Zeichner (1999), who defines five aspects of current research: conceptual and historical research; examining learning to teach; survey research; case studies; and investigating the nature and impact of teacher education programs. One view of current higher education is that it 'has been split between the world of knowledge and the world of pedagogy' (Maher & Tetreault 1999), even in schools.
of education. A suggested consequence is that teacher education is devalued, and that research in education has tended to focus on philosophical, psychological, sociological or historical areas and away from school- and teaching-centred topics. However, at least based on Australian evidence, this notion appears to be not well-founded (DETYA 2000).

The nature of research, since it typically addresses new issues or challenges, is to develop and evaluate alternatives that may promote change. The current system is consistently considered 'conventional', the untried is typically identified as 'innovative'. Thus a consequence of vibrant research in a discipline is pressure for change. Where teacher training resides in the universities where the educational research is also dominantly centred, there is the opportunity for the nexus between research and application to operate.

The Australian universities currently play a dominant role in initial teacher training. Significant changes in school curricula and assessment procedures need to be reflected in approaches to teacher education. With both school reform and teacher development beyond initial training increasingly becoming focii for attention, the way forward in these areas is under study and debate. There has been a suggestion that the quality of teacher training is at the core of reform in the school system (Hattam & McInerney 2000). Some involved in the debate view the conventional approach to teacher education in Australia as tired, if not obsolete (Smith and Finger 2000), and see a focus on information technology as a key to the future.

What represents a model teacher education system has been debated for decades. For the sciences, the complexities are well recognised (Fensham & Northfield, 1993), but critical goals have been suggested (Dass 1999). Smith (2000) has proposed basic principles for a new model as involving three parts: the knowledge base; the design and delivery platform; and the structural and management organisation.

The way students perceive teaching and transform knowledge into applicable modes for the practice of teaching has led to various concepts and approaches. Developing students’ capabilities towards reflective teaching has been one area of focus (Mills & Satterthwait, 2000; Nichols et al, 2000). Problem-based learning is also becoming adopted as a teaching strategy in teacher education.

Addition of simply more practicum to university courses in teacher education is not considered by Thompson (2000) to be sufficient; he sees new forms of university-school partnerships as an important development. Partnerships and collaboration between secondary and tertiary education in teacher training has emerged as an important strategy in ‘field based learning’ (Howard & Butcher 1999). The emphasis on collaboration between secondary schools and universities is an international trend, and replaces a more one-sided approach where university educators simply accessed schools as required. Collaborative projects between schools and universities are not without their inherent problems, relating to different expectations of the project, geographical separation, time demands from other tasks and project quality control (Johnson et al 1999).

For science, mathematics and technology, there are national and international agendas directed towards reform of education in these fields. It is natural that these agendas should be reflected in growing interest in the quality and effectiveness of relevant teacher preparation programs. A national research consortium was established in recent years in the USA to question the perceptions, beliefs and
teaching skills of beginning secondary science teachers and how these relate to their
teaching philosophies and content knowledge (Simmons et al 1999). The outcomes
may direct changes in teacher education in the sciences.

2.7 Beyond initial teacher education

In this section we briefly explore teachers ‘in practice’ – the ultimate role for those
trained in initial teacher education programs. Because this lies beyond our brief, this
section is restricted to two issue only; first, how well are our children performing in
the classroom under the guidance of teachers; second, how can the standards of
teachers be enhanced following initial teacher education, as part of their process of
life-long learning. These are addressed in particular because both topics are of
concern to those in the sciences whose perspective is the training of future
professionals in science, mathematics and technology.

In Australia, we are seeing a continuing decline in enrolments in high level
mathematics and enabling sciences (RACI, AIP, AMSC & IEA 2001). However, in
the USA, it seems that more students are taking higher level courses than in 1990
(Manzo 2000). The concerns about students being taught by teachers without
majors in the subjects are common to each country, however. In the USA, the
National Commission on Mathematics and Science Teaching of the 21st Century,
headed by John Glenn, is promoting expenditure of billions of dollars on tackling the teacher
shortages in science, mathematics and technology. The Commission sees teacher
quality as at the heart of the problem, and looks to an overhaul in both teacher
preparation programs and professional development (Lewis 2000).

2.7.1 How good is current teaching and learning in
science, mathematics and technology?

Assessing the success of education systems requires relevant information. This has
given rise to a number of comparative international studies, prompted by
organisations such as the OECD as well as by national authorities responsible for
education policy. In the 1990s, we have seen reporting of the Second International
Mathematics Study, SIMS (Keeves 1992), and the Second International Science
Study, SISS (Postlethwaite 1994), the latter followed by the largest of its kind, the
Third International Mathematics and Science Study (TIMSS). A repeat study (TIMSS-R)
was conducted in 38 nations in 1999; preliminary results suggest overall comparable
performances to the 1995 study. These are comparative studies, which focus on
issues common to most education systems. A key aspect of these surveys is that
they attempt to comment on not only what society wants to be taught (the intended
curriculum), but also what is actually taught (the implemented curriculum) and what
participating students actually learn (the attained curriculum).

TIMSS, which completed its initial reporting in 1998, places Australian students
well above the international average of the 41 participating countries in each
population category studied (nine-year-olds, 13-year-olds and Year 12 students). On
tests of scientific literacy and mathematics, our students came equal second, and
third in physics (Jones 1999). This major study covered approximately 500,000
students in the 41 participating countries in the 1995-96 school years. It was
conducted by the International Association for the Evaluation of Educational Achievement (IEA), a consortium of research institutes, and funded by the USA government.

Australian nine-year-old performed very strongly in TIMMS. From the parallel strong achievements of Australian 13-year-olds in TIMMS, it is possible to infer that the teaching of science in primary and middle school was satisfactory in the era prior to the study. This was not wholly anticipated, since all states have been committed from the mid-1990s to introduction of new curricula, on the basis of other evidence of a crisis in science education in schools. Given that the TIMMS results reflect student performance before reforms, and are clearly favourable, the validity of the concerns could be questioned. However, the results do not match well with other measures of performance conducted within Australia. The Monitoring Standards Project in Western Australia (1993) found student understanding clearly below the anticipated level. The Learning Assessment Program in Victoria (1996), held over a year after the TIMMS tests, found school student learning in English and mathematics to be satisfactory, but that in science to be highly unsatisfactory. The inconclusive character of the findings of international achievement comparisons have been commented on in Australia (Fensham 1999) and other countries (Wang 1998).

Fensham (1999) has reflected on the meaning of the strong performance of our students in TIMMS. He believes it does not reflect strong scientific conceptual knowledge, but that

the success of Australian primary students in TIMMS is an outcome of their general literacy in the rather verbose contexts the TIMMS science items presented, together with their abilities to reason out answers to the questions posed.

He sees building on these general literacy and reasoning skills as a clear way forward for teachers in the presentation of science in schools at least at primary school level.

### 2.7.2 Professional standards and further training

Of concern to the teaching profession is their status in society and the public perception of their image and professionalism. Changes in public attitudes have led secondary students to place a greater emphasis on image and financial reward in career planning. Both teachers and scientists do not feature highly in popular portrayals of successful adults. There is a general perception that these do not represent rewarding, satisfying and well-remunerated careers. It is the combination that presents a particular dilemma; potential teachers must be ‘sold’ on both science and education. That we are failing to do so at present is reflected in the shortfall in qualified candidates for science, mathematics and technology teaching positions. The shortfall is particularly severe in the country and in lower socio-economic regions where, traditionally, participation rates in further studies in the enabling sciences have been reasonably high. Ineffective teaching has the potential to cut the loop and further exacerbate numbers of students choosing teaching in the sciences as a career. Many who study science point to the influence of a particularly charismatic schoolteacher on their career choice. What does the future hold if the ‘apostles’ of the sciences fade from our schools?
Although it is not a focus for this study, it would be inappropriate to ignore some reference to the place of the teacher of science, mathematics and technology beyond initial training. Obviously the first ‘place’ is in the schoolroom, since this is the immediate task of teacher education. The loss of trained teachers from the profession is concerning, and may reside in part with new teachers feeling they are like shipwrecked sailors – stranded and uncertain in a new and difficult environment.

Most new teachers, regardless of the extent of their training, question their suitability for the teaching profession as commencing teachers. Of course, the process of initial teacher education is but a first step. An area of concern is the transition from student teacher to classroom teacher. Perhaps a perspective on this from the point of view of a new teacher can be gleaned from comments on an Australian web site separate from the educational providers and directed towards classroom teachers: The Next Step – Learning how to teach when you finish studying (Burton 2001). The author, a beginning teacher, writes:

> I feel [I] am capable of looking after a class without falling apart or losing the ability to maintain a solid behaviour management system. However I do not see myself as a professional teacher per se.

Further, with regard to the transition, he wrote:

> It is one thing to know the theories, to be able to cite great educational educators, to know the ‘academics’ of teaching. It is quite another to walk into a classroom of 20–30 children and know in your heart and mind that not only can you ‘manage’ the class, you can also teach them and help the children to learn.

The comments clarify what every new teacher knows – real life in the schoolroom demands a continuation of learning beyond the formal training. Given the complexities of teaching, no vision for the future can be complete without provision for on-going training; life-long learning must be a truism for the professional teacher. This is hardly peculiar to this profession, of course. We should note a range of appropriate approaches to assisting transition and maintaining effectiveness that have gained favour:

**Mentoring**

The new teacher should be able to anticipate the school that he or she enters has a well developed and effective mentoring program. The mentor to whom they are assigned should have appropriate skills and experience in their field of teaching, and the capacity to assist in development of the new teacher. In the early stages of their career, it has been suggested that reduced load may assist new teachers in establishing reflective and polished teaching performances.

**Further training**

The commencing teacher is not an expert. They should expect to have to expand their skills on-the-job, as in any profession. The concepts of life-long learning should be sufficiently well established in initial teacher training to form a platform for the future. For science, mathematics and technology in particular, where change is inevitable and often rapid, teachers need to have the opportunity to catch up from time-to-time with their discipline’s growth. Perhaps the relevance of this is best summed up by the Chief Scientist in The Chance for Change (Batterham 2000):
It is vital that teachers are given widespread opportunities for their professional development, to ensure that their skills and understanding of the application of science in the broader community are up to date and at international levels.

Accreditation

There have been a number of studies of the readiness of beginning teachers to practise, and areas in which they are anxious prior to beginning their teaching career are quite broad. What is certainly clear is that many teachers, on reflection, consider that 'survival' was the key factor through their first year in the schoolroom (Lang 1999). While growth as teachers comes about through in-school mentoring and reflective personal practice, there is now recognition that some form of continuing training may serve the discipline well. The use of formal levels of accreditation of teachers, with concomitant opportunities for training, represent one mechanism which is finding favour. Such a proposal also has the potential to develop the professional standing of teachers.

Professionalisation of teaching is a strong area of focus in Australia currently, driven by reports such as the Ramsey report (2000) in New South Wales. The desire of practicing Australian teachers to take some control in their own professional development has been reported by Sachs (1997). Since the early 1990s, funding for professional development has been directed towards programs that promote partnerships between universities, teacher associations and education authorities. The National Professional Development Program has overseen a number of such collaborative activities. In the USA, similar programs operate, for example via the Center for Educational Renewal's Better Teachers, Better Schools program, formed in 1994 at Seattle's University of Washington.

The Australian Science Teachers' Association, in a collaboration with Monash University, are pursuing a project designed to develop standards and performance assessments for highly accomplished teachers, with a view to providing some mechanism of certification (ASTA 2000). This project recognises prior development in the USA by the National Board for Professional Teaching Standards and the Council of Chief State School Officers. Engaging teachers in a detailed and lengthy process of analysis of and reflection on their teaching is seen as an important component of performance assessment. The Ramsey report (2000) in NSW recommended establishment of an Institute of Teachers, and included a call for a staged accreditation system for practising teachers at three levels, to recognise professional competence, professional specialisation and professional leadership. A three-level performance-based process of certification had earlier been proposed in the USA state of Indiana (Andersen 2000).

2.8 Visions for the future

Whatever one’s vision for the future of teacher education for the sciences, the base of serving national technological development on which it must stand is clear. Dr Robin Batterham, Australia’s Chief Scientist, succinctly defines the need in his report The Chance for Change (2000):

Excellent teachers are the key to exciting and sustaining interest in science in schools.
He also pins our future as a knowledge economy on our school education system’s capacity to deliver:

*Australia’s success as a knowledge economy is dependent on a highly skilled, informed and scientifically literate workforce who receive a strong foundation of SET (science, engineering and technology) knowledge throughout their primary and secondary schooling.*

The growing recognition of science, mathematics and technology as the keys to a reinvented national economic future sets an agenda for the immediate future around which a vision for education can be built.

Projecting our vision too far ahead is problematical. The world in 2100 is impossible to describe effectively, yet the world of 2020 is perhaps nearly within our predictive reach. This, then, is to where our immediate vision should be directed. Indeed, the appeal of achieving ‘2020 vision’ has not gone unnoticed by others!

The changes in technology and society from 1980 to 2000, while vast, occurred within a slowly evolving gross social environment. This is a signal that the (even likely accelerated) change from 2000 to 2020 will not occur with a fracturing of our current social system; government structure, basic social frameworks, and the education and health support systems will be retained. We expect, therefore, that the school will remain the principal mechanism for educating our children. This is hardly a bold statement, since the anticipated continuation of workforce participation by both or sole parents alone relies on their children being in school. We also boldly predict that universities will remain the principal, if not the sole, providers of trained teachers, and our views are based on this premise. Indeed, for the sciences and technology, the growing and ever-changing sophistication of ideas and equipment demands training in an environment that is directed towards being at the forefront of this intellectual change – the universities.

It is clear that there needs to be a close relationship between the school education system and teacher preparation programs. But what will the school of 2020 be like, and how should science, mathematics and technology be taught in the ideal school of the future? Goodrum and coworkers (2000) in their recent report on *The Status and Quality of Teaching and Learning of Science in Australian Schools*, proposed an ideal picture of contemporary school science in terms of a set of nine themes. These translate to science, mathematics and technology more generally, and hence it is appropriate to partially restate their themes under a number of subheadings.

**The classroom environment:**

- Excellent facilities, equipment and resources support teaching and learning.
- Class sizes [that] make it possible to employ a range of teaching strategies and provide opportunities for the teacher to get to know each child as a learner and give feedback to individuals.

**The curriculum:**

- The … curriculum is relevant to the needs, concerns and personal experiences of students.
- Science and science education [that] are valued by the community, [and] have high priority in the school curriculum …
Teaching and learning:

The teaching-learning environment is characterised by enjoyment, fulfilment, ownership of and engagement in learning, and mutual respect between the teacher and students.

Teaching and learning ...[which is] centred on inquiry....

Assessment [that] serves the purpose of learning and is consistent with and complementary to good teaching.

Teachers:

Teachers ...[who are] supported, nurtured and resourced to build the understandings and competencies required of contemporary best practice.

Teachers of science [with] a recognised career path based on sound professional standards endorsed by the profession.

... science teaching is perceived as exciting and valuable, contributing significantly to the development of persons and to the economic and social well-being of the nation.

Their view was that teacher education should match and sustain these ideals. It should be noted that several of these expectations are clearly outside the brief of teacher educators. However, they represent reasonable and proper concerns for a well-developed education system generally and for science, mathematics and technology in particular.

For a teacher in science, mathematics or technology, there are some key domains, which are the foundations for excellence. These involve experience and competency in relevant disciplines; in teaching; in learning; and in the school environment. Development of effective teachers needs to address competencies in a range of such aspects during their initial education.

Of parallel concern beyond the training of teachers for the sciences is the downward trend in the enabling fields of mathematics, chemistry and physics. A level of the serious concern felt by the major professional bodies, the Royal Australian Chemical Institute, the Australian Institute of Physics, the Australian Mathematical Sciences Council and the Institution of Engineers Australia is outlined in their recent joint document Rebuilding theEnabling Sciences (RACI, AIP, AMSC & IEA 2001). They suggest that the worst scenario 2020 vision for secondary school participation in chemistry, physics and advanced mathematics, based on the current rates of decline, is simply no enrolments. Pertinent to this report, they call for:

Provision of high quality training and a stimulating and rewarding career environment for teachers at all levels of education, together with allocation of resources to the education sector that ensures education of students in the ‘enabling sciences’ at the highest international standard.

It is, taken in its purest form, a splendid vision.
3. Research methods

3.1 Overview
This project was established with five main strands to provide information, as follows:

- Reviews of the literature.
- A survey of teacher education programs across Australia.
- A survey of science deans.
- A survey of professional bodies.
- Case studies of innovative practice.

The rationale and methodologies used in each are described below.

3.2 Literature reviews
Two separate reviews were prepared – a general review and a specific review, as follows.

The general review
This was a wide-ranging overview, which covered general issues of current interest in mathematics, science and technology teacher education, within Australia as well as overseas. The purpose of this review was to provide background information for non-Education stakeholders. Our view was that teacher education is a partnership between those with expertise in education and those with expertise in the sciences. However, those with expertise in the sciences do not necessarily have a deep background knowledge of educational issues. Consequently, the purpose of this review was to summarise some current practices and issues in order to provide this background information, and to provide a context for the rest of the report.

This review is presented in Chapter 2. It was intended to provide information related to educational policies and the general structure of teacher education programs, by referring to data from universities, state and federal government formal reports, literature and web-based data. Information about current issues and opinions was gleaned from a range of sources ranging from formal reports through to recent newspaper articles. The intent was to produce a snapshot of current academic and societal views and approaches in an historical context, pertinent to the project and its tasks.
The specific review

The second literature review was intended to directly address the terms of reference of the project, with information from the refereed educational research literature. The purpose of this review was to help to inform the identification of innovative practice and the selection of case studies. Our reasoning was that, as innovations should seem to offer a relative advantage and should be designed to improve teaching and learning, then we needed to partly consider what the research literature has described as high quality practices with regard to teaching and learning.

The education research literature was briefly summarised with respect to each of the terms of reference of this project. This review is presented in Chapter 4.

3.3 Survey of teacher education programs

Rationale

The purpose of this strand was to provide a brief summary of the main programs for initial teacher education in mathematics, science and technology at both primary and secondary level, at each institution across Australia. The summaries were intended to provide three types of information:

(1) program description which was relevant to the terms of reference of the project;

(2) information about innovative practice in these programs, from the point of view of the education providers (it was decided that the views of the education providers would be useful in helping to identify any innovative practices within their own programs);

(3) information about any challenges, constraints or difficulties which may have impacted upon the program or upon innovation in the program (it was recognised that any factors which restricted the development of innovation in programs should be described).

All data were obtained through individual telephone interviews.

Method

List of institutions

The first step was to create a full list of all the universities in Australia and their contact details. This was done via DETYA information. Next, the website of each institution was examined to identify those that offered current teacher education programs including science, mathematics and or technology. Thirty-six such institutions were identified and they are listed in Appendix B-1.
Permission from the deans of education
The next step was to seek permission from the education deans/heads of school to survey their programs. These persons were identified from each university’s website, and were sent an email, which explained the project and requested their participation (the request letter is presented in Appendix B-2). As the website information was not always accurate, further emails and phone calls were sometimes necessary to make contact with the right person. Eventually, permission was obtained from the relevant person at all 36 institutions. Most of the deans/heads of school also indicated particular staff members to be contacted for the project, and some also identified specific programs which were innovative and worthy of study.

Initial contact with participants
The next step was to identify university staff and request their participation in the project. Where particular staff members had been identified by the dean/head of school they were contacted by phone and/or email and asked to participate (the request letter is presented in Appendix B-3). In other cases, the relevant program coordinator was contacted. Other appropriate staff were also contacted on the advice of these people.

A total of 119 staff agreed to participate and were interviewed (almost without exception they appeared to be very willing to be involved in the study, however, there were five to ten other staff members who declined to participate, usually on the grounds that they were too busy). The number of participants from each institution varied from one (at three institutions) to six (at one institution). Most of them were mathematics, science or technology education specialists, and others were program coordinators. The great majority of the participants were Education faculty/school staff, but a small number (less than 10) were from other faculties. A full list of participants is presented in Appendix B-4.

Telephone interviews
After the initial contact, each participant was interviewed by telephone at a later, mutually agreeable time. The interviewer used a speaker phone, and a tape recorder was placed next to the phone, to record each interview (the interviewees were informed of this before the interview). The interviews varied from 15 minutes to up to an hour in length, but were typically about half an hour. The interviewer prepared for the interview by studying the program description from the university website (this information was found to vary considerably in its accuracy). All the interviews were carried out by one of the project coordinators.

Interview questions
The interview protocol was developed from two pilot studies. The first pilot was an interview with Kath Grushka, the coordinator of the Bachelor of Teaching/Bachelor of Design and Technology at the University of Newcastle. The second pilot was an interview with Chris Dawson, Associate Professor in Education at the University of Adelaide. Each pilot interview was carried out by telephone, and
lasted about one hour. In each case the interviewees were asked to respond to a series of questions about their program, and were then asked to provide feedback to us about the quality of the questions. Our thanks to Kath and Chris for participating in this process.

The final list of interview guide questions was designed to address the terms of reference of the project, as well as providing information about innovations and challenges in the programs. The questions varied slightly according to the nature of the program (e.g. graduate programs typically do not contain content/discipline studies; and interviewees for primary programs were not specifically asked about literacy studies, because this content was assumed to be present). Further clarifying and probing questions were asked as necessary. The guide questions and their rationales are presented in Appendix B-5.

Program descriptions

The information from the interviews was used to create program description summaries. Each description focussed on one particular program, but also briefly described other, related programs at the same institution. For example, one approach was to focus on the four-year, undergraduate program in more detail, then briefly mention the corresponding graduate entry program. However, there was no standard pattern used, and the type of focus program varied from institution to institution, so as to create a balance. It should also be noted that many universities have multiple campuses, each with their own minor or major variations of the standard program - in these cases, either one variant of the program was described as an exemplar, or information from more than one campus was combined.

All the program descriptions were presented in the same format. After naming the institution, the focus program and the contributing interviewees, the first section was an introductory paragraph which described the age of the program, the numbers of students enrolled and the general structure of the program. This was followed by a series of subheadings, as follows.

Content/Discipline Studies contained information relevant to the first term of reference of the project ("the nature and level of content studies undertaken").

Curriculum Method Studies contained information relevant to the second term of reference ("articulation between content studies and pedagogical studies"). Our reasoning was that it was in these studies that the students made the closest links between their content studies and pedagogical practice (i.e. by designing learning experiences which were appropriate for specific discipline content) and they were usually the only program components in which the mathematics, science or technology students were together as a coherent group.

Teaching Practice contained information relevant to the third term of reference ("the integration of teaching theory and practice").

Literacy and Numeracy contained information relevant to the fifth term of reference ("skilling teacher education students in practices to develop literacy and numeracy in school students in relation to these content areas"). This question was not asked in relation to primary education programs because it was assumed to be an integral part of the program.
School/Industry Links contained information relevant to the sixth and seventh terms of reference (‘the exposure of teacher education students to school projects and programs designed to improve student outcomes in their method area’; and ‘the links between the teacher education programs and business/industry’).

Things We Like contained interviewees’ descriptions of aspects of the program which they were particularly proud of, or which they particularly liked. This information was used to help identify innovative practice.

Innovations contained interviewees’ descriptions of innovative aspects of their programs.

Challenges contained information about constraints and difficulties which impacted on the program.

Other Programs contained information relevant to the fourth term of reference (‘differences in teacher education between different types of programs’). This section briefly described the other, related programs at the same institution.

The program descriptions were limited to one to two pages, in order to facilitate a fair comparison, and to make the information ‘reader friendly’.

The program descriptions were endorsed by emailing them back to the original interviewees, who were asked to check them for accuracy and to make any changes or corrections. The version that we received back from them became the final version, which was included in the study. All the original program descriptions were endorsed in this way. However, this process was not without its problems, as some people needed to be contacted two or three times before they replied. A further problem was that many program descriptions contained information from more than one person - both people were sent the draft of the summary, but sometimes only one replied. In these cases we adopted the view that as long as at least one of the interviewees had checked the program description then it was considered to be endorsed.

The program descriptions are presented in Chapter 6, and are separated into (1) primary education, (2) secondary mathematics/science education, (3) secondary technology education, and (4) middle school education.

3.4 Surveys of science deans and professional bodies

Rationale

This strand of the project was intended to collect opinion about innovative practice in teacher education, but from outside the education faculties. Our view was that decisions about innovative practice should be partly informed by the views of non-education stakeholders, particularly science discipline providers, professional bodies in the sciences, and professional bodies for teachers.
Survey of deans of science

Each dean of science (or that person’s analogue) was contacted via e-mail using a current list of deans provided by the Australian Council of Deans of Science. Each Australian university represented on that list, including those not directly involved in teacher education, was asked to respond to a list of four questions. The letter to science deans is presented in Appendix C-1. A summary of the project objectives was also provided at the same time, and is presented in Appendix C-2. The e-letter contained the following questions:

1. If you have a teaching partnership with the Education Faculty/School at your university, would you describe how the partnership operates? To what extent would you consider this partnership to be innovative?

2. Does your faculty provide all science/mathematics discipline courses/subjects for teacher education students in your university? To what extent would you regard your present teaching arrangements for these courses/subjects as representing innovative practice?

3. Are you aware of any current programs for the preparation of science, mathematics and technology teachers anywhere in Australia that you consider are innovative and important?

4. If you have any views on what should definitely be included in future innovative high quality programs of science, mathematics and technology teacher training, would you care to expand?

A summary of their responses is presented in Chapter 5.

Invitations to professional bodies

It was recognised that there is a range of professional associations, including teachers’ associations at national and state level, and societies and associations for the professional disciplines of mathematics, science and technology, which might have an interest in teacher education. An internet search was used to identify Australian professional bodies and their contact personnel. A total of 69 such bodies was identified as having possible interest in mathematics, science and technology teacher education. In each case, the president/director/chair or other contact person was e-mailed a letter inviting them to identify innovations in current teacher education programs, as well as innovations which they would like to see included in future programs. The letter of invitation (sent along with the project objectives summary, Appendix C-2) is provided in Appendix C-3, and a summary of their responses is presented in Chapter 5.

Contributions from the teaching profession

Input from science, mathematics and technology teachers was sought via their professional bodies as a part of the formal surveys, as described above. Although seeking opinion directly from in-service teachers was not a component of this project, one informal meeting with a group of fifteen science and technology teachers in country high schools was held. Discussion was led by one of the report authors, but was not heavily structured.
A summary report is included in Chapter 4. It is not intended to represent general opinion amongst teachers, but to merely provide an additional aspect for consideration.

### 3.5 Case studies

#### Selection of case studies

One of the main purposes of this project was to provide a series of case studies of innovative practice. The first step in the selection of case studies was to identify innovative practice through study of the program descriptions. This was done by firstly grouping the program descriptions into specialisations (primary, secondary mathematics/science, secondary technology and middle school programs). The main types of practices were then identified in a synthesis (or general summary) of each specialisation. Any practices which appeared to stand out from the group, and which appeared to represent high quality practice, were named and briefly described in the syntheses (Chapter 6).

The second step was to decide which of those innovative practices, which had been highlighted in the syntheses, should be case-studied. It was decided that the case studies should be selected according to the following guidelines:

1. At least one case study should be chosen for each of the seven terms of reference of the project.

2. There should be appropriate representation of primary programs, middle school programs and secondary programs in both mathematics/science and technology.

3. There should be good representation across the different states of Australia. It was recognised that each state had its own educational policies and procedures, and that a balanced cross-fertilisation of ideas from different states would enrich the project.

4. The case study programs should contain reasonably healthy numbers of students, as evidence of their transferability.

The final list of 13 case studies was decided upon after consultation between the project directors and the project advisors, and after reference to the submissions from professional bodies and science deans. The list is presented at the beginning of Chapter 7.

#### Case study data collection and reporting

In most cases, the original interviewees were contacted once again to invite their cooperation in a case study. Most were very happy to oblige, but in two cases they declined, and these were not pursued any further. In some cases, the original interviewees arranged for us to contact particular colleagues of theirs who were more closely involved with the aspect of the program under case study.
Each case study had a slightly different focus and a slightly different methodology. However, a standard approach was for one of the program directors to visit the relevant university campus and interview the staff and students, and other stakeholders (such as teachers) as appropriate. These interviews were audiotaped, and usually lasted about 45 minutes. Interviews with students were normally carried out without the staff being present. On several occasions the director also sat in on classes at the university and visited schools to make observations and interviews. There were some case studies that did not involve student interviews, and there were also some cases in which the director did not visit the campus, but these are clarified within each case study in Chapter 7.

The interview transcripts were used to prepare the case study reports. Because of the variety of case studies, it was decided to use a variety of approaches to writing the case studies, rather than sticking to a single, inflexible format. The reports therefore varied a lot in content, structure and writing style, to reflect their differing foci, and simply to provide variety.

Each case study focussed only on one aspect of the program, rather than the program as a whole. Thus, it was not intended to provide a more in-depth summary of the whole program, but rather to magnify one particular innovative feature.
4. Review of the literature

4.1 Rationale

The purpose of this chapter is to provide a brief overview of the main findings of the education research literature, which relate directly to the terms of reference of this project. The findings will then be used to help to inform the identification of innovative practice. Our reasoning for this was that as innovations are intended to improve teaching and learning, then we should be informed by what the literature says about high quality teaching and learning in these specialisations.

It was not the intention of this project to carry out a comprehensive literature review, but rather to briefly summarise the main issues and developments. To facilitate this process, it was decided to make extensive use of the major reviews of teacher education that had been published during the last decade. As a result, this chapter contains many references to sources such as *The Handbook of Research on Science Teaching and Learning* (especially the chapter on research on science teacher education by Anderson and Mitchener 1994), chapters in the *Handbook of Research on Teacher Education* (edited by J. Sikula 1996) and various sections of *The International Encyclopedia of Education* (edited by T. Husen & T. Postlethwaite 1994). These are complemented by individual papers, which present more recent findings.

The research quoted below does not only apply to initial teacher education, but also refers to research on teachers and teaching generally, and learners and learning generally, as all of them will presumably help to inform high quality initial teacher education.

4.2 Nature and level of content studies

The three main components of teacher education programs are content studies, educational studies and teaching practice. With regard to content studies, much of the research has been guided by reference to Schulman’s three categories of content knowledge for teachers (Anderson & Mitchener 1994). These are:

*Subject matter knowledge:* This is the nature of subject matter preparation, which is traditionally regarded as (for example) science discipline knowledge. It is usually offered outside of the education faculty and is not different in form to the content provided to non-education students majoring in that discipline.

*Pedagogical content knowledge (PCK):* This is the pedagogical knowledge of the content that is taught. It concerns teachers’ beliefs and conceptions regarding purposes for teaching subject matter, knowledge of students’ understandings and misunderstandings of particular topics within a subject matter and the methods of instruction for specific content.
Curricular knowledge: This concerns understanding how to work with a particular subject in terms of the aims and design of the instructional area. It is important for prospective teachers to understand their subject vertically through the grade levels as well as laterally across disciplines.

For the purposes of this study, content knowledge will refer only to Schulman’s category of ‘subject matter knowledge’. The other two categories (PCK and curricular knowledge) will be addressed in Section 4.3 (below).

Providers of content knowledge / subject matter knowledge
The main purpose of the science, mathematics or technology content studies taken by prospective teachers is to develop a firm knowledge base that can be used to develop instruction. In most teacher education programs, the students learn subject matter knowledge in the relevant non-education discipline department. The advantages of locating content studies outside of the education faculties have been outlined by Lovat (1999). He argued that, in the past, content studies were located within the faculty of education and these were often more pedagogy than discipline oriented. They became courses that were essentially about how to teach the discipline rather than the discipline itself. This left the teaching profession open to claims that less credibility and status could be attached to these content studies.

Importance of content knowledge in teacher education
Early reviews of the teacher education research literature were conflicting as to the importance of discipline content knowledge. Some reviewers asserted that there was little evidence to support the idea that better teachers had a better content knowledge, but more recent evidence does suggest that greater knowledge of science for example does help to make one a better science teacher (Anderson & Mitchener 1994). For example, some of these studies found positive correlations between the number of hours of discipline content studies and teaching effectiveness. While these correlations were quite low, they did provide some support to those who wanted to increase the science subject matter studies of science teaching students.

The research also suggests that teachers’ knowledge of the content they teach affects not only what they teach but also how they go about teaching it. When teaching a particular subject, teachers have a tendency to place more emphasis on content areas of which they have a better understanding, and they are likely to de-emphasise or avoid teaching topics in which they have less content knowledge (Grossman 1994). The depth of their content knowledge also influences their teaching strategies. Teachers with good content knowledge will use more interactive approaches. For example, teachers with relatively weak content knowledge in mathematics ‘are likely to represent the nature of mathematical knowing as arbitrary and rule bound’ (ibid, p. 6118). Furthermore, those teachers with good content knowledge in a certain area have the ability to construct high quality explanations, questions and activities for students. It has been found that beginning science teachers ‘ask cognitively lower level questions in areas in which they were less knowledgeable and higher level questions in those areas where they felt themselves to be knowledgeable’ (ibid, p. 6118). These findings would suggest that pre-service
secondary science teachers (for example) should ideally receive content studies in all the topics which they will be required to teach at both junior and senior levels of high school.

**Nature of content knowledge**

An important aspect of subject matter understanding involves knowing about the discipline: what experts in the field do, how knowledge evolves, and what the standards of evidence are. For example, in science, the four dimensions of subject matter knowledge that affect teaching and learning (Anderson & Mitchener 1994) are:

- content knowledge (the traditional subject matter knowledge of science);
- substantive knowledge (the paradigms that are used to guide inquiry in the field and to make sense of data);
- syntactic knowledge (knowledge of the way knowledge is created, such as scientific inquiry); and
- beliefs about the subject matter (how individual teachers view science and which aspects of it they consider to be more important).

It is easy to see how these are important to teacher education – for example, science teachers who do not understand the nature of science will have difficulty describing it to their students in a useful manner.

In response to these ideas, a number of dimensions of content knowledge were identified for teacher education (Coble & Koballa Jr 1996). In science, these consisted of:

- **Science content knowledge**, which covers the 'big ideas' about the physical environment, the living environment, the human organism and the technological world. These big ideas should form the core of content knowledge for science teachers, with a depth according to the chosen level of teaching (a measure of sufficient depth would be the ability to guide and respond to students’ questions).

- **Science concepts**, which for physical science, for example, would include ‘the structure of the universe and the major processes which have shaped the planet Earth, and the concepts with which science describes the physical world in general - organised for convenience under the headings of matter, energy, motion and forces’ (ibid, p. 463).

- **Scientific enterprise.** All teachers need to understand that science is a human endeavour and how the history of science has contributed to our current understanding of the universe. The emphasis is that scientific knowledge is durable, yet subject to change; that some questions cannot be answered by science; and that scientific inquiry can be used to explain and predict.

- **The history of science.** Knowledge of the history of science ‘enables a teacher to provide illustrations of the culture in which scientific ideas were conceived and what led to their acceptance or rejection by the scientific community’ (ibid, p. 463) as well as providing insight into how science affects culture.
Thematic ideas. Teachers of science need to recognise that there are thematic ideas, which transcend the boundaries of science, technology and other disciplines. These include the ideas of systems, models, stability, patterns of change, evolution and scale, structure and function, cause and effect, and diversity. Ideas like this appear repeatedly no matter what science is being studied - they are powerful explanatory concepts and should be part of the thinking and explanations of teachers.

Scientific attitudes. Teachers of science are responsible for the attitudinal development of their students, so they need to have a good understanding of what those attitudes are. Science attitudes such as reliance on data, a willingness to modify explanations, respect for reason, cooperation, curiosity, openness to new ideas and scepticism are important scientific attitudes (a separate type of attitude is attitude towards science - a positive interest in and liking for science is also identified as an important outcome of science education).

Science skills, such as information gathering, problem solving and decision making are necessary for addressing scientific questions and resolving technological problems. Process skills such as observing, classifying, measuring, predicting, inferring, communicating, controlling variables, designing experiments and formulating models are information gathering skills which teachers should be able to practice. The skills required for problem solving include those needed for information gathering plus the ability to state questions, identify problems, interpret data, identify alternative solutions, and assess the costs, risks and benefits of solutions.

Given that there are several dimensions to subject matter knowledge, the challenge to teacher education is to consider how best to introduce this knowledge into teacher education programs. Reviewers have commented that the amount of research in this area is growing but still remains sparse:

Little is known about what students really learn in their subject area courses, which is particularly interesting in the light of the fact that students in teacher education spend the majority of their academic time taking courses in [non-education] departments.

Anderson & Mitchener (1994, p. 15)

However, some interesting findings have arisen, and the following sections will describe some of the particular aspects of content studies in mathematics, science and technology that have appeared as issues in the education research literature.

Inquiry in content studies

Studies show that an inquiry approach in science for example, has a significant positive effect on secondary students' performance, but most secondary science teachers have never been exposed to science content courses that employ inquiry teaching as a strategy (Anderson & Mitchener 1994). Most of the university science courses consist of lectures in which concepts are conveyed by an instructor. These are accompanied by 'structured laboratory activities where students follow experimental procedures in “cookbook” fashion. In these courses, science is presented as a body of facts to be learned, with little emphasis given to science as a
process of inquiry’ (Coble & Koballa Jr 1996, p. 471). By the end of their science content studies, many students have not posed hypotheses, designed scientific experiments or completed original research (Bailey, Scantlebury & Johnson 1999). As a result, it has been suggested that undergraduate research should be a component of the science content studies in teacher education programs. One trial program to implement this idea involved a semester-long course in which students had to design and complete their own research projects (Melear et al. 2000). It was found that:

*The students overcame hurdles never before presented to them in traditional science classes. They eventually learned to: work cooperatively and independently, design extended open-ended self-initiated experiments, interpret experimental data, formulate results and present a portion of their work in a scientific format both orally and in writing.*

Melear et al. (2000, p. 89)

A parallel approach has occurred in mathematics teacher education, and some innovative mathematics content courses have appeared. For example, Shoaf (2000) described one case in which a mathematics content course involved secondary mathematics education students in new teaching methods and the use of technology. As a result, the preservice mathematics teachers were able to ‘connect ideas across mathematics courses and develop personal self-confidence and a disposition to seek, evaluate and use quantitative and spatial information in problem solving’ (ibid, p. 151).

**The needs of secondary science education students**

Secondary school science specialists should be expected to have a very in-depth knowledge of any subject that is their senior teaching area. One problem for science teachers is that the junior high school science curriculum spans all of the natural sciences. However, traditional university science is either focussed on a series of courses in one domain of science, or provides isolated courses in general science which do not provide for a continual increase in rigour and depth. It has been suggested that an improvement would be to provide teacher education students with an integrated component that would give them a strong background in interdisciplinary science (Anderson & Mitchener 1994; Huntley, 1999). An alternative suggestion (Coble & Koballa Jr 1996) is that content studies should allow education students to:

- experience the investigative nature of science;
- have classroom and laboratory experiences in biology, chemistry, Earth/space science and physics;
- understand the interrelatedness of science disciplines and the connections between science and other areas of knowledge; and
- learn scientific content and thinking processes in the context of contemporary, relevant, personal and societal issues and problems.
The needs of primary education students in science and mathematics

The depth and breadth of content knowledge will vary according to the teaching specialisation (Gimmestad & Hall 1994). Primary education students should have basic subject matter knowledge across a number of fields since they will be expected to teach across a wide range of Key Learning Areas (KLAs) including mathematics, science and technology. However, the 1989 National Discipline Review of Teacher Education in Mathematics and Science (Speedy et al. 1989) identified serious problems in the mathematics and science content knowledge of primary education students and teachers. With regard to mathematics, the report emphasised the importance of student teachers being mathematically competent and having higher order mathematical knowledge, but its findings were that many students entering initial primary programs had a very poor knowledge of mathematics. A number of studies throughout the 1990s provided more evidence of this problem. It was found for example, that student teachers were able to perform mathematical operations but were unable to apply their knowledge to real life situations; they were poor in many areas of mathematical knowledge, and were particularly poor on word problems (Taplin 1998). Many of these preservice teachers also had mathematics phobia as a result of their past experiences in the subject (Schuck 1999). As a result, some teacher education programs adopted the policy that it is necessary to change student teachers’ negative attitudes towards mathematics (Biddulph 1999). It was also suggested that preservice programs should ensure that graduate primary teachers have a competent procedural knowledge (knowledge of the rules and algorithms and the symbols representation system), and conceptual knowledge (the relationships and interconnections of ideas that explain mathematical procedures), as well as being ‘competent problem-solvers’ (ibid, p. 60).

The discipline review (Speedy et al. 1989) also described a ‘crisis’ in primary science, and this was later supported by a considerable body of research during the 1990s. In summary, this research found that many primary teachers and primary education students had a very limited science knowledge, and also disliked science, especially the physical sciences (Skamp 1992; Trumper 1998). These negative feelings arose from earlier experiences in science (at high school) and overshadowed learning during teacher training (Tosun 2000). This, together with their weak content knowledge, led to many students having a lack of confidence in their ability to teach the subject (Akerson & Flanigan 2000; Bischoff et al. 1999; Yates & Goodrum 1990). As a result, many of them ended up teaching little or no science with their primary children, and those that did, taught it poorly.

These findings led to considerable interest in the science studies of primary teacher education students, and a number of strategies were trialed. It was found that combining content and pedagogy in courses for primary education students can be an effective way to enhance their learning of science and their attitudes towards it. For example, McLoughlin and Dana (1999) trialed a content/methods course and found that the students felt that the combination of content and methods made the course more relevant to their studies in teacher preparation and helped them to gain the confidence to teach the subject. These authors emphasised that primary science content courses should be explicitly tailored to the needs of prospective primary teachers. Ginns and Watters (1999) studied the needs of beginning primary school teachers in science and concluded that science courses in preservice programs must provide more authentic practices and experiences, and be the source of credible
role models for participants. Watters and Ginns (2000) found that ‘student centred instructional strategies that address the dimensions of meaningful learning, and motivation and affect can change preservice teachers’ beliefs about their ability to teach science’ (ibid, p. 317). It is now recognised that science content studies need to be able to motivate primary education students to develop positive attitudes if programs are to produce enthusiastic and committed teachers (Watters & Ginns 2000).

**Technology content studies**

Given the diversity of technology, the issues of what a technology teacher should know and be capable of teaching has been a core concern worldwide (Lewis 1993; Zuga, 1994), including in Australia (Middleton 1997). Recent studies have indicated that common goals and themes for technology education have yet to be established (Lewis 2000). The professional literature for example, contains reference to a range of approaches, from technical, manual arts type programs (such as woodworking, metal fabricating and drafting) to highly innovative, learner-centred, constructivist approaches. Nowadays, it is widely accepted that a central feature of technology education should be to develop critical thinking and technological problem solving skills (Wicklein & Rojewski 1999). Technology education has therefore moved towards a domain dominated by intellectual methods and processes rather than factual content. In fact, it has been suggested that:

Curriculum that emphasises technical content tends to be rather short lived and is constantly changing due to the rapid accumulation of knowledge and techniques used in business and industry. In comparison, the mental processes and techniques used in solving technological problems could remain rather consistent over time... This type of curriculum would be united not by the types of technological devices present in the laboratory, but by the mental processes that were being developed, strengthened and encouraged for each student.

Wickelin & Rojewski (1999, p. 40-1)

Lewis, Petrina and Hill (1998) have described a ‘technological method’ which, briefly summarised, consists of the processes of posing and clarifying problems, identifying relevant technical methods and knowledge, inventing a probable solution, then trialing, modifying and implementing that solution. However, they argued that although critical thinking, communicating and problem solving are skills that have appeal both in the schools and in the workplace, the present technological method or design process of problem solving ‘appears to be ineffective as pedagogy. Classroom studies suggest that students find the methods cumbersome to utilise and if held accountable, merely retrofit methods and their stages to the actual experience’ (ibid, p. 9). Furthermore, they pointed out that prior knowledge is arguably the most important aspect of problem solving:

Technologists possess deep knowledge about the fields in which they practice. It is that knowledge which enables them to understand what they do not know, and what needs to be known. ... People come to problems in the content domains that preoccupy them.

Lewis, Petrina & Hill (1998, p. 27-8)

They concluded that:
Technology teacher educators have to help future teachers understand the conditions under which children learn best and to set such learning as the central aim of their pedagogy. Future teachers must come to understand that creativity cannot be engendered by mere formula. Rather they will have to create the conditions for its expression by exposing their students to the content of technology in the authentic context of laboratories that are rich in technological opportunities in manufacturing, construction, transportation, energy and power, communication, and bio-related technologies.

(Lewis, Petrina & Hill 1998, p. 27-8)

Lewis (2000) described a movement towards design as the basic problem solving approach of technologists, but did however point out that design is still not a content-independent skill (i.e. it would seem absurd that knowledge of design in construction would be transferable to design in electronics). In most technology teacher education programs therefore, a high percentage of instructional time is focussed on specific technical content, and the technical content area, such as operation of equipment and explanation of technical processes is typically viewed as a prominent aspect of the technology education curriculum (Hill & Wicklein 2000).

4.3 Articulation between content studies and pedagogical studies

The educational studies component of teacher education programs includes foundation studies and curriculum method studies (Ben-Peretz 1994). Firstly, studies in the foundations of education have included topics such as history, philosophy, psychology and sociology of education, as well as the study of contemporary issues, multicultural education and educational policy. Research on components of teacher education programs has suggested that students may perceive the foundations courses as only marginally relevant. It has been suggested that they could be improved by making closer links between theory and real life practice, and by linking these studies to practical experiences in schools (Ben-Peretz 1994). However, most of the articulation between education studies and discipline content studies occurs in the curriculum method studies, because these studies focus on how to present discipline content in the classroom. Therefore the emphasis in the remainder of this section will be on the curriculum methods component, which includes the skills and knowledge which has a direct bearing on the teaching of particular content areas.

Research on teacher education programs has indicated that content studies for secondary teachers are usually in the hands of the relevant non-education discipline faculties of universities, and these studies in general do not have a strong articulation with the education component (Ben-Peretz 1994). This means that it is the curriculum methods courses that act as the main bridge between content studies and pedagogical studies (Anderson & Mitchener 1994). Methods courses are intended to help education students to integrate their content knowledge and pedagogical knowledge, and high quality methods courses allow the students to gain experience in applying this integrated learning in actual school settings with real students, as well as in simulated environments with peers (peer teaching). Most of the research on preservice science and mathematics teacher education has been...
carried out in, or relates to, these curriculum methods courses (Anderson & Mitchener 1994). It is through these courses that students develop their pedagogical content knowledge, as follows. (It should be noted that students also develop their knowledge of curriculum in the methods subjects, but studies of this aspect are strangely lacking in the education research literature.)

**Pedagogical content knowledge (PCK)**

At its simplest level, PCK is a combination of general knowledge, content knowledge and pedagogical knowledge; and can be considered to be an amalgam of these:

> Included in PCK is knowledge of typical misconceptions that students will have when learning a particular concept. PCK entails having knowledge of and the ability to draw upon powerful analogies, illustrations, examples, explanations and demonstrations that will make sense to specific students. It also includes knowledge of the background of experiences and culture that learners bring to the classroom and the frames of reference they bring to the learning of specific subject matter concepts and principles.

Gimmestad & Hall (1994, p. 5999)

For example, in mathematics, PCK includes useful representations, unifying ideas, clarifying examples and counter-examples, helpful analogies, important relationships, and connections among ideas (Grouws & Schultz 1996).

It should be noted however, that the definition of pedagogical content knowledge has been evolving over time, and has been criticised by some as being unclear. It has been argued that creating a distinction between content knowledge and pedagogical content knowledge creates a complicated and possibly untenable dualism, but most researchers have agreed that the concept does have the potential to improve teaching, and as such has potential for teacher education (Anderson & Mitchener 1994). For example, Smith (2000) has described how PCK can be used both as a map for the design of a primary science methods course and as a mirror for teacher educators to reflect on their work. In addition, research in mathematics has indicated that ‘providing teachers with certain types of pedagogical content knowledge results in teachers changing their classroom practice in ways that result in increased student learning’ (Grouws & Schultz 1996, p. 444).

In the following sections, particular research findings that have informed PCK in mathematics, science and technology will be briefly described.

**Constructivism**

Constructivism is a theory of learning developed by theorists such as von Glaserfield, Confrey, Driver and Piaget, and is the dominant paradigm of learning in mathematics, science and technology education (Coble & Kohalla Jr 1996; Richardson, 1997). As opposed to this, learning used to be viewed as the simple transfer of knowledge from teachers to students, and students were viewed as ‘empty vessels’, which could be filled up with knowledge. However, according to the constructivist perspective, learners actively construct meaning by interpreting the information they receive in the light of their previous experiences. This view of
learning places importance on the students’ prior knowledge (as this will determine how they interpret any new information).

Research on students’ prior knowledge in science, for example, indicates that students come to science classes with pre-existing conceptions about scientific topics, and these conceptions often differ markedly from scientific views (Coble & Koballa Jr 1996). Furthermore, these ‘misconceptions’ occur in nearly all science topic areas. They are the result of students’ everyday life experiences and are considered to be tenaciously held and difficult to change when standard methods of instruction are used. Numerous studies during the 1980s found that high school science instruction which failed to address students’ prior knowledge often left unchanged many of their science misconceptions (Coble & Koballa Jr 1996). Instead the research has indicated that children do not discard their initial conceptions unless these beliefs are directly challenged in science lessons. A summary of the research in this area concluded that:

If we wish to improve students’ conceptions we must acknowledge that: (a) students come to science class with ideas; (b) students’ ideas are often different from scientists, (c) students’ misconceptions are strongly held, (d) traditional instruction will not lead to substantial conceptual change, and (e) effective instructional strategies enable teachers to teach for conceptual change and understanding.


Examples of constructivist preservice science teacher education programs, such as that reported by Hand & Peterson (1995), can be found in the literature and reflect their popularity. A constructivist perspective also dominates the research in mathematics education and technology education, and serves as the main basis for restructuring how these disciplines are taught and learned (Lewis, Petrina & Hill 1998). For example, current approaches to children’s mathematical thinking are based on the idea that ‘a student builds mathematical power initially by being confronted with novel problem situations and being given an opportunity to invent solutions’ (Maher & Davis 1994, p. 3669). Interestingly, it has been found that an individual student’s mathematical learning is immensely complex, with many elements shared by large categories of students - students’ misconceptions for example, tend to occur in systematic ways in regular and persistent patterns (Niss 1999).

Constructivist approaches to teaching

It has been found that teachers who have a constructivist approach to mathematics regularly make high level cognitive demands on their pupils, which are intended to develop their high level thinking skills (Maher & Davis 1994). In adopting a constructivist approach, the teacher shifts the emphasis from teacher-dominated activities to student-centred strategies. The teacher then becomes a facilitator of learning, who presents students with experiences that are designed to challenge their misconceptions. In science, for example, demonstrations and laboratory investigations should be structured so as to challenge students’ ideas about a phenomenon or to encourage students to look to unexpected solutions (Coble & Koballa Jr 1996).
Several models for implementing a constructivist approach in the classroom were extensively trialed and implemented during the 1980s. These included the Learning Cycle, which is an inquiry based instructional strategy that consists of an exploration phase (involving hands-on experiences), followed by an intervention phase (discussion to try to make sense of the experiences) and application phase, in which students apply what they have learnt to a different context (Coble & Koballa Jr 1996). The Generative Learning Model, is similar to the Learning Cycle but also includes a preliminary phase in which learners are questioned about their ideas. Studies during the late 1980s and early 1990s showed that approaches such as this were very successful in bringing about conceptual change, and were also able to improve reasoning skills, scientific process skills and attitudes. These types of models encouraged students to question their preconceptions, to recognise them as flawed, and to reconstruct them by referring to meaningful contexts (Coble & Koballa Jr 1996).

Constructivism in teacher education

It has been argued that the constructivist approach to teaching and learning should also be carried over into the realm of teacher education (Coble & Koballa Jr 1996). The reasoning is that teacher education students construct knowledge through their own intellectual activities, and like the children who they will be teaching, are also learners and social beings who need encouragement and support in order to develop. Research carried out in methods courses during the late 1980s and early 1990s indicated that constructivist approaches were effective in helping preservice teachers construct their own knowledge (Coble & Koballa Jr 1996). Studies have shown for example, that the Learning Cycle approach can help pre-service elementary teachers develop a better perspective on mathematics education (Grouws & Schultz 1996).

An implication for teacher education programs is that students must understand the need for restructuring children’s existing knowledge, so they should learn as much as possible about the nature of children’s prior experiences and the types of preconceptions which have grown from these experiences, and they should be able to design instruction based on an awareness of students’ prior knowledge. There is therefore a need to provide prospective science teachers with a model for constructivist learning situations and to help them develop the practical knowledge of expert teachers (Anderson & Mitchener 1994). This implies that the types of interaction and communication expected of constructivist teachers should also be modelled by university instructors. For example, one study in a mathematics methods course concluded that:

[Teacher educators] need to practice what they preach. In order for preservice teachers to teach in a way that they may not have experienced before, teacher educators need to help them build an image of such teaching by modeling it in their methods and mathematics courses.

Taylor (2000, p. 254)

However, reviewers have cautioned that much more remains to be learnt about constructivist teaching, and many things are still not known about how to educate teachers to successfully teach in this manner (Anderson & Mitchener 1994).

Reviewers have concluded that:
The big advances in understanding about student learning have not been matched by equivalent advances in understanding about teaching. . . . it seems obvious that research in science teacher education needs to move in this direction as well (i.e., researching how to teach teachers to teach in a constructivist manner).

Anderson & Mitchener (1994, p. 37)

Another issue is that some educators have suggested that if the teacher is a facilitator of learning then there is no need for him/her to have a strong subject matter knowledge. However, Schuk (1999) supported the view that:

People who are knowledgeable about a subject know more than just facts and ideas; they have also formed the connections between these ideas and further understand how to approach new problems and produce new ideas within the subject.

Schuk (1999, p. 111)

Therefore, subject matter knowledge should not be downgraded in teacher education programs, as an extensive subject matter knowledge is required to present content in an orderly, coherent and connected way. For example, Manouchehti and Goodman (2000) found that teachers’ mathematical knowledge was the greatest influence on how they planned their instruction, interacted with students and used the textbook in their classes.

A further issue is that implementation of the constructivist approach will require widespread change in current ideas and practices. For example, most mathematics students have had a traditional mathematical background. If they are to be able to help school students obtain more authentic and productive notions about mathematics then their own ideas must change (Lappan 2000). This position has been supported by Grouws and Schultz (1996) who stated that:

Teacher educators must overcome their students’ lifetime of experience in traditional classrooms in a culture that holds as valid a number of assumptions about mathematics and mathematics teaching. These assumptions are that doing mathematics means following the rules laid down by the teacher; knowing mathematics means remembering and applying the correct rule when the teacher asks a question; mathematical truth is determined when the answer is ratified by the teacher; . . . Unless teacher educators realise that making an impact on prospective teachers requires powerful interventions, it is unlikely that teacher educators will be able to alter the continuity of traditional mathematical teaching and learning.

Grouws & Schultz (1996, p. 449)

The sections below will outline some specific techniques which have been informed by the constructivist approach and which are directly relevant to the teaching of science, mathematics and technology.

Cooperative learning

Peer interaction in small group work has become an important area of research in education (Brodie 2000) and the opportunities for dialogue found in these cooperative learning situations are thought to provide a meaningful context for
students to connect their new experiences to prior knowledge. Studies of cooperative learning in science have indicated that:

*Group dialogue permits students to present their notions about the world and have them challenged. The challenges can lead to cognitive development as individuals realign their thinking as a result of having participated in the dialogue. Cooperative group work also serves to build peer relationships that foster learning.*

Coble & Koballa Jr (1996, p. 466)

Similarly, small group interaction is seen to ‘provide support for the construction of mathematical meaning by pupils, since it allows more time and space for pupil talk and activity’ (Brodie 2000, p. 9).

Cooperative learning can also be an effective strategy in teacher education courses. One study which explored the group work model for mathematics teacher education found that:

*By working in groups, sharing ideas, and making and testing conjectures, prospective teachers gain confidence in their own ability to do mathematics and develop a variety of useful problem solving strategies.*

Spungin (1996, p. 73)

Similarly, studies have indicated that social interaction is necessary if learners are to be exposed to new ideas about science teaching and learning and to coordinate their own ideas with those of others (Coble & Koballa Jr 1996). A review of previous studies (Springer, Stanne & Donovan 1999) demonstrated that various forms of small group learning were effective in promoting greater academic achievement, more favourable attitudes towards learning and increased persistence through courses and programs. Cooperative learning has been shown to promote student interaction and communication in science methods classes and to positively affect students’ attitudes towards science. However, Brodie (2000) pointed out that working with small groups is not unproblematic because ‘pupils might struggle to communicate and learn from each other, and might reinforce rather than challenge mathematical misconceptions’ (ibid, p. 9), so teacher intervention is therefore central to the success of small group work.

**Problem solving**

Problem solving has become the central activity in reform curricula in mathematics (Lappan 2000) and technology (Lewis, Petrina & Hill 1998) because of its ability to facilitate students’ construction of meaning. Previous studies in traditional mathematics classes for example, have shown that much of the cognition is ‘situated’ in the classroom and is of limited use to students in the real world (Boaler 1999). Mathematics curricula have therefore moved towards more problem-centred or inquiry oriented bases, and the application of mathematics to real life situations is now firmly established in programs (Lappan 2000).

The implication is that teacher education programs should allow ‘opportunities to actually be involved in doing mathematics through interesting problem situations that embody important mathematical ideas’ (Lappan 2000, p. 323). Posing mathematical tasks in this way creates new classroom roles for instructors. This
Impacts teacher education programs (Lappan 2000) because if learners are to have opportunities to explore rich mathematical problems, then the instructor has to be able to:

(a) engage learners in problems in context;
(b) push learners’ thinking while their exploration is proceeding;
(c) help learners to make mathematics more explicit during group and whole class interactions; and
(d) create a classroom environment in which all learners feel empowered to learn mathematics.

In response to this need, some problem solving strategies have been developed. For example, one approach (Lewis, Petrina & Hill 1998) for mathematics problems is to:

(a) understand the problem;
(b) devise a plan;
(c) carry out the plan; and
(d) check the results and reflect.

However, such strategies are not always seen as desirable, and it has been argued that a constructivist perspective would suggest that ‘students must arrive at their own problem solving methods and strategies; they cannot rely on a communal strategy’ (ibid, p. 10).

**Problem based learning (PBL)**

Problem based learning is a constructivist approach, which combines problem solving and group work. It emphasises the use of real life problems or scenarios as a stimulus for learning. The students are divided into groups of up to ten and meet (say) twice each week under the guidance of a tutor (Berkel & Schmidt 2000). The process of PBL firstly involves presenting the students with a scenario, case, or vignette, which relates to real life, as a departure point for the learning process. The students then brainstorm themes and questions - this process is designed to allow them to clarify their preconceptions about the topic and to identify their learning needs (Dahlgren & Oberg 2001). The advantages of this type of learning are that it is authentic (in that the problems are taken from real practice) and it involves cooperative learning. Studies have shown that PBL can be motivating for students and can develop their problem solving abilities (Berkel & Schmidt 2000).

Although PBL has been used in medical and other tertiary courses, it has not been widely implemented in teacher education (Kiggins 2001). However, Peterson and Treagust (1998) trialed a PBL approach in a primary science unit. The students worked in groups of three or four on each problem for a six-week period. The study reported that the pre-service teachers had developed their knowledge base and pedagogical reasoning.
Hands-on inquiry

The shift towards a constructivist theory of learning has placed added emphasis on inquiry as a learning activity. Inquiry involves making observations, posing questions, obtaining information from books and other sources to establish what is known, planning investigations, using tools to gather, analyse and interpret data, proposing answers, explanations and predictions, and communicating the results (Keys & Kennedy 1999).

Twyford and Burden (2000) have, in a UK study, shown how design and technology, with its creative components, can have the power to effectively engage students in learning. They argued that hands-on creation or experiment is a powerful tool that technology teachers can employ in the classroom even at primary level. The emphasis in Australia on engagement of students in hands-on tasks reflects this approach (Ginns, McRobbie & Stein 1999).

The inquiry approach also holds promise for teacher education programs. Authors of one study have pointed out that:

> Teachers will be required to teach science in ways that develop interest and positive dispositions in students. Student teachers therefore need to experience effective and fun science education programs that encourage them to value science and the teaching of science.

Watters & Ginns (2000, p. 317)

McLoughlin and Dana (1999) found that an activities-based approach in a primary science method class helped students to better understand the content material and gain confidence to teach science. The students reported being motivated by their own scientific explorations.

However, Keys and Kennedy (1999) argued that a lot more needs to be known about how teachers can best implement inquiry in their classrooms. They identified problems such as lack of equipment, safety issues, management difficulties and the need to teach the ‘basics’ as being barriers to widespread teaching by inquiry. Another problem was that teachers felt frustrated when they could not just tell the students the answer.

Integration

Integration involves making links between different learning areas by studying the ways that each is relevant to a particular issue or theme. Burlbaw et al. (2001) saw compartmentalisation of knowledge as a concern in the sciences, where it has also been noted that narrowing or specialisation of knowledge may be accelerating as scientific knowledge continues to grow at a rapid rate. However, by integrating between learning areas, it is possible for learners to make important connections across disciplines. This involves a recognition that natural connections exist across subject matter areas, and that students’ real life experiences do not reflect the sort of artificial barriers created by different subject areas.

Integration has been recognised as an important way to help students, especially middle school students, to make connections across the curriculum, develop situated knowledge and a broader understanding of concepts (James et al. 2000).

Teachers working in integrated mathematics and science programs have reported
that their students have ‘expanded their knowledge and skill in problem solving, teamwork, technical expertise, and creativity’ (ibid, p. 27). Curriculum integration and the learning of higher order technical and academic skills are also becoming more important in technology education (Herschbach 1998) and one study of the classroom implementation of technology (Kirkwood 2000) indicated that teachers had successfully integrated it with other curriculum areas.

Integration has also become an important aspect of teacher education programs, as it is recognised that it will help preservice teachers to avoid compartmentalising the disciplines, and carrying this forward to the classroom. For example, in one study (McNaughton et al. 2000) teacher educators integrated mathematics education with other education studies to produce a transdisciplinary curriculum which was intended to help students see the connections between what they were learning and its relevance to real life. The researchers concluded that collaboration by university instructors as they teach together can have a positive impact on the experiences of preservice teachers. Integration of appropriate technology with science and mathematics in teacher education programs is another aspect which is currently topical (Niess, 2001).

However, despite the popularity of integration, it has been pointed out that:

Few empirical studies exist to support the notion that an integrated curriculum is any better than a well-designed traditional curriculum. Some educators question integration across the curriculum, because in the effort to integrate topics, science and mathematics content becomes superficial and trivial.

Czerniak et al. (1999, p. 421)

While studies have shown that preservice primary teachers can have positive attitudes towards integration in their programs, these same people can also have a lack of subject matter knowledge in mathematics and science, which means that their connections between disciplines may be superficial at most (Pang & Good 2000). The successful integration of mathematics and science ‘is one of the most daunting tasks educators face’ (ibid, p. 78).

Use of computer technology

Computer technology has been increasingly recognised as important in facilitating teaching and learning in mathematics (Chinnappan & Thomas 2000). This has involved an increase in the use of graphics calculators and computers, as well as the use of computers to ‘access and evaluate information that is available on the Internet as well as to create new information that can be used in the mathematics classroom’ (ibid, p. 173).

The use of new technologies provides opportunities and promise in Australian mathematics teacher education in the same way that it does for the learning of mathematics in the classroom (Arnold 1996). The use of interactive multimedia resources for the development of both knowledge and practical skills of preservice teachers has been one focus (Herrington et al. 1998).
Science-Technology-Society

One development that has highlighted links between science and society is the Science-Technology-Society approach, which emphasises the coupling of science with technology and their relationship to issues in society (Anderson & Mitchener 1994). One of the advantages of this approach is that it focuses on the relevance of science in students' everyday lives, by integrating it with contemporary issues. Relating science and mathematics to everyday life is one of the characteristics of innovative programs for primary education students (McDevitt et al. 1999) and this approach has appeared in some teacher education programs. For example, Burlbaw et al. (2001) reported a project, in which preservice science teachers at Texas A&M University were required to develop an STS project in concert with social science student teachers. They concluded that the teamwork between disciplines helped to develop a broader world view amongst the science education students.

However, many teacher educators have given STS a low priority (Anderson & Mitchener 1994). The difficulties in incorporating STS issues into teacher education courses have been described, including:

...[the] often intense resistance of prospective teachers toward accepting multicultural STS issues as being a legitimate component of courses focusing on science teaching methods ... and the general perception by teachers at both levels that the exploration of social and political issues have a limited role (if any) in science teaching and learning.

Sweeney (2001, p. 1)

Apart from the teaching approaches described above, teacher education programs have also been informed by several other issues and developments. For mathematics, technology and science teacher education some significant factors are described below.

Reflection

During the 1980s, the image of the teacher as a technical expert shifted more towards one of the reflective practitioner (Anderson & Mitchener 1994). A reflective practitioner is one who develops a capacity to reflect on his or her actions 'not only by devising new methods of reasoning, but also by constructing and testing new categories of understanding, strategies of action, and ways of framing problems' (Anderson & Mitchener 1994, p. 16). With respect to science for example, reviewers have noted that 'planned opportunities for reflection increasingly are becoming a part of the pedagogical experiences of preservice science teachers' (Coble & Koballa Jr 1996, p. 473). Reflective habits of self-questioning about aspects of teaching and learning have been shown to positively affect preservice teachers’ confidence and beliefs about the nature of teaching science, as well as developing their awareness of issues such as the poor relationship between people’s daily science knowledge and that taught in schools (Coble & Koballa Jr 1996).

Specific strategies for implementing reflection have also been developed. For example, Artzt and Armour-Thomas (1999) developed the Phase-Dimension Framework for the Examination of Mathematics Teaching, and found that it
provided a useful ‘guide for teachers to reflect on their instructional practice and underlying cognitions in a structured, comprehensive manner’ (ibid, p. 211).

Some reviewers have however, cautioned the preservice emphasis on reflection because:

\[
much \text{ of the important teacher education must take place in the school context with teachers who have gotten far enough beyond the trauma of initial job survival that they can reflect on their work in deep ways. In this classroom context there is the potential of addressing the essence of both constructivist learning and teaching.}
\]

Anderson & Mitchener (1994, p. 36)

**Cultural diversity**

Research has indicated that teachers must be aware of students’ cultural diversity and the diversity of learning styles which children have (Coble & Koballa Jr 1996). Many western countries contain a mixture of culturally diverse communities which are foreign to the teachers, and cultural barriers can be one of the major contributing factors to low participation, interest and achievement by minority students in science and mathematics (Fraser-Abder 2001). It has therefore been argued that teachers must understand the cultural backgrounds and the contributions that each student can bring to the classroom, in order to facilitate learning.

**Gender**

Gender differences are arguably one of the most important forms of pupil diversity in mathematics and science education. Much of the research in mathematics education for example, has focussed on gender differences in enrolment, with many more males than females typically enrolled (Gill 1997). This has been thought to be a result of cultural factors as well as school factors such as ‘teacher attention, student attitudes, timetabling, student counselling, perceptions of usefulness and teacher accessibility’ (ibid, p. 344). Similarly, science teaching does not always benefit males and females equally. Studies have identified that gender-biased teaching behaviours and strategies can contribute to females receiving a significantly poorer science education than males. For example, girls in junior science classes reported that ‘they are not likely to answer questions or participate in class discussions because they are afraid of being laughed at by their peers’ (Bailey, Scandlebury & Johnson 1999, p. 159).

Teacher education students therefore need to be aware of how to promote gender equity in classrooms (Haggerty, 1996), through strategies (Coble & Koballa Jr 1996) such as:

- avoid calling on males more than females;
- do not allow females to be dominated by males in cooperative group work – if possible, create all-female groups;
- promote cooperation rather than competition in science classes;
use examples which illustrate the relationships between science and real people;
- avoid the use of questions which require knowledge of male experiences, such as football and auto repair.

Technology education also suffers from a gender problem in that the technology education population is disproportionately white and male, and has been referred to as a 'culture of exclusion' (Volk 2000). It has been suggested that, if women are to be more involved in technology education, then the change from industrial to technology education has to be a political project (Braundy et al. 2000).

Casual lecturers

In some instances, practising school teachers have been seconded to teach in education programs. This enables school teachers to gain significant professional development for themselves and it also has the advantage of ensuring that recent and relevant experience is available to teacher education students as they are involved in their university studies. One study found that there were substantial benefits from such a program, including the establishment of cooperative links between the schools and university, the provision of recent and relevant school experience to students in the program, and even a certain level of professional development to the professional staff at the university (Perry, Walton & Conroy 1998). Similarly, Hill and Wicklein (2000) concluded that ‘teacher educators should seek new ways to use experienced exemplary teachers in the initial preparation of technology education teachers’ (ibid, p. 19).

Primary technology

It was decided to mention primary technology in a separate section because of the unique problems in this area.

Technology education is not a major component of the primary curriculum in most institutions. In fact, Linnell (2000) surveyed teacher education institutions in the USA and concluded that ‘it is rare that a technology education methods class – or even a class that includes technological concepts – is required or even available’ (ibid, p. 92). In those courses that do exist, problem solving was the most frequently mentioned strategy, followed by designing and constructing projects. The activities emphasised a ‘learn by doing’ approach which was based on hands-on activities. The author emphasised that technology can be a creative and relevant method of integrating in the primary classroom because:

If future and current elementary teachers understand the value of correlating technological skills and concepts with elementary subject areas and they have access to the appropriate training, resources and activities, then they will create an environment in which children are comfortable using and understanding technology.

Linnell (2000, p. 100)

At this stage, however, its potential is largely unexplored.
4.4 The integration of teaching theory and practice

Teaching practice is the third major component of teacher education programs (along with content studies and education studies). The major purpose of teaching practice is to help the education students to become competent teachers (Gimmestad & Hall 1994). Through a variety of field experiences, including student teaching in school classrooms, the students have the opportunity to implement what they have learnt in their courses, and gain practical experience in teaching, managing a class and becoming a part of the school culture. Supervision of student teaching is generally carried out by a university supervisor and a cooperating teacher (the teacher in whose classroom the teacher education student is working). Most students go through a series of school placements in order to give them experience in a variety of situations (Anderson & Mitchener 1994). Many teacher preparation programs also contain opportunities for students to observe classes and interact with children either individually or in small groups as part of their curriculum method studies (Coble & Koballa Jr 1996). However, the emphasis on this section will be on formal practicum.

Models of supervision

In most institutions, both the cooperating teacher and the university supervisor are expected to supervise and guide the student teacher’s development. In most cases, cooperating teachers are expected to hold conferences with their student teachers and to provide instruction on skills of presentation and classroom management. A review of university supervision of student teaching identified three different approaches that had been studied in preservice education (Cooper 1994). The first was Siedentop’s applied behavioural approach, which involved agreement on a set of teacher competencies, designing a valid system for observing those behaviours, observing improvements in student teacher behaviours as a result of the feedback, and ensuring continuation of these behaviours. Alternatively, in Gitlin’s model of horizontal supervision, supervisors and student teachers together established and defined the goals, then lessons focusing on the goals were observed and feedback given. Studies of this approach indicated that its use led to student teachers becoming more reflective and viewing teaching holistically rather than as a set of skills (Cooper 1994). The third approach was Copeland’s series of studies which compared the effect of giving the student teacher direct advice, as against eliciting ideas from the student teacher and only offering advice as a last resort. It was found that student teachers preferred the direct approach early in the internship, but showed a preference for the non-direct approach towards the end. It was concluded that this change in approach should be implemented in teacher education programs. In other words, the supervisor and cooperating teacher should assess the student teacher’s capabilities, and modify their supervisory approaches as the student teacher develops greater reflective skills (Cooper 1994).

Problems identified by the research

Research over the last 20 years has also identified a number of problems with teaching practice.
One problem is that the goals of supervision are often unarticulated or lack congruence with the rest of the teacher education program (Cooper 1994). Two different types of goals have been identified. The first is the apprenticeship model, in which students are expected to develop the skills to take their place within the existing school situation, without challenging the status quo. The other model is the laboratory experience model in which the student teacher is expected to develop their reflective and inquiry skills so as to consider a range of possibilities beyond the existing school situation. Depending on which of these views is held by the university supervisor, cooperating teacher and student teacher their expectations will vary markedly. For example, research has shown that cooperating teachers are more inclined towards the apprenticeship model and often stifle student teachers’ efforts to try new approaches. The result is that there are often conflicting values amongst student teachers, cooperating teachers and university supervisors (Cooper 1994). Willard-Holt and Bottomley (2000) have pointed out that the probable result of this conflict is that the field experience may in fact be counter productive in that it runs counter to the university’s emphasis on trends and innovations not yet widely practised in the field. One example applies to gender equity. It has been found that most cooperating teachers have been in the classroom for several years and may have completed their university studies before gender equity issues were widely discussed and debated, so they may be unaware of equitable practices (Bailey, Scantlebury & Johnson 1999). A further example is the recent move towards a more inquiry oriented mathematics curriculum - the difference between what is taught in mathematics teacher education and what is practised in the classroom is one aspect of concern in Australia (Ensor 2000).

A second, and related, finding is that the university supervisors often have a limited impact on the student teacher. It seems to be the cooperating teachers who have the major influence (Cooper 1994). This is not surprising as the cooperating teacher spends a lot more time with the student during practicum. In addition, there are several studies in which the majority of students have reported that their cooperating teacher was more help to them than the university supervisor. Some possible reasons have been suggested for this. University supervisors can be allocated anywhere between 12 and 36 students to supervise, and where they have large numbers of students the time they spend with each one is reduced. This means that supervisors are unable to provide a substantial amount of observation and feedback to the student teacher, and their role may be ‘reduced to one of liaison and moral support’ (ibid, p. 6001). Another possible reason is that at many universities, practicum supervision has low status, so supervision may not be given priority by many faculty members (Cooper 1994).

One possible impact of this is a widening of the gap between theory and practice. Commencing student teachers tend to compartmentalise their training between practical learning experiences in a school-based environment, and theoretical learning experiences in the university environment (Graham & Thornley 2000). They therefore need specific help interpreting the classroom experience in an atmosphere conducive to reflective discourse. If however, this assistance is not forthcoming, preservice teachers may fail to see the connection between the content of their program coursework and the realities of the school classroom (Brindley & Emminger 2000). Graham and Thornley (2000) showed that student teachers frequently retain this perception throughout their programs and they see little integration between theory and practice. They argued that the interplay
between theory and practice frequently goes unrecognised during students’ field experiences, and making the connections is of concern to educators. These authors proposed that information technology for example, could be utilised to make the links between university studies and field experience.

Another problem concerns the selection of cooperating teachers (Cooper 1994). It has generally been found that universities have little control over the selection and qualifications of cooperating teachers or the classes to which student teachers are allocated. It is generally left to the schools to assign students to cooperating teachers, and it is often simply those teachers who volunteer for the task who are allocated the students. As a result, it is often difficult to place students with high quality teachers.

A further problem is that cooperating teachers are generally unprepared for the task of student teaching supervision (Cooper 1994). It has been found that many cooperating teachers are not very interested in observing student teachers, and instead view them as aides who can help reduce their workload. However, evidence from a number of studies has also indicated that in-servicing these teachers can be effective. For example, it has been found that ‘as a result of training, cooperating teachers valued their clinical supervision expertise, improved their supervisory skills, felt more comfortable as supervisors, and were more eager to accept student teachers’ (ibid, p. 6000). Other studies have found that providing cooperating teachers with training in peer coaching techniques could help to prepare them to work effectively with student teachers (Clarke 2000). Unfortunately, such training programs have not appeared on a wide scale, mainly because of lack of time and funding constraints (Cooper 1994). Kahn (2001) found that, up to the new millenium, cooperating teachers were still calling for greater support and collaboration from the university community, not only in the form of improved communication about university expectations and more in-servicing for cooperating teachers, but also in the form of more input from cooperating teachers into the methods courses and teacher education program development at universities.

Finally, it has been found that if not properly prepared for practicum, student teachers may become disillusioned and confused when their teaching experience does not live up to their expectations (Brindley & Emminger 2000). In this case, the experience may actually be harmful to professional growth.

**Trends and innovations**

There is little evidence that major changes are occurring in teaching practice. Reviewers have reported that:

> The existence of the student teaching triad, the dominant influence of the cooperating teacher on the student teacher, the relatively infrequent visits by the university supervisor, inadequate training for cooperating teachers, the atheoretical nature of the student teaching experience and the reliance on the apprenticeship model seem to be in little danger of extinction. Many examples exist of instances where the negative effects of these patterns have been counteracted through training or new models. However, on the whole, they have not succeeded in replacing these long-standing dominant patterns.
Cooper (1994, p. 6003)

However, although many aspects of teaching practice could be improved, studies have shown that in many countries, students view their practice teaching as the most useful part of their teacher education program (Ben-Peretz 1994). There is evidence that through their field experiences, students can become more integrated thinkers, as well as learning valuable survival skills, and can get to know children as individuals (Brindley & Emminger 2000).

It is possible to identify some further patterns and trends. In many programs in the USA, students have only around 100 hours in schools (Anderson & Mitchener 1994). However, studies have noted that although the time allotted to practice teaching can vary greatly between institutions, there is no doubt that the amount of practice teaching is generally increasing (Ben-Peretz 1994). Another trend has been to increase the number of hours that education students spend in schools, working with children, before the actual teaching practice begins. It has been found that giving students early involvement in schools (i.e. in the first year of the program) can improve preservice teachers’ performance of specific behaviours modelled in method courses (Anderson & Mitchener 1994).

Hope (1999) argued, however, that quality rather than length is the most important factor in field experiences. Aspects such as coverage, intensity, prior knowledge of the student teachers, time in schools, training of mentor teachers, relevance of the instruction provided and the quality of the student teacher intake will all be contributing factors. The following are some examples of strategies that have been directed towards improving the quality of field experiences.

Some institutions have moved towards the development of school-based teacher education programs (Ben-Peretz 1994). For example, one project studied a school-based program that occupied a full year of study, located entirely in two primary schools (Davies et al. 1999). During the mornings, the student teachers taught in the classroom, and in the afternoons they attended education methods classes at the school. They also participated in lectures, seminars, demonstrations and reflection sessions with university staff at the school. An important aspect of this partnership was the staff development component, which consisted of monthly meetings where classroom mentors shared curricular growth, innovative ideas and teaching philosophies. The mentor teachers reported increased self-reflection as well as a range of other positive effects of the partnership.

The use of school-based experiences in conjunction with curriculum method studies has also been shown to have a positive influence. For example, Mewborn (2000) found that a field experience which involved one-on-one work in mathematics with a child for 45 minutes each week for seven weeks had a positive impact on students’ understanding of teaching mathematics, while avoiding many of the inherent problems of practicum described above.

The idea of ‘professional development schools’ is also one that seems to hold promise. These schools are intended to be places in which best practice, high quality induction and reflection would all exist, and which may hopefully go a long way towards creating a high quality environment in which learning, teaching and supervision could flourish (Cooper 1994). Some research suggests that education students at professional development schools (PDSs) appeared to be better prepared for their first year of teaching than were their non-PDS counterparts; and
the PDS experience also had a positive influence on both the student teachers and their mentor teachers (Cobb 2000).

4.5 Differences in teacher preparation between different types of programs

The literature has not as yet, dictated any definite consensus on teacher education program structure. Instead, there is a diversity of approaches and programs, and considerable diversity amongst researchers as to what constitutes the ideal program (Anderson & Mitchener 1994). This diversity reflects the lack of consensus about theoretical perspectives towards teacher education. The points made below must be considered in the context of this general lack of agreement for the profession.

In addition, although the following sections primarily report on the findings of the research literature, it should be emphasised that teacher education programs are accredited by state departments of education, so they will have an important effect on the nature and character of preservice programs (Howey 1996).

Knowledge base

The professional education for the secondary education students typically includes an educational foundations component (which covers the historical, sociological, philosophical and psychological aspects of education, as well as professional issues such as equity, literacy, technological awareness, professional ethics and multicultural education), content studies, curriculum methods components and field experiences. For primary education students, there are typically five to seven curriculum methods courses, which cover the primary learning areas (Howey 1996).

Attributes of high quality programs

In general, obtaining an appropriate balance between theory and practice in teacher education programs has been recognised as important in developing program excellence (Southwell 1996). However, more specific guidelines have been developed. In the early 1990s, studies in the USA identified seven attributes of high quality teacher education programs (Howey 1996). These were:

- a thoughtful conceptual framework, which would present the program’s assumptions, philosophy and research base and the implications of that knowledge for teaching;
- themes that interrelate courses and key activities in the program. The themes should have logical consistency, clarity to students, be reasonable in number, and reflect a balance of the different dimensions of learning to teach;
- grouping of student cohorts to promote group activities and positive socialisation. For example, the use of small groups of 6-8 students working closely together for varying periods of time throughout the course can promote interpersonal development, planning as a team for instruction,
cooperative learning, collaboration and collective feedback, and in effect forms a learning community;
- the use of early diagnostic measures and screening of preservice teachers;
- the development of facilities such as microteaching laboratories and video libraries. Novice teachers need to engage in structured peer teaching experiences in much the same way as pilots learn to fly in simulators. Extensive use of such simulation experiences is important because, as lecture and discussion remain the remain the major components of teaching in education programs, the students respond to the abstract nature of these activities by developing the belief that school classrooms are the only place to really learn how to teach;
- the use of student portfolios to track student development over time; and
- the development of a core curriculum about teaching and learning which is advised by best practice.

However, it has been reported that many programs are only making marginal or moderate progress in attaining these goals (Howey 1996). Reviewers have noted that ‘one of the main problems in teacher education has been the lack of professional consensus in terms of what, if anything, should constitute essential study by all teachers’ (ibid, p. 148) which would advise the core curriculum component of the points above.

The situation for technology programs can be used as an illustration of some of the issues in this area. One conclusion reached was that:

*There is little tradition in technology education of coherent course sequences for grades K through 12 that are premised upon inquiry, or that are agreed upon by communities of practitioners.*

Lewis (2000, p. 75)

However, others have reported a more positive view. For example, Hill and Wicklein (2000) surveyed recent technology graduates and concluded that their technology education programs at university had well prepared them in the thinking skills associated with the subject (ie. critical thinking and problem solving activities). They concluded that with regard to instructional pedagogy and critical thinking/problem solving skills ‘collegiate programs in technology education are approaching the equivalent of a good classification in these two areas’ (ibid, p. 17). However, elementary programs remain problematic. Linnell (2000) surveyed teacher education institutions and found that only five universities in the United States offer technology concepts courses for elementary education and technology education majors throughout the academic year. This probably is related to the general lack of technology education in the US and some confusion about what technology education should consist of. In fact, issues such as declining enrolments, curriculum uncertainty and budget cuts are recognised in as distress signals in technology education programs, and there is a need for further research efforts to determine the effectiveness of programs (Hill 1999).
Length of programs

The majority of teacher preparation programs are four years duration (Gimmestad & Hall 1994) and there is some support that this is an adequate amount. Butcher (1990) for example, explored the viability of standards for Australian technology education programs and found that technology teacher education programs should be a four-year preservice degree developed from a philosophical statement consistent with the aims of technology education in the school curriculum.

Some programs have been intentionally designed to take five years, and others have had requirements added so that five years is needed for completion (Gimmestad & Hall 1994). Five-year programs, however, are atypical, and a comparison of technology teacher education programs in the USA and Taiwan (Lee 1992) indicated that the appropriate proportion of general course work, technical studies and professional courses remained undetermined, but that five-year programs were not a viable option in the near future.

Reducing programs to less than four years also poses some inherent difficulties. For example, Government policies in New Zealand have lead to four-year primary teacher education degrees being reduced to three years, with mathematics education being reduced in the process (Biddulph 1999). This may create a potential problem because ‘a significant proportion of the students have deeply negative feelings and attitudes, and lack understanding of relatively simple mathematics’ (ibid, p. 64) and it is difficult to see how a reduction in the program (and mathematics content) would rectify the situation.

Graduate and undergraduate programs

Within the four-year framework, there are two main ways of completing teacher education. The first is the undergraduate program, which contains both content studies and pedagogical studies. In these programs, the professional education studies may begin in the first year of study and continue through to completion of the program. The second are the graduate programs, in which the first three years of study are in the discipline content area, resulting in a standard undergraduate degree in a non-education faculty. After graduating, the students begin their education studies, which may take either one or two years.

A recent trend in technology education for example, is a move towards more graduate programs. In the USA, programs that prepare technology teachers are spending a greater proportion of their effort on graduate students (Volk 2000). However, the problems of graduate programs have been highlighted by Lovat (1999), who endorsed the view that:

While apparently secure in the discipline base, this form of training was said to be inadequate as professional preparation, largely owing to the short duration of the award, but also to the lack of connectedness between the discipline base and practical experience dimensions.

Lovat (1999, p. 119)

Undergraduate programs, in which the content studies run alongside the pedagogical studies, are considered more appropriate for the preparation of teachers because the students have the opportunity to focus on the pedagogical
implications of the content and not solely on the substantive knowledge of the discipline (Ben-Peretz 1994). However, supporters of graduate programs have recognised that the age of commencement in teacher education programs may have an influence on performance. It has been suggested that there is a significant difference between 18-year-old and 21-year-old commencing students in terms of commitment to teaching, with older students more committed (Andersen 2000).

Innovation and trends

Studies throughout the 1970s and 1980s found that most universities still maintained the traditional curriculum of university education coursework and education related fieldwork (Anderson & Mitchener 1994) and there was little variation in this design from institution to institution. Differences did exist however at course level within programs:

[Innovations] usually are directed at changing one or two isolated components within a program, as opposed to the program as a whole. Such changes . . . are often seen in creating interdisciplinary subject matter courses, reworking science methods courses, and adding field experiences.

Anderson & Mitchener (1994, p. 23)

Some general trends have however, been observed worldwide (Gimmestad & Hall 1994). There is a general trend towards requiring more general education and more professional/pedagogical education in teacher education programs in developing countries. In addition, differences between the amount and nature of educational preparation between primary teachers and secondary teachers are becoming less, with many primary education programs being extended to the same length as secondary education programs. Two types of trends that deserve special mention are developments in distance education, and compressed courses, as follows.

Distance learning

Distance learning refers to interactive instruction that occurs when the student is separated geographically from the instructor. It typically uses electronic devices and print material to deliver and receive instruction. Technologies used for distance learning now include satellite delivery, television broadcast, compressed video, computer conferencing, multimedia, audioconferencing, radio and videotapes. Because it is now possible to transmit live, two-way signals, the teacher-student interaction is greatly improved (Ndahi 1999). Research on distance education has mainly centred on media comparisons, and comparatively little is known of other aspects, such as how faculty members react to using distance technology and how it contributes to program design (Ndahi 1999).

Web-based teacher education programs have been developed in Australia in recent years, and offer flexibility and opportunities for those challenged by distance or social situation. For example, Rodrigues (1999) described on-line distance learning offered in one Australian science education masters course. Dealing with the relative isolation of students studying by this technology presents a concern for this mode of teaching, as identified by Bloomfield (2000). Implementing curricula and meeting expectations of Australian society will, according to Carter (1997) depend increasingly on the broad use of information technology. The implication for
teacher education is a clear need to develop in student teachers both expertise and adaptability as the technology inevitably changes.

Compressed programs

Changed approaches to teacher education programs are sometimes the result of external factors such as teacher shortages, rather than carefully researched evaluation (Hope 1999). For example, Volk (2000) documented the continuous decline in industrial arts/technology teacher graduation rates in the USA (less than 850 students graduated from technology education programs in 1999). The implication was that with such small numbers of graduates, it is unlikely that traditional programs will be able to meet the projected demand for technology teachers. As a result, a number of alternative programs have appeared and the numbers of students gaining provisional teaching certificates is expanding.

In Australia, a number of programs have been developed which admit students on a recognition of prior learning (RPL) basis. RPL refers to recognition of non-credentialled or informal learning (Taylor & Clemans 2000). No research-based model for RPL has as yet been developed, so at university level, there are still ‘difficulties in determining the appropriateness and extent of experiential learning’ (ibid, p. 263). These authors noted that many faculties of Education are still in the process of development of procedures for recognising prior learning.

Some of the programs that have been developed in response to teacher shortages have the potential to inform best practice in this area. For example, the University of Auckland introduced a January to December program involving partnerships with local primary schools (Hope 1999). The program involved continuous placement in one school per term for three days of each week, and university lectures on the other two days. Hope proposed several postulates, which were supported by the program:

- a compressed program is possible for mature and motivated students;
- equal partnership with schools is an essential element;
- continuous placement in school is preferable to block placements;
- trained mentor teachers in schools will enhance the quality of practicum experiences;
- student teachers must have a range of practicum experiences likely to provide contact with a range of students; and
- reflective practice should underpin the course.

4.6 Skilling teacher education students in practices to develop literacy and numeracy in school students in relation to these content areas

In order to simplify the presentation of the research literature, this section will be divided into the three categories, general literacy, numeracy and scientific literacy.
General literacy

This type of literacy can roughly be described as language skills. These involve ‘gaining competencies involved in effectively using socially-constructed forms of communication and representation’ (Kellner 2000, p. 249). Early versions of literacy involved:

The skills and drills curriculum of primary schools, placed high emphasis on accuracy in encoding and decoding: on spelling and handwriting, on error recognition, on naming parts of speech, on word perfect recitation and on recall of written information in response to questions involving literal and inferential comprehension.

Morgan (2001, p. 32)

More recently however, literacy is viewed as socio-cultural practice which changes according to the contexts of use, so modern school curricula tend to advocate the explicit teaching of the functional features of language, but within authentic contexts which extend beyond the school English classroom (Morgan 2001).

Literacy is a significant issue in Australian education, and has been recognised as ‘a necessary condition to equip people to participate in the local, national, and global economy, culture and polity’ (Kellner 2000, p. 249).

One of the literacy challenges which faces children is learning to manage the distinctive grammatical features and text structures which are used in specialised curriculum areas. Unsworth (1997) pointed out that literacy was a significant aspect of science learning, as there are characteristic ways in which language constructs scientific understanding for young learners, and conversely, a good standard of literacy in science will enhance students’ ability to communicate and to comprehend, for example, information in factual texts. Thus science teachers have an important role to play in enhancing students’ general literacy levels. Similarly, with regard to mathematics, the research has indicated that:

Language factors have a strong influence on the learning of mathematics and that there are strong links between the development of literacy capabilities and mathematics learning.

Perry et al. (2000, p. 16)

In response to this sort of thinking, literacy skills such as reading, writing, speaking and listening have been integrated into the curriculum in each of the Key Learning Areas in states such as NSW (Perry et al. 2000). Research in schools has shown that, although some mathematics teachers, for example, have not significantly implemented these policies, other mathematics teachers have developed innovative and creative literacy practices, such as:

students presenting a written account of certain curriculum topics; peer assessment of oral reports; the negotiation of meaning via the modification and reconstruction of students’ own language; genuine reciprocal communication between teachers and students about the purpose, process and product of mathematical activities, underlining of key words in written explanations and definitions; packs of mathematical activities which take literacy issues into account; and close partnerships between mathematics teachers and support teachers.

Perry et al. (2000, p. 17)
In the present period of dramatic technological and social change it has also been argued that educators need to foster a variety of literacies, including print literacy, media literacy, and computer and information literacies in order to allow schooling to respond constructively and progressively to the technological and social changes that we are now experiencing (Kellner 2000). Morgan (2001) has described three strategies for using information and communication technologies (ICT) to promote literacy:

- drill-for-skill programs are efficient and can promote assimilation in several overlapping forms;
- enhancement or amplification of information, types of text and literacy practices; and
- transformation through new genres and new hypermedia literacy practices.

**Numeracy**

There are still many differences in the way people define numeracy (e.g. ‘mathematical literacy’). It is generally accepted that numeracy is having the competence to use mathematics to meet the general demands of life at home, at work and in the community (Hogan 2000). This could include for example, such home activities as shopping, budgeting, cooking, dressmaking, designing a home addition or buying an insurance policy.

Wedge (1999) argued that mathematics is a contextualised activity, and that a person’s mathematical knowledge will depend on the context in which it is being used. This has created an emphasis that the school curriculum should contain real life contexts, or authentic and meaningful contexts, so students can develop the skills to apply mathematics in real world situations. This is in contrast to traditional school mathematics, which is usually learned in isolation from the real world; and it has been found that adults typically make very little use of the mathematics routines that they learned at school (Hogan 2000). Modern curricula therefore encourage pupils to ‘think mathematically’ and to ‘do mathematics’ rather than having an emphasis on meaningless algorithms (Maher & Davis 1994).

Dubinsky (2000) argued that mathematical literacy is important to students in areas that relate strongly to mathematics, such as physical and life sciences, computer science, engineering, management, architecture, linguistics and library science, as well as students in areas such as English, history and cultural studies. This was ‘because every educated citizen who would like to have a more than superficial understanding of society needs this kind of literacy’ (ibid, p. 289). It follows that if there is to be an increase in mathematical literacy of the general population, then it must begin in schools and continue in universities.

The *Numeracy Across the Curriculum Project* (Hogan 2000) suggested that, to be numerate in any particular situation, a person needs a blend of mathematical knowledge (an understanding of number, space, chance and data, algebra and measurement), contextual knowledge (the capacity to link mathematics to life experiences) and strategic knowledge (being able to identify the key features in a problem, and decide on, select, and apply the appropriate mathematics). The role of the teacher is then:
to ensure that the students engage in the debate, use mathematics to understand
the arguments being put, teach the mathematics where it is not understood, show
the students how mathematics looks in the situation and coach the students in
applying the mathematics to the problem.

Hogan (2000, p. 19)

Scientific literacy
Another way in which the term literacy is used is with respect to ‘scientific literacy’.
Scientific literacy refers to ‘an appreciation of the nature, aims and general
limitations of science, coupled with some understanding of the more important
scientific ideas. It is sometimes coupled with public understanding of science’
(Jenkins 1994, p. 5345).

Scientific literacy became one of the goals of science education during the 1980s.
However, for many people it is a problematic notion, and the term has been used to
describe a range of understandings (Jenkins 1994) including:
- an appreciation of the nature, aims and limitations of science;
- an appreciation of the nature, aims and limitations of technology;
- a knowledge of the way in which science and technology work, an
  appreciation of interrelationships between science, technology and society;
- an understanding of language and concepts of science;
- an ability to interpret numerical data, especially data relating to probability
  and statistics;
- an ability to assimilate and use technical information and the products of
  technology; and
- an understanding of where and how to get information about matters
  relating to science and technology.

Several arguments have been put forward to support the importance of scientific
literacy (Laugksch 2000). Firstly, it has been argued that the economic well-being of
a nation depends on a steady supply of scientists and engineers, and only nations
whose citizens possess an appropriate level of scientific literacy will be able to
sustain this supply. Secondly, higher levels of scientific literacy should translate into
greater support for science itself. Thirdly, the more the general public understands
about science the more they will have reasonable rather than unreasonable
expectations of science. Lastly, scientific literacy should have advantages to
individuals by making them feel more competent to deal with science related issues
in everyday life.

Although this concept has become an educational goal (Galbraith, Carss & Grice,
2000), it does depend on a number of assumptions and interpretations, and it is
often regarded as ill-defined and difficult to measure (Laugksch 2000).
4.7 Exposure of teacher education students to school projects and programs designed to improve student outcomes in their methods area

There are many different types of school projects and programs (e.g. Reading Recovery programs) but focus in this section will be on those that are relevant to mathematics, science and technology. For example, programs for gifted and talented students have been studied, and the following are some examples from mathematics.

Talent searches

Talent searches have been used since the early 1970s to identify academically talented mathematics students. One example of such diagnostic testing is the Appalachia Model Mathematics Program (MMP), which has been combined with an individualised program for the delivery of mathematics content to talented students (Rotigil & Lupkowski-Shoplik 1999). In general, the above-level testing offered by regional talent searches is useful in (a) identifying mathematically talented students, (b) tailoring educational recommendations to the abilities of the students, and (c) providing challenging educational opportunities for the students’ (ibid, p. 330).

Gifted and talented programs

Many mathematically gifted students are not fully challenged by their schoolwork and are in need of special attention if they are to meet their potential (Mingus & Grassi 1999). A number of reports have focussed on strategies to meet the needs of gifted and talented learners. One type of approach has been to offer gifted students a program which proceeds at an accelerated pace. However, Kalchman and Case (1999) have argued that the wide diversity of learners within accelerated classes means that some pupils still find the work either too challenging or not challenging enough. An alternative approach is to use a curriculum in which everyone learns a core set of concepts, then explores different kinds of functions independently. Students in an experimental mathematics curriculum of this type were shown to score higher and to have much more diversity in their answers than students in control groups (Kalchman & Case 1999).

Other examples of school programs

The following are three examples, which have been chosen to illustrate the variety of school projects that have been studied for science and technology. Firstly, Dori and Tal (2000) reported an innovative project in which children worked with groups of parents from the community to design and manufacture within an agreed-upon theme such as ‘Industry Out of Waste’, ‘Sweets’ or ‘Packages and Packaging’. They found that through this collaborative project, which involved students, parents, teachers and the community at large, the children were able to gain a more complex view of real world problems. Secondly, Trumbull et al. (2000) reported the results of a project, which involved both children and adults...
investigating the seed preferences of birds. They found that this sort of authentic science, in contrast to traditional, tightly scripted school laboratory investigations, provided a forum for children to engage in scientific thinking processes. Thirdly, Parker and Gerber (2000) investigated a five-week science intervention program based on an inquiry curriculum with real world applications, and found that middle school students' science achievement and attitudes towards science were higher following participation in the program.

However, many school projects and programs have not been evaluated in the research literature. The following are some examples of mathematical programs which have appeared during the last decade. While they appear to be innovative projects with the potential to interest students, formal evaluations of them with respect to teacher education are still to be made.

**Maths camps**

Two-day or three-day maths camps can be used to promote interest in mathematics amongst interested students. For example, one such camp for high ability Year 11 students:

> … provided a valuable mathematical experience for the students, but also brought together students of similar ability. These students are in a minority in their own schools, and it did them good to mix and discuss mathematics with others of equal ability. Participating staff also mingled and discussed mathematics on an equal footing.

Anderberg (1993, p. 23)

**Maths labs**

Maths labs are hands-on activity centres for group learning activities in mathematics. They are usually set up in one of the schoolrooms and are used about once per week. The classes are divided into small groups of students, and each group does a different activity on a rotating basis. Instructions are provided in activity folders, and students write answers in their own exercise books. Proponents of maths labs point out that they have many advantages including, hands-on learning, the pace is controlled by the students, they allow development of reading, discussion, teamwork and problem-solving skills, and they improve attitudes towards mathematics (Ryan 1993).

**‘Mathematics in Action’**

Through Mathematics in Action, students in mainstream classes can participate in mathematical experiences in real life situations. For example, an excursion to Australia’s Wonderland in western Sydney, offered the opportunity for students to work in small groups to complete worksheets on ‘relevant mathematical questions while enjoying the rides’ (Wallace 1993, p. 3).

**Maths challenge days**

Maths challenge days allow students in junior high school to form small group teams and compete against students from other schools. Students gather in the
school hall and work in groups of four at tables to try to solve problems as a team. The aim is to challenge and motivate talented students through providing them with a variety of activities (Burke & Nimac 1999). Similarly, Mathsearch is a competition for talented students from years 9-11, in which they are given a take home project, which they are required to complete themselves, with minimal assistance (Mitchell 1993).

4.8 Links between the teacher education program and business/industry

Some technology teacher education programs are making special efforts to establish and increase cooperative relationships with business and industry (Lai 1998). For example, to reflect the rapid technological changes in society, Taiwan’s technology teacher education programs have undergone the transition from basically industrial arts education programs to diverse technology education programs (Lai 1998). This has included increased collaboration with industry and business. University-industry linkages in Australia were reviewed broadly in an earlier DETYA report (Turpin et al. 1996). In mathematics and science teacher education, however, the links have often taken the form of informal education experiences and partnerships, as below.

Informal education

Informal education agencies have an important role to play in improving scientific literacy amongst the general population, as well as education students. These informal agencies include museums and science centres, science shops, the media and zoos. Science centres and museums offering interactive, hands-on experiences are designed to promote an understanding of scientific concepts, rather than merely display scientific objects (Jenkins 1994). A substantial volume of research has addressed children’s learning experiences during their visits to informal learning centres. Much is known about the effects of different kinds of exhibits on visitors, the distraction caused by the novelty of the environment, and pre and post-visit strategies for enhancing learning during school organised class visits (Anderson, Lucas, Ginns & Dierking 2000). Informal learning and ‘out of classroom experiences’ are encouraged on most levels of the education system as a means of strengthening students’ interest and motivation, but they can also provide considerable learning outcomes for students (Henriksen & Jorde 2001).

While such centres of informal learning can have a significant impact on children’s understanding of science, they may also be useful for mathematics learning. It is important to recognise that excursions may offer mathematics students the opportunity to apply mathematical principles and concepts in real life situations. For example, an excursion to the Maritime Museum could offer an opportunity for students to investigate topics such as navigation and shapes (Stanton 1993).

However, although there has been study on the effects of informal learning experiences for school pupils, studies of their usefulness in teacher education are still needed, and the impact of these types of experiences in teacher education programs should be further explored.
Partnerships

One problem with inquiry approaches to science is that many teachers are reluctant to use them because of inadequate training and experience in inquiry methods (Caton, Brewer & Brown 2000). It has been suggested that teacher-scientist partnerships may be one way for teachers to develop an increased understanding of scientific processes and have greater confidence in their ability to teach science using inquiry methods. In one study of a teacher-scientist partnership, it was found that teachers had:

...increased appreciation for inquiry, greater confidence in teaching using inquiry, and greater use of inquiry in the classroom. Moreover, scientist partners reported increased familiarity with the principles of science education and best teaching practice.

Caton, Brewer & Brown (2000, p. 7)

4.9 Summary

This literature review was intended to provide a summary of the education research literature that is relevant to the terms of reference of the project. The purpose of this literature review was to identify the main innovations and issues in science, mathematics and technology teacher education programs, so they can be used to inform the identification of innovative practice. Our reasoning was that as innovations are intended to improve teaching and learning, then we should be informed by what the literature says about high quality teaching and learning in these specialisations.

In point form, some general findings of the literature review were:

- Content Studies should include aspects such as the history of the discipline, as well as the concepts, attitudes and skills of the discipline. There should be an inquiry component in content studies, and attitude change should be an aim for mathematics and science.

- The pedagogical content knowledge, which is presented in curriculum method studies, should emphasise a constructivist approach, and may usefully involve strategies such as cooperative learning, problem solving, problem-based learning, hands-on inquiry and integration. Students should develop skills for reflective practice and be aware of gender and cultural diversity issues.

- Teaching practice should have clearly articulated goals, and a balance of inputs from the classroom teacher and the university supervisor, to create a bridge between theory and practice. Other strategies for achieving this link include training of mentor teachers, school-based programs, and non-practicum experiences with small groups of children.

- High quality programs should have a thoughtful conceptual framework as well as a variety of links between different components. Distance learning technologies and compressed programs were two types of innovations.

- With respect to the other terms of reference (literacy and numeracy, school projects and programs, and links to business and industry) the literature
suggests that these should be included in school programs, but their nature and usefulness in teacher education programs is still to be evaluated.

The information above has given some indication of practices that may improve the quality of teacher education programs. However, it is possible that many new and useful innovations may not yet have been evaluated in the research literature. The information in this literature review should therefore be interpreted as an advisory guide rather than a prescriptive list. As such it will be used to partly inform the identification of innovative practice.
5. Outcomes of science deans and professional bodies surveys

5.1 Introduction
This strand of the project was intended to collect opinion about practice in teacher education, but from outside the education faculties. Our view was that decisions about innovative practice should take into consideration the views of non-education stakeholders, particularly science content providers, professional bodies in the sciences, professional bodies for teachers and teachers themselves.

5.2 Opinions from deans of science

5.2.1 Rationale
In considering the education of science, mathematics and technology teachers, it is reasonable to anticipate that those responsible for the relevant discipline content should play some partnership role. Students opting to study education via a postgraduate diploma or degree will in general have completed their studies in the relevant discipline and will spend the whole of their postgraduate education program in the education faculty or school. For students taking an undergraduate single or double degree program however, the education and science components are usually taken in an overlapping manner. This requires some level of partnership between education and science. The purpose of this strand was to obtain the views of science deans about their partnerships with education and to seek their views on innovation with respect to that partnership, the teaching of their content courses, and teacher education programs. These views would then be used to help inform the identification of innovative practice.

5.2.2 Results
A total of 16 responses were received (a response rate of 44 per cent). However, in two of these, the science dean had passed our request to the education dean, who had replied. As the views of Education personnel have been sought elsewhere in this project, the discussion below refers only to the 14 responses from science deans. The names of the respondents and their institutions have not been included, to preserve anonymity.
Responses to Question 1

If you have a teaching partnership with the Education Faculty/School at your University, would you describe how the partnership operates? To what extent would you consider this partnership to be innovative?

In most of the responses the deans named and briefly described the main teacher education programs that they shared with Education. Few details were typically given about the detailed nature of the partnership. However, one response described the partnership as consisting of the offering of dual degree programs, course development, course review, course administration, representatives on committees and meetings between heads of school:

The partnership is based on the offering of undergraduate dual degree programs for mathematics and technology teacher education (Bachelor of Teaching/Bachelor of Arts) in NSW. Course development and course review processes and course administration are shared and consultative processes that also involve representatives of the Board of Studies, Department of Education, TAFE, practising master teachers and employer/industry or professional association representatives, as appropriate, are involved. Close links and communication are maintained by having a School of Education (NSW) (in the Faculty of Education) representative on the School of Arts and Sciences (NSW) Committee (in the Faculty of Arts and Sciences) and vice versa. The Heads of School meet regularly to discuss issues as they arise and they and other staff attend various forums of relevance to science, mathematics and technology education.

The deans described a wide range of innovations, including:

- placements for science students to assist with teaching in schools, as part of an undergraduate ‘project’ subject;
- the use of external teaching flexibility which helps overcome the classical problems of allowing science students away from their laboratories to undertake teaching practicum;
- the development of a fast track qualifications upgrade pathway;
- a new technology program, which includes study at TAFE and industry experience;
- a new outreach program for primary schools, which has an Education Faculty member assessing the impact the program has in the classroom; and
- a specialist school in science and mathematics, which will be located on a university campus.

We are aware of other activities beyond those identified by respondents, such as the senior academic appointment in the science faculty at the University of New South Wales with a primary role of liaison with education in the development of science teacher education. The information available would suggest a firm partnership in many locations.
Responses to Question 2

Does your faculty provide all science/mathematics discipline courses/subjects for teacher education students in your University? To what extent would you regard your present teaching arrangements for these courses/subjects as representing innovative practice?

All the responses except one stated that the content studies for secondary education students were all taught by the relevant non-education department/school (in one case, some mathematics discipline was taught by an Education Faculty member). It was argued that this was imperative for ensuring up-to-date material, and it was also good for the education students to mix with other science and mathematics students. Only four responses mentioned whether the science faculty was involved in primary programs (two stated ‘yes’, one stated ‘no’, and the other was a joint effort) so the situation for primary was not made as clear.

The innovations mentioned in this section included:

- the development of new units for primary teachers, which focus on the reality of a teacher’s needs but also have sufficient academic rigour;
- expertise in flexible teaching methodologies including classical distance education, on-line teaching and learning, and multimedia based teaching and learning;
- designing the program so that no student is required to undertake professional practice courses at the same time as discipline courses, thus alleviating difficulties of non-attendance due to practical teaching;
- the development of innovative courses for primary teacher preparation;
- the provision of bridging Mathematics and Chemistry subjects, and allowing them to be counted towards the B.Sc. and B.App.Sc. degrees to a maximum of 6 units out of the 72 required. This brings in significant numbers of students who would otherwise not be able to study science;
- modelling best teaching practice in discipline units;
- increasing use of on-line study resources for both internal students and those enrolled by distance education mode; and
- problem- and project-based learning approaches as well as some interdisciplinary units at first-year level (e.g. Physical Science; Environmental Science) which have particular relevance to Education students because of the multidisciplinary nature of the Years 1-10 science curriculum.

Responses to Question 3

Are you aware of any current programs for the preparation of science, mathematics and technology teachers anywhere in Australia that you consider are innovative and important?

Most of the deans either did not reply to this question, or answered in the negative. However, some of them did describe some important programs, which included:

- the development of a national on-line masters degree in science education;
the development of Diplomas of Science, which allow teachers without appropriate mathematics and science backgrounds to achieve the required standard; and

- programs for qualified science teachers to retrain to teach senior chemistry or physics.

**Responses to Question 4**

If you have any views on what should definitely be included in future innovative high quality programs of science, mathematics and technology teacher training, would you care to expand?

The most common response in this section (43 per cent of respondents) was the importance of education students having a sound science/mathematics content knowledge, and practising teachers having the opportunity to develop their content base. It was suggested that discipline studies to third year level were appropriate and that a basic discipline degree plus a graduate diploma of education was satisfactory. Some deans also mentioned the importance of future teachers having a good knowledge of information technology and how to implement it in the classroom.

Other deans emphasised the importance of strong collaborative links between schools and university science faculties, CSIRO or other research organisations, to provide models of working scientists. One response described the Science Challenge, a project developed by the Faculty of Science and Mathematics and the Faculty of Engineering, which had actively involved students in at least 60 high schools:

*In essence the Science Challenges alert students that Science and Engineering can be fun and challenging while at the same time information about possibilities can be conveyed. Incorporation of similar ways of covering material and information at high school level could be a standard part of teacher preparation.*

Some other issues were also mentioned. For example, the importance of having a pathway which does not lock students into the teaching profession, and the importance of students developing a passion for science. Several further points were made by one respondent:

*Future innovative high quality programs of science, mathematics and technology teacher training would rely on:*

- an appropriate blend of education and discipline units delivered by education and science faculties/ departments in collaborative arrangements;

- a commitment to the scholarship of teaching by both the scientists and educationalists as a sound basis for collaborating and sharing the benefits of research;

- learning in both Science and Education that is strongly student-centred;

- interdisciplinary/multidisciplinary contexts for science curricula where possible, particularly at first year level; [and]

- learning experiences in science disciplines that are founded on sound pedagogy and best practice.
Other comments
Three of the deans expressed concern about teacher education because of issues such as lack of students. One stated:

The Faculty is greatly concerned at the lack and continuing decline of physical sciences and mathematics teachers. As a regional university, we are alert to the great pressures on country high schools, and especially central schools, following the new HSC and schools’ difficulties in offering two or more science programs. Increasing, universities are attempting to help fill the gap. These pressures are not helping to improve the status of school science and, in turn, incurs yet more pressure as fewer students elect to study university science and consider science teaching as a career option.

Another mentioned the effects of this and lack of funding:

We previously ran a unique B.Sc. (Science Education), which we discontinued from the start of 2000 due to financial constraints and small course numbers.

Concluding remarks
These responses have described a range of links between faculties of science and education. Indeed, both comments and a number of schemes described which emanate from the sciences suggest a strong concern and desire for the training of a strong cohort of teachers in the sciences. Overall, there appears a reasonable level of satisfaction with the form and functioning of interaction between their faculties and education faculties.

5.3 Opinions from professional bodies

5.3.1 Rationale
There is a range of professional associations that have a direct or indirect interest in mathematics, science and technology teacher education. These include teachers’ associations at national and state level, as well as institutes, associations and societies associated with the professional disciplines of mathematics, science and technology. The purpose of this strand was to obtain advice from these bodies about innovative practice in teacher education programs. These views would be used to help to inform the identification of innovative practice.

5.3.2 Results
A total of 10 submissions were received (a response rate of 15 per cent). Their responses are summarised below under the subheadings Primary Teacher Education, Secondary Mathematics/Science Teacher Education, and Technology Teacher Education. Submissions of significant length (one page or longer) are also presented in full in Appendix C.
Primary teacher education

The response from the Australian Academy of Technological Sciences and Engineering (ATSE) was directed mainly at primary teacher education. No innovative existing programs were identified in this submission. However, it did note concerns with,

- the qualifications of those selected into teacher training courses in our universities;
- the quality of the preservice training of teachers in the universities, particularly in respect to science and technology teaching in primary schools;
- the quality, amount and formal recognition of in-service training provided for teachers;
- the facilities available in primary schools for science and technology teaching;
- the climate of teacher employment and the culture of confrontation between the public employers of teachers and the Teachers Unions.

In conclusion, the ATSE submission:

*expresses an interest in the current inquiry. It notes the restrictive terms of reference. It expresses concern that the outcomes of the work may be used to suggest that there is no problem. There is a real possibility that evidence of exemplary behaviour by teachers who have survived the system will be used to conclude that there is nothing to be done.*

This submission is included in full in Appendix C.

The submission from the Royal Australian Chemical Institute emphasised that **relevant** science content should be included in primary teacher education programs and that there should be:

*an emphasis in the course on science as a way of questioning and finding explanations for things around us, rather than a store of facts, so that teachers are excited and motivated to teach it in this way.*

This submission is included in full in Appendix C.

Secondary mathematics/science teacher education

Submissions were received from the Australian Mathematics Trust (AMT), Canberra Mathematical Association, a representative of the South Australian Science Teachers Association, the Royal Australian Chemical Institute (RACI) and CSIRO Education. The submission from the RACI identified the Master of Teaching program at the University of Sydney, but no other innovative existing programs were identified in these submissions.

The submission from the RACI expressed concern at the state of the ‘enabling sciences’ (chemistry, physics and mathematics) because of the decrease in student numbers in these subjects. It listed 19 propositions for science teacher education programs, including needs for: course delivery to model effective teaching approaches; additional funding; ongoing involvement of lecturers in research and
school teaching; subject specific pedagogies; a solid science discipline background; study of other branches of science outside their major/minor discipline areas; links with practising scientists; literacy and communication skills; assessment based on actual teaching; dialogue between mentor teachers and universities; supportive mentor teachers; increased practicum time; and adequate computing and data logging skills. This submission is presented in full in Appendix C.

The AMT identified some general changes in mathematics education over the last 20 years, such as the move to a more experimental and exploratory way of teaching, and the wish to make mathematics appealing to a broader cross section of the population. It noted declining entry requirements for mathematics, and questioned whether the changes toward dependence on expensive calculators in the classroom, which are not used in later life, are really beneficial. It also highlighted the Mathematics Challenge for Young Australians Enrichment Program as complementing the mathematics as taught in the classroom. This submission is included in full in Appendix C.

Several submissions made suggestions for future directions and innovations, as follows.

- It might still be wise to look at ways to ensure that students who eventually might pursue quantitative studies in University, whether in science, engineering or technology, are given as much of a theoretical background as possible to give them the necessary options in the future.

- All teachers in the 21st Century should make use of student fascination in space and astronomy by being equipped with the necessary resources and knowledge. These topics should be included in teacher training for Maths, Science and Technology in the future. This submission noted the programs that NASA runs through its education centres, and the use of online webcasts, and video links, and NASA’s intention to runs its education programs from the International Space Station, and the electronic product ‘Pipehenge’ which is a daytime astronomy aid to teach about ‘Our Place in Space’.

- CSIRO Education was concerned that many student teachers have no background in scientific research themselves, and that the CREST Program (Creativity in Science and Technology) would be a suitable vehicle for teachers to become involved in research methodology. This submission is included in full in Appendix C.

- CSIRO Education also suggested that student teachers should be exposed to different teaching scenarios, and that extension education resources such as the CSIRO Science Education Centres provide a different approach to science education and as such requires some different teaching skills to those found in most schools.

- CSIRO Education also suggested that student teachers should learn of some of the resources that are available to support education, such as the Double Helix Science Club and Scientriffic.
Technology teacher education programs

Four submissions related specifically to technology education: the Australian Council for Education through Technology (ACET), Technology Educators Association of Victoria (TEAV), the Industrial Technology and Design Teachers Association and the Australian Institute of Food Science and Technology. These submissions identified several programs, as follows.

- The Bachelor of Technology Education at Griffith University has a high level of acceptance of its graduates among the schools and teachers in the field. It has high success rates in students being employed in competitive situations (e.g. prestigious private schools against experienced teachers).
- The primary technology component at Deakin University, includes a 'community project' which requires students to identify a need in the community and then work through a design process with their 'client' to provide a solution for this need. This is a very successful part of the course and is challenging for the students.
- The program at LaTrobe University, is the only course available for secondary technology education in Victoria. This program targets people from the trades and has a VET focus.
- The B.Ed. at Edith Cowan University has an innovative final year internship and an intensive sponsored postgraduate program for technology teachers.
- Various universities in NSW have government-sponsored programs involving scholarships.
- The program at Southern Cross University (Coffs Harbour) was also identified as innovative.

In addition, the Australian Institute of Food Science and Technology made the following three points about future directions for technology teacher education.

- The teacher education program should contain adequate discipline content about the food industry, as this is poorly understood in schools. Certainly a lack of awareness of the extent of the food industry recognising that it is the largest employer of people of any industry grouping in Australia. In fact much of the advice regarding the food industry appears to be negative or emphasising contentious issues without a balance of information for both viewpoints. Examples of such issues would be the use of food additives, GM foods and nutritional labelling.
- In teaching practica, the standard of support and supervision by university and/or contracted tutors can be minimal, and needs to be improved. Much of this can be traced back to university funding, or lack of it. This is certainly an area which requires creative solutions if students are to receive an education which will equip them to successfully function in the current school climate whilst retaining motivation for teaching. The practice teaching component is of major importance in the training of motivated teachers.
- There is a need to strengthen the linkages between university staff involved in teacher education and industry/business, perhaps by staff secondment to industry and vice versa.
All of the technology respondents were generally concerned about the state of technology education in Australia and comments referred to both the low numbers of programs as well as the low numbers of students.

5.4 Opinions of practising teachers

5.4.1 Rationale
The in-service teacher is both the product of teacher education programs and a key stakeholder in the school system. Although this project intended to concentrate on teacher education courses, it is nevertheless informative to consider the opinions of a group of practising teachers. Reflections of a group on their experiences are presented below, based on a discussion held in Muswellbrook, NSW, on 7 September 2001. Teachers present came from state, Catholic and private schools in the region, thus being drawn from the three key providers of education. They included science and technology teachers, as well as a student teacher on practicum placement. Thus, the group represented, as much as practicable in a single small group, a reasonable representation of teachers who are seen as the products of teacher education investigated in this study.

5.4.2 Group discussion with Upper Hunter Region science teachers

The process
An informal discussion with eleven science teachers, one student teacher on practicum, and one technology teacher graduate of the two-year full-time BHP retraining program of the University of Newcastle who had a prior trade certificate. This group discussion was held during the Coal and Allied Science and Engineering Challenge Day run by the University of Newcastle at Muswellbrook for selected Years 9 and 10 students, at which the teachers were present. The led discussion occupied approximately 45 minutes.

Outcomes
A number of issues were addressed in the discussion, and key points are summarised below.

Teachers felt their professional teacher training was competent, reasonably interesting and of a good standard. In reflection, they were on balance generally satisfied with the efforts of their lecturers and their program of study.

However, there were a number of shortcomings noted. Those who followed the pattern of a science degree followed by a diploma of education felt some lack of practical focus in terms of their preparation. Lack of integration of their prior science degree with their training in the diploma was noted. It was not always clear
where the relevance of prior knowledge to teacher preparation lay, and linkages were not necessarily made. This is exemplified with one comment, which struck a chord with most teachers present:

We were trained to teach science, but really our job is to teach children.

There was general agreement that this view may reflect the recognition that training in a science degree has a natural focus for training for a workplace (dominantly industry and government scientific organisations), which is the major destination of science graduates. This workplace environment is markedly different from that met in secondary education.

All teachers felt that their initial training did not provide sufficient practical experience in developing ‘people management’ skills. More prior skills in dealing with students as people would have been valued; most felt they were not fully prepared for the realities of looking after around thirty individuals.

Some subjects at University were not seen as too relevant to the practical tasks of teaching in the classroom. Those mentioned were largely in the philosophy/psychology fields, rather than the more ‘practical’ ones. However, the need to learn about teaching, as distinct from how to teach, was recognised.

The methods of teaching and assessment they experienced as students were sometimes thought to be not relevant to the ‘real world’ of teaching. Courses taught only by formal lectures and examined solely by a number of essays were mentioned as one example where the linkage to practical teaching was not easily made, and where transfer of the knowledge was consequently not facile.

There was a concern, also, that their training was too heavily content-based. A commonly held view was that they needed to learn more about how to access information and knowledge rather than know a vast background of detail personally. This comment related as much to their scientific as to their education courses.

Most teachers, particularly those taking a diploma following a degree, considered that they had had too little practical teaching experience during their initial training. However, they nevertheless considered an overall four years of full-time training sufficient in length, and were not in favour of five years of training. Even if the additional training meant more practical experience being obtained, they felt the formal training demand would be excessive. For single parents and mature age students, there are personal costs, such as for additional child-care during practicum periods, that form part of the equation, and which should be considered. Additional in-service training was seen as preferable, with simply the need to get out and earn an income an important consideration.

Survival is a primary concern of the beginning teacher. The teachers suggested that it took them from one to three years to feel really comfortable and competent in taking classes. During this period, as one teacher suggested, you frequently ask yourself questions such as:

Am I really cut out to be a teacher?

The quality of the induction system and mentoring of new teachers in high schools is, from teachers’ responses, variable. Some felt they had a sufficient and effective introduction to teaching, including participation in a well-constructed induction program. Others were less well served, and it was suggested that it depended partly
on ‘luck’ in terms of placement, with larger city-based schools more likely to provide the sort of support initial teachers deserved. One teacher was sent for her initial placement to a western NSW school where she was the sole science teacher, with the next nearest science teacher ‘about 120 km away’. She found herself teaching a wide range of science and technology subjects; she even had to teach a group of farmers’ sons about tractors, made less formidable only, fortuitously, because her father had owned and worked with tractors.

Most felt that the first experiences as a teacher in a school are important, as they probably affect whether you stay as a teacher for a long time, or leave the service. The teachers saw teaching as much as a ‘calling’ as a profession. If you didn’t have a certain disposition towards teaching, you wouldn’t last.

Being required to teach beyond their skills and knowledge ‘comfort zone’ is a clear concern of teachers. The mature-entry teacher who spent the prior approximately fifteen years as a tradesperson with BHP in Newcastle before studying in a mixture of part- and full-time modes for his degree under the special retraining program operating at the University of Newcastle, exemplifies the problems. He initially envisaged teaching design and technology with a focus on his prior experience; in reality, he found himself teaching a wider spectrum of material. He has coped, and is able to boast of having ‘even looked after home economics classes’.

In considering what could best help commencing teachers following their initial training, there were a number of suggestions forthcoming, which had broad support:

- an initial paid semester of placement and mentored training in designated schools where an effective and fully-developed induction and mentoring program would operate;
- a reduced load for teachers commencing their first placement for a period, to allow them to reflect on their efforts and develop their teaching presentations;
- a greater use of country high schools for teaching practice during initial teacher training, to develop familiarity with the special problems and attractions of teaching outside the major cities.

Despite concerns expressed, the group was positive about their roles as teachers and intending to stay in teaching. They also saw their comments as constructive and focussed towards assisting the next generation of teachers. Their commitment to their chosen profession was clear.
6. Summary of initial teacher education programs

6.1 Introduction
The purpose of this chapter is to highlight the main features, issues and innovations of the teacher education programs surveyed in this project. The chapter summarises the information contained in the program descriptions (which are presented in Appendices D-G) and is divided into four main sections, which cover teacher education programs for primary (Ch. 6.2), secondary mathematics/science (Ch. 6.3), secondary technology (Ch. 6.4) and middle school/ P-12 (Ch. 6.5).

6.1.1 Identifying innovation
Within each of these sections (e.g. primary programs) the common practices are described, and any innovative practices are highlighted by naming individual programs. The two steps in the identification of innovative practice were as follows. Firstly, the programs were compared to identify the standard practices which most of them seemed to have in common. Secondly, any practices, which stood out from the rest because they seemed to offer an improvement that might potentially improve teaching and learning, were named as innovative. Thus, practices did not have to be new in order to be classified as innovative – instead, the emphasis was on the identification of interesting and potentially useful ideas which might inform future program development. Information about high quality practices, as described in the literature review (Chapter 4) was partly used to inform this process.

Thus, in each of the sections below, the programs that are named can be considered to be innovative and noteworthy, given the loose definition adopted for this project. However, it should be emphasised that a program does not have to be innovative in order to be high quality, and it is possible that some innovations will eventually be shown to be less effective than was first thought. The findings below should consequently be interpreted as simply providing a range of interesting ideas, which we believe should be considered when developing future teacher education programs. To aid this process, we have also described many of the reasons, issues and challenges which interviewees offered in explanation of their programs.

6.2 Primary teacher education programs
There were 39 program descriptions for primary teacher education, and these are presented in Appendix D. Each program description concentrates on one particular ‘focus program’ (which is usually a four-year undergraduate program at that institution), but information about the corresponding graduate programs is also
briefly presented (under ‘Other Programs’). Thus, each of the institutions involved in primary teacher education has an undergraduate program described, as well as a brief mention of their graduate programs. It should be emphasised that this is not a complete list of all the programs on offer, because many institutions have more than one campus, each with their own major and minor variations in programs.

6.2.1 Summary of findings

Most of the primary undergraduate programs were of the four-year Bachelor of Education type, although there were about half a dozen combined degree programs (spread across New South Wales, the Northern Territory and Victoria). The primary undergraduate programs were typically well-enrolled, with many having 100–200 students in each year.

There were also 18 two-year graduate programs and 10 one-year graduate programs identified (many institutions had an undergraduate program and a graduate program for primary teacher education). All the graduate programs in the Northern Territory, Queensland, South Australia and Tasmania were two-year, whereas the other states typically had some one-year and some two-year programs (except Western Australia, which had no two-year programs). Enrolments in the graduate programs were usually lower than in the undergraduate programs, with many having only 40–60 students.

Unless otherwise indicated, the information below refers only to the undergraduate focus programs (the graduate programs typically had no separate content studies for mathematics/science, and the students were often in the same classes as the undergraduates for their education subjects). The numbers in parentheses are the program description numbers as listed at the beginning of Appendix D.

Nature and level of content studies/articulation between content and pedagogy

The faculty delivering the content studies

In about one third of the undergraduate primary programs, all the subjects were Education offerings and there was no direct involvement of the science faculty. In these programs, Education staff delivered all of the content. However, in the other two thirds of the programs, the science faculty was directly involved in compulsory discipline subjects, or the offering of mathematics/science electives. In these cases, both faculties were therefore involved in the delivery of content, as the Education staff typically taught the curriculum methods subjects, which also contained significant amounts of content.

The types of subjects which contained discipline content

Discipline content was available to the students in a number of different types of offerings, including general science faculty electives, compulsory foundation subjects, compulsory curriculum method subjects and education faculty electives, as follows.
1. In almost half the programs, students were able to choose a sequence (e.g. a major or a minor or less) of general offerings of the science faculty. Interviewees stated that this approach gave the students a very strong background in the discipline, which would enable them to become science or mathematics specialists at primary level. However, the numbers of students choosing this option was relatively small, and interviewees reported that most primary education students preferred to choose non-science discipline areas. In a very small number of programs the electives were tailored for education students. For example, students in the Bachelor of Education – Primary at Edith Cowan University, were able to choose a series of mathematics discipline units in which they learnt how to make mathematics interesting by focusing on number tricks, mathematical puzzles and mathematics in magic (D38).

2. Almost one quarter of the programs included a compulsory science foundations subject which was specially designed for primary education students, but was a science faculty offering (e.g. D10, D19, D22). However, only about ten percent of the programs had mathematics foundation subjects of this type (none of the programs had technology subjects of this type). In some of these science subjects, the lectures/tutorials were shared between science staff and education staff (e.g. D11, D32, D39).

3. Almost half the programs had a compulsory foundations subject (for mathematics or science) which was an education offering. About one tenth of the programs also had technology foundation subjects of this type (this was a low proportion, but in the NSW programs, technology was typically combined with science). One example of innovation in this area was the ‘Hollywood Meets the Labcoat’ unit in the Bachelor of Primary Education at Monash University, in which students developed an interest in science by studying the science in popular movies (D33). A second example was the numeracy subject in the Bachelor of Education (Primary) at Charles Sturt University, in which students carried out a community-based investigation of mathematics in society (e.g. comparing costs in different supermarkets) which challenged their conceptions of mathematics (D4).

4. Almost one third of the programs offered education electives, which combined content and pedagogy (in science, mathematics or technology). Some innovative examples of these included:

- the suite of six technology electives in the Bachelor of Education (Junior Primary and Primary) at the University of South Australia, which allowed students to have up to 23 per cent of their studies in technology education (D27). This program is also described in Case Study 1 (Chapter 7).

- the ‘Environmental Education’ elective offered in the Bachelor of Education (Primary) at the University of New England, in which students go on an extended coach trip to northern and central Australia (D8); and

- the theme-based science and technology subjects in the Bachelor of Education in Primary Education at the University of Technology Sydney, which emphasised the relationship between different science disciplines (e.g. the human body unit incorporated biophysics aspects, D12).

Interviewees reported that these subjects were often quite popular with students. For example, the Year 4 science elective in the Bachelor of Education at the University of Tasmania, attracted about half the year group (D30), and more than half the
students in the Bachelor of Teaching/Bachelor of Education in Primary Education at the University of Wollongong, would typically enrol in at least one of the science and technology electives (D14).

5. Nearly all of the programs included at least one compulsory curriculum methods subject, which combined content and pedagogy. These were all Education offerings. An innovative example of this type was the technology education subject in the Bachelor of Education: Primary Teaching at the University of Canberra, which covered the design and pedagogy of a broad range of technologies, from computers to didgeridoos, and in which the students interviewed members of the general public about their views of technology (D2). Many programs however, had more than one curriculum method subject. The Bachelor of Teaching/Bachelor of Education at La Trobe University for example, had a compulsory science subject in each of the four years, and each subject focussed on different topics (e.g. kitchen chemistry, astronomy or sport) which served as vehicles for the method studies (D32).

Several interviewees reported that the curriculum methods were very ‘hands-on’ subjects in which students were highly engaged and actively involved (e.g. D6, D17, D26, D33, D34, D38). In addition, several interviewees emphasised that in these subjects, the lecturers modelled the teaching strategies that they were espousing, for example, by role-playing a primary classroom with the students. This enabled the students to reflect at a very high level because they could see the strategy working from a child’s point of view (e.g. D2, D4, D12, D33, D38).

In almost half of the programs, interviewees stated that attitude change in mathematics or science was a significant aim in these curriculum method subjects (because of the importance of this issue, it is addressed in a separate section, below). In addition, some programs had a well-defined philosophy towards their method subjects. For example, the Bachelor of Education (Primary) at the University of Melbourne emphasised pedagogical content knowledge, so their advanced subjects offered primary mathematics at an advanced level, rather than moving on to high school mathematics (D36). Similarly, in the Bachelor of Primary Education at Monash University, the science method subjects emphasised early childhood approaches and children’s natural curiosity and learning styles, rather than high school approaches to science (D33).

Attitude change in mathematics, science and technology

In just under half of the programs, interviewees stated that attitude change was an important priority. They stated that many students initially had fear and dislike of mathematics/science, and lacked confidence to teach it (they were concerned that after the students graduate, these negative attitudes might carry over into their classrooms, with disastrous consequences). Many of the interviewees claimed to have achieved success in attitude change, but interestingly, different people did it in different ways. Their techniques included constructivist/interactive approaches (e.g. D2, D19, D23, D35), using simple explanations of science concepts (e.g. D21), emphasising the fun and the challenge in the work (e.g. D22), adopting a social/cultural perspective for the subject (e.g. D33, D39), modelling of interesting and motivating teaching techniques (e.g. D6, D13, D35), enthusiasm of the lecturer (e.g. D35), working with children who were enjoying the subject (e.g. D36), and studying everyday experiences (e.g. D29). As an example, science attitude change in
The Bachelor of Education (Primary) at Central Queensland University, is described in Case Study 4 (Chapter 7).

The proportion of discipline content in the program

In order to gauge the proportion of mathematics, science and technology content in the programs, it was decided to include both content/discipline studies and curriculum method studies, as both of these types of subjects included discipline content. It was also decided to focus only on compulsory studies in these areas, rather than including electives, which many students may not take. On this basis, most of the programs had two, three or four semester-length mathematics subjects in their four-year programs (ie. the proportion of mathematics in the program was usually either 2/32 or 3/32, or 4/32). There was typically less science and technology, with most programs having either two or three subjects in these areas. The Bachelor of Education (Primary Education) at the University of Sydney was noteworthy because it had the relatively high proportion of four science and technology subjects (D11), and similarly, the Bachelor of Teaching/Bachelor of Education at LaTrobe University had one mathematics subject and one science subject in each year, including one subject which integrated mathematics and science (D32). Stand-alone technology subjects were however, much less common, being present in less than one-third of the programs.

The integration of teaching theory and practice

Two types of teaching practice were identified - the first was formal practicum and the second was school-based experiences associated with non-practicum subjects, as follows.

Formal practicum

The KBC Mentoring Program at the University of Wollongong was innovative because it did not contain block practica. Instead, the program operated in a school-based, problem-based mode in which students spent two days per week in schools for the whole program, and developed much of their knowledge of teaching and learning through a series of school-based problems (D15). This program is further described in Case Study 5 (Chapter 7).

The other programs typically contained block practica and dispersed days, which constituted the formal practicum. Over the four years of the undergraduate programs, there were typically 18-22 weeks of practicum. Three programs were distinguished by having exceptionally high amounts of formal practicum – the Bachelor of Education at RMITU had 38 weeks, of which a maximum of 26 weeks was in a primary school (D34), the Bachelor of Learning Management at Central Queensland University had 26 weeks of practicum (D20), and the Bachelor of Education (Primary) at the Gold Coast campus of Griffith University had 26 weeks of practicum (D21). In almost one third of the programs, the final practicum was extended and took the form of an internship, in which students taught up to a full teacher’s load.

Over half of the programs contained dispersed days (ie. a series of single days spread over several weeks) as well as blocks of practicum. The dispersed days were either intended to let the students carry out observations of classroom practice, to
provide students with continuity with a particular school and a particular classroom teacher and/or to provide lead-in days to a block practicum. These dispersed days were seen as helping to create links between theory and practice because each week, students had experiences in schools as well as experiences on campus. An alternative arrangement was that during each block practicum there were days when the students came back to university to discuss their experiences (e.g. D12, D23).

Some programs also created links between theory and practice by having each practicum focus on a particular learning area. For example, in the Bachelor of Teaching (Primary) at Northern Territory University, year 2 students taught a design and technology program which they had developed in their method subject (D17). Some other programs had similar links between method subjects and practica (e.g. D6, D8, D21, D27, D39).

Some programs reinforced the links between theory and practice by having a strong university presence in the school. For example, in the Bachelor of Education (Primary) at Murdoch University, a university staff member was present in the practicum school for the whole school day (D39, and Case Study 7 in Chapter 7) and in the Knowledge Building Community program at the University of Wollongong, university staff visited each school in the program every week of the semester (D15).

The Master of Teaching at Queensland University of Technology, was notable for combining many of the innovations described above into a two-year graduate program (D24).

One common problem with practicum was that, if held during university semester time, it clashed with students’ discipline studies in other faculties. There were several ways of dealing with this problem, including scheduling practicum blocks at the end of semester or during university vacations, spreading a one-week block over two weeks (or a 10-day block over three weeks) so students could attend university on their heavy days, encouraging students to enrol in distance education subjects for their discipline studies, restricting the students’ choices of discipline subjects to those which have night classes, and expecting students to negotiate missed work with their discipline lecturers and catch up in their own time. In the Bachelor of Education at the University of Tasmania, if discipline lecturers wished their subjects to be on the recommended list for discipline studies, then they had to be willing to negotiate to avoid clashes (D30).

The Bachelor of Teaching (Primary) at Northern Territory University, was notable for having a constructivist approach to practicum, in which students chose competencies on which to focus, and thus drove the learning process themselves (D17). This approach is described in Case Study 6 (Chapter 7).

Other field experiences

A number of programs also offered school-based experiences associated with non-practicum components. In about one-third of the programs, students were required to interview children in schools, make observations of classrooms, or tutor children (e.g. mathematics tutoring on a one-to-one basis) as part of their requirements for general education subjects or curriculum method subjects (e.g. D3, D11, D12, D38). In several programs, students were required to teach a sequence of science, mathematics or technology lessons to students (e.g. D7, D14, D19, D21, D31, D32,
D36) and interviewees stated that the advantages of doing this were that, it ensured that students had a genuine opportunity to teach science and technology (as many classroom teachers did not necessarily include it in their regular programs), it helped to create good pedagogical partnerships with schools, the school experiences helped to make the subjects popular with students, and it allowed students to practise innovative teaching strategies. In the Bachelor of Teaching (Primary)/Bachelor of Science at Deakin University, the mathematics and science method subjects were offered in school-based mode, in which workshops were held in schools and students worked with small groups of children to practise the techniques (D31).

**Differences in teacher preparation between different types of programs**

In addition to the undergraduate programs described above, most of the institutions also had one-year or two-year graduate programs. These programs typically had the same or similar mathematics and science education subjects as the undergraduate programs, but did not contain discipline subjects or electives. One issue raised by interviewees was that as these students had previous degrees, their content knowledge was assumed, but in mathematics, science and technology their content knowledge varied widely, and many students actually lacked knowledge and confidence in these subjects.

It should be noted that early childhood programs usually cover the infants years of primary school, as well as the pre-school years, and these programs are capable of offering high quality mathematics and science experiences. The Bachelor of Education – Early Childhood at the University of Western Sydney was included as one example (D13).

It should also be noted that students studying to be school counsellors at primary level had degree programs in which the mathematics and science content was often identical to the mainstream primary programs (e.g. D4, D21, D22).

It should also be noted that several institutions had indigenous teacher education programs, of which the Bachelor of Teaching (Anangu Education) at the University of South Australia (D28) and the Advanced Diploma of Teaching (Primary) at the Batchelor Institute (D16) were examples. These programs were interesting because they took the view that different cultures have different knowledge systems. Therefore, mathematics and science were treated as products of western culture, to be compared and contrasted with indigenous views of the world.

**The exposure of teacher education students to school projects and programs designed to improve student outcomes in their method area**

Students were involved in a variety of other school-related mathematics, science and technology programs, including Streamwatch (e.g. D5), Waterwatch (e.g. D35), the Science Talent Search (e.g. D36), the Oliphant Science Awards program (e.g. D27), the Mathematics Challenge (e.g. D20), an on-line mathematics club (e.g. D20), gifted and talented programs (e.g. D13) and the Greenhouse Lab (D21). In addition, students had active involvement with teacher education conferences and in-service programs (e.g. D30, D36), state teachers’ associations (e.g. D27) and the science and technology teachers’ journal (D7).
The links between the teacher education program and business/industry

About half the programs had links to the wider, non-school community. Most of these involved centres of ‘informal’ learning such as museums, science centres, environment centres, botanical gardens and field studies centres. Two of the programs contained other noteworthy examples of community involvement. In the ‘Conservation and Environmental Issues’ elective in the Bachelor of Primary Education at Monash University, students studied the urban environment by working with the city council on community-based development projects related to children’s issues (D33). In the ‘Cultural Mathematics’ unit in the Bachelor of Education (Primary) at Murdoch University, students learnt about mathematics in the real world by, for example, planning the viability of a home laundry business using real data which they had collected themselves (D39).

Other innovations

Innovative pedagogy

Several programs contained subjects that were noteworthy because of their integration of mathematics and science (e.g. D8, D27, D32, D34). As an example, the integrated mathematics/science units in the Bachelor of Education (Junior Primary and Primary) at the University of South Australia are described in Case Study 1 (Chapter 7).

Another noteworthy example was the Master of Teaching at Queensland University of Technology, which adopted a research-based approach to teacher education and created integrated, interdisciplinary learning area subjects (D24). Similarly, the Bachelor of Learning Management at Central Queensland University, adopted a modular approach to much of its educational content (D20).

However, interviewees also stated that the development and maintenance of integrated subjects was a difficult and time-consuming process because of the meetings and negotiations involved, and because many staff were traditionally most comfortable in their own discipline areas.

A small number of programs had also introduced a problem-based learning approach to mathematics/science/technology or other subjects (e.g. D22, D23, D34). The Master of Teaching at the University of Sydney (D11) and the KBC Mentoring Program at the University of Wollongong (D15) had, significantly, adopted a problem-based approach at program level (case studies 8 and 5 in Chapter 7).

Casual teaching staff

Interviewees in about one quarter of the programs raised the issue of casual staff, who were practising teachers, being involved in the program. Some thought that these casuals had a positive and innovative effect because they provided a direct link to schools and they used authentic examples from schools, so students reacted positively to them. However, the alternative viewpoint was that they made it more difficult for the institution to maintain links with schools because permanent staff
were not teaching the subjects in the program, it was difficult to get quality staff in a range of subjects, and it was difficult to train casual staff in innovative, student-centred approaches.

**Information technology**

Interviewees in about two thirds of the programs described how they had integrated information technology into particular subjects, or into the program generally (e.g. web-based materials, chat/discussion facilities, electronic journals and CD-ROMs). However, a small number of interviewees did express concerns about IT – mainly because it was expensive, it was difficult to ensure equality of access, pressure to include it contributed to an overcrowded curriculum, and how to make best/effective use of it was sometimes an issue. However, the Bachelor of Primary Education Studies at Charles Sturt University, was noteworthy in offering a continuum of on-line support to enhance its distance education offerings (D5).

**Intensive mode**

The Bachelor of Learning Management at Central Queensland University, introduced a trimester arrangement in which there was a six-week intensive semester in November/December each year, allowing the students to graduate in three years rather than four (D20). With some exceptions (e.g. D25) very few undergraduate programs had adopted this approach, but several of the two-year, graduate programs were offered in intensive mode over 18 months (e.g. D17, D19, D21, D27, D34). One stated drawback of the trimester arrangement was that it allowed the lecturers to have very little time off from teaching throughout the year.

**Challenges**

The most common challenge or difficulty described by interviewees was lack of funding and its associated effects. These effects included: pressure to reduce contact hours with students and to move towards mass lectures rather than tutorials; difficulties maintaining equipment and resources (e.g. specialised mathematics or science classrooms); reductions in staffing; and the funding of practicum (some programs had reduced their in-school component of field experience as a result). A related effect was high student numbers, which made it more difficult to work with individual students, more difficult to do hands-on activities and more difficult to introduce school-based experiences.

Many interviewees also described a lack of time for the presentation of their subject material, with the result that students may have been put under pressure trying to cover the work. This problem was exacerbated by the negative student attitudes towards mathematics, science and technology, and weak student knowledge in these areas, which argued a need for significant time to be spent on them.

Some interviewees also referred to community and political pressures to continually add new (worthwhile) components, such as computing and aboriginal studies, into programs, without dropping off any of the existing components, with the result that programs were becoming overcrowded.
Finally, several interviewees mentioned aspects of their relationships with schools, including the difficulties in bringing about change in teachers’ practices, the variability of science and technology in schools, and the great commitment needed to establish and maintain close links with schools.

### 6.3 Secondary mathematics/science teacher education programs

There were 44 program descriptions for secondary mathematics/science education, and these are presented in Appendix E. Each program description concentrates on one particular ‘focus program’, but information about other, related programs at the same institution is also briefly presented (under ‘Other Programs’). Twenty-three of the program descriptions had a focus on undergraduate programs, fourteen had a focus on one-year graduate programs, and five had a focus on two-year programs. Each of the institutions involved in secondary mathematics/science teacher education had at least one of their programs described, as well as a brief mention of other programs. It should be emphasised that this is not a complete list of all the programs on offer, because many institutions have more than one campus, each with their own major and minor variations in programs.

#### 6.3.1 Summary of findings

About half a dozen universities had no undergraduate programs for secondary mathematics/science teacher education (University of Wollongong, University of Adelaide, University of Tasmania, and several in Victoria). Most of the institutions, however, did have an undergraduate program, and most of these were of the dual degree type. However, eleven Bachelor degree programs were identified (scattered across all states except the Northern Territory and Tasmania) and interestingly, about half of these were currently being phased out. With only two exceptions, the undergraduate programs were of four years duration (one was four and a half years, at James Cook University; and one was five years, at University of Sydney).

All the institutions had graduate programs for secondary teaching, and these were of either one or two years. In Queensland and Tasmania, all the graduate programs were two-year; there were no two-year programs in the Northern Territory or Western Australia; and the other states had some one-year and some two-year programs.

In the information below, the numbers in parentheses are the program description numbers as listed in Appendix E.

#### Nature and level of content studies

This section refers only to the undergraduate programs, as none of the graduate programs contained explicit mathematics/science discipline studies.
Nature of the content studies

In all the undergraduate programs, the mathematics/science discipline content was delivered by the science faculty/school and these units were almost invariably general offerings of the standard B.Sc. or its equivalent. Interviewees were generally supportive of this arrangement because it provided a rigorous, professional science/mathematics discipline background (rather than a 'school science' background). However, several programs had tailored the content to more closely suit the needs of education students, by either compiling a list of recommended subjects for the education students (e.g. E16, E25) or by allowing the education students to modify their assignments to focus on the educational implications of the discipline content (e.g. E8, E40). There were very few discipline subjects in which the content itself was modified to suit the needs of education students. However, one notable example was the chemistry subject which linked scientific theories to typical secondary school experiments (which emphasised the use of everyday materials) in the Bachelor of Education at the University of Ballarat (E35).

The Bachelor of Arts (Education)/Bachelor of Science at Edith Cowan University (E40) was chosen for case study to highlight the characteristics of high quality discipline studies from the point of view of education students (Case Study 2 in Chapter 7).

Level of the content studies

The discipline studies typically consisted of a major (subjects to Year 3 level) and a minor (subjects to Year 2 level) in areas such as physics, mathematics, biology, chemistry and earth sciences. A small number of programs had two majors in these discipline areas (e.g. E21, E22, E25, E44) – in the Bachelor of Science and Bachelor of Education (Secondary) at the University of Southern Queensland, the pairs of discipline majors had been designed with some units common to both majors, to reduce the overall number of credit points needed (E25).

Articulation between content and pedagogy

Proportion of content studies compared to education studies

In about half the undergraduate programs, the discipline content was set at 50 per cent. In most of the other programs it was either slightly above or slightly below this level.

Timing of the content studies within the program

The typical pattern was for most of the science/mathematics content studies to be concentrated in the earlier years, and most of the education studies to be in the later years (in many programs, the final year was all education studies). However, most of the programs had some education subjects alongside the discipline content studies in the early years. Some interviewees stated that they liked the concurrent development of discipline studies and education studies because it allowed students to take a teaching focus into their content studies.
Cross-faculty links

Interviewees generally stated that they had established good links with the science faculty (or its equivalent). For example, science staff had input into such things as compiling lists of selected units, designing curriculum methods units, suggesting program modifications, and establishing status for students’ previous studies.

Education staff also had links to science staff through their own science higher degrees, their personal research, or through their use of laboratories located in the science buildings. The point was made that on campuses that used to be teacher education colleges, the science/mathematics staff often still had an interest in teacher education (E40). The programs at the University of Canberra were notable for their close links with the mathematics student resource centre, which included the sharing of mathematics tutors between the two schools (E3).

Curriculum method studies

The curriculum method studies represented one of the closest links between content and pedagogy, as these courses typically contained some content as well as pedagogy, and in many programs, they were the only classes in which the science/mathematics education students came together as a group. The following points refer to both graduate and undergraduate programs.

The common pattern was to have one or more curriculum method subjects which focussed on junior secondary science or mathematics (in some programs this was linked to their minor specialisation) and another subject which focussed on senior secondary subjects (their major specialisations). One approach, in classes where there were small numbers of students who had a range of senior specialisations (e.g. physics, biology, chemistry) was to teach them as one group, but let them do their assignments in their own discipline area.

In conjunction with the junior/senior focus, the curriculum method subjects covered topics such as the syllabus, lesson planning, programming, management, teaching strategies, safety and assessment. Several interviewees mentioned peer teaching sessions (which were videotaped) and innovative assessment tasks such as portfolios, peer assessment and self evaluation (e.g. E32, E39, E40). In almost half the programs, the method lecturers introduced and modelled innovative teaching strategies that represented constructivist, student-centred, hands-on and motivational approaches. Some examples of those mentioned were debate, role play, hands-on mathematics and science activities, problem solving, discrepant events, social discourse, use of technology, small group work, creative writing, drama, investigations and field studies visits.

In several programs, the curriculum methods studies were taught by casual staff who were practising teachers. Interviewees stated that this had a positive and innovative effect because they provided a direct link to schools, they often brought the students into their schools to work with their classes, and their input was relevant and credible to the students. However, one concern expressed was that some casual staff put less focus on broader issues such as constructivism.

Some particular innovations in these subjects included:

- Visits to primary schools were included in subjects at Deakin University and LaTrobe University (E30, E31). One advantage of these was to expose the students to the student-centred teaching skills of primary teachers.
Students in the Bachelor of Teaching (Secondary)/Bachelor of Science at Deakin University, interviewed senior science teachers about how they implemented units in the syllabus, then their combined reports were made available as an on-line resource (E30).

The Graduate Diploma in Education (Secondary) at the University of Melbourne had a high-quality school-based component, which allowed students to practise innovative strategies with small groups of children and do other activities in a series of different schools (E36).

In the Bachelor of Science/Bachelor of Teaching at the University of New England, there was a ‘compulsory optional extra’ series of activities on Friday of every week, in which students visited a series of schools and community sites to study laboratory safety, field studies sites, year 6 classes, vocational education, community links and other topics (E9).

In the Bachelor of Education (Specialisation) at the University of South Australia, there were six method subjects in each teaching specialisation, and students could tailor their own sequence of subjects according to their major and minor specialisations and interests (E28).

Several interviewees mentioned that cross fertilisation of ideas was encouraged by having graduates and undergraduates together in the methods classes, and by having the students mix with students from other specialisations in their general education subjects. This was particularly effective if there was close communication with the staff in the general education subjects, so teaching strategies were reinforced.

The integration of teaching theory and practice

The information in this section applies only to the focus programs. Two types of teaching practice were identified - the first was formal practicum and the second was school-based experiences associated with non-practicum subjects. These are treated separately, as follows.

Formal practicum

Most of the undergraduate programs included 16-20 weeks of practicum. The Bachelor of Teaching/Bachelor of Science at Charles Sturt University was notable in having 24 weeks of practicum (E6). The amount of practicum in each year generally tended to increase towards the end of the four-year program, and many programs had an internship in the fourth year.

Two-year, graduate programs also typically had 16-20 weeks of practicum, and the Bachelor of Teaching (7-12) at the University of Tasmania had 21 weeks (E29). One year, graduate programs typically had 8-10 weeks of practicum (the Graduate Diploma in Education at the University of Western Australia however, had 12 weeks; see E43).

The practica typically contained blocks and dispersed days. Dispersed days were commonly used as lead-up days to a block, or for students to carry out observations or tutoring in schools. In a small number of programs the students were placed in schools one day per week for a whole semester or longer (e.g. E2, E19).
Interviewees stated that these dispersed days gave students a consistent presence in the school, so they could form relationships, and integrate theory and practice on a weekly basis. Where the dispersed days occurred very early in the program, they also had the advantage of letting students see what schools were like, so if they decided they didn’t want to be teachers they could pull out of the program before the HECS due date.

In several programs the practicum component included observational days in primary schools, which allowed students to study transitional aspects or developmental stages (e.g. E6, E7, E13, E25, E31, E42, E44).

A small number of interviewees emphasised that the method lecturers did the practicum supervision, so there was a strong link between the methods subjects and practicum (e.g. E13).

One common problem with practicum was that, if held during university semester time, it clashed with students’ discipline studies in other faculties. There were several ways of dealing with this, including: scheduling practica during the university vacations; doing most of the practica in the later years when there were less or no discipline studies; spreading a one-week block over two weeks (or a 10-day block over three weeks) so students could attend university on their heavy days; expecting students to move their discipline subjects around to other times; encouraging students to enrol in distance education subjects; and expecting students to negotiate missed work with their discipline lecturers and catch up in their own time.

Some interesting innovations in teaching practice were:

- In the Master of Teaching at Queensland University of Technology, each practicum had a focus, such as ‘the role of the teacher’, ‘planning and management’, ‘inclusive curriculum’ or ‘decision-making’ (E23).

- In the Bachelor of Science + Bachelor of Education at Murdoch University, students had one teaching block for their major specialisation and another for their minor, and supervisors were located on-site in schools for the duration of the practicum (E42). This approach is further described in Case Study 7 (Chapter 7).

- In three programs, the students were actively encouraged to do practica in rural schools (E6, E36, E44) and in the Graduate Diploma in Education at the University of Adelaide, there was a cooperative arrangement with the Department of Education and Training, to give students experience in rural towns (E27).

- In the Bachelor of Science/Bachelor of Teaching at Northern Territory University, there were no stipulated dates set for practica, instead, students could choose to do their block practica at any mutually agreeable time after semester 3 (E16).

Other field experiences

A number of programs also offered school-based experiences associated with non-practicum components. In about one quarter of the programs, students were required to carry out observations and interviews in schools as requirements for other education subjects. Alternatively, they were required to work as teacher aides.
Clever Teachers, Clever Sciences

(e.g. E38) or to teach mini units in schools (e.g. E17). Some innovative examples of this type were:

- In the *Graduate Diploma in Education* at the University of Western Australia, mathematics students spent one hour each week at a local school, assisting in the classroom (E43).

- In the *Bachelor of Science/Bachelor of Education* at Monash University, students had a three-day residential camp in which they taught Year 7 students (E32).

- At Flinders University, a secondary school will soon be built on campus, which will facilitate links to the *Bachelor of Education: Secondary Science* program (E26).

### Differences in teacher preparation between different types of programs

The main types of programs offered were four-year undergraduate programs and one-year or two-year graduate programs. In institutions that offered both graduate and undergraduate programs, interviewees almost invariably stated that the education components of the two programs were very similar if not identical. Graduates were, for example, typically in the same methods classes as the undergraduates, and the students complemented each other.

However, there were two stated disadvantages to the one-year programs. Firstly, it has already been noted above that students in one-year programs had considerably less teaching practice than those in the two-year and undergraduate programs. Secondly, several interviewees expressed concerns that one year was a very short time for students to read and reflect about teaching, to develop confidence in their teaching, and to develop a strong personal belief structure about teaching.

There were also some concerns about the previous discipline studies of graduate students in general. It was noted that the nature of their discipline studies varied widely, and although they often had good knowledge in specific areas, they usually did not have a good grounding in the full range of the sciences (e.g. engineering majors were lacking studies in biology). For this reason, the University of Canberra had introduced a self-paced bridging program in mathematics (E3) but other interviewees suggested that, especially in two-year programs, some time should be found for discipline studies in students’ areas of need. On the other hand, some interviewees noted that many of the graduate students were high quality students, some with honours and higher degrees, and that their previous experience in industry would probably strengthen their teaching. One interviewee stated that after they began teaching, there were few apparent differences between those who had been graduate students and those who had been undergraduates.

There were also some trends observed in student enrolments in different types of programs (it should be emphasised that this study was not intended to provide accurate enrolment figures - interviewees were only asked to estimate student numbers). Firstly, although 24 of the institutions had introduced double degree programs, they were, on the whole, poorly enrolled, with student numbers in each year typically less than ten. To provide a comparison, 10 institutions were identified in which there was a double degree program and an equivalent one-year graduate program (and for which student numbers had been provided). In these institutions,
the one-year programs had higher enrolments in all but two cases (in these two cases the numbers in both programs were similar). For example, at Charles Sturt University there were 11 students in one year in the double degree, and about 100 in the one-year graduate program (E5, E6). Secondly, in states where students had a choice between one-year and two-year programs, many of the latter attracted very low numbers of students (however, there were some significant exceptions to this, at the University of New England (E9), the University of South Australia (E28) and the University of Sydney (E12)).

As described under ‘Challenges’ (below) a common concern amongst interviewees was the low numbers of students in all types of secondary mathematics and science education programs and the associated teacher shortage in these areas. We therefore included as examples, information about two mathematics retraining programs that, although they were not designed for initial teacher education, may play a role in inducting teachers into these critical areas. The first was the Graduate Certificate in Middle School Mathematics at the Australian Catholic University, which contained mathematics discipline content and pedagogy, and was intended for people who were already teaching mathematics but did not have mathematics qualifications (E1). The second was the Graduate Certificate in Mathematics Teaching at Murdoch University, which contained general mathematics offerings, and was mainly intended for practising teachers who intended to move into mathematics teaching but had not yet done so (E42).

It should be noted that at many institutions, a significant proportion of the students in the junior method classes were only doing mathematics or science as a minor, and their major was often physical education (e.g. E17, E30, E35, E37). One comment was that, as the major interest of these students was in PE or other areas, their commitment to becoming science teachers was questionable.

It should also be noted that at several institutions the mainstream B.Sc. undergraduates were able to have valuable experiences in schools through programs such as the Peer Tutor program at RMITU (33) and the STAR program at Murdoch University (E41). These programs provided enriching experiences for the students, and close links to education personnel both at the university and in schools.

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**Skilling teacher education students in practices to develop literacy and numeracy in school students in relation to these content areas**

Literacy and numeracy were included in nearly all of the programs, and were often located either in the general education subjects and/or the curriculum method subjects. In about one quarter of programs there was a separate subject for literacy/numeracy. For example, in the Bachelor of Teaching (Secondary)/Bachelor of Science at Deakin University, there were two cross-discipline courses in which students investigated and reported on literacy and numeracy in schools and the community (E30). One of these courses is described in Case Study 10 (Chapter 7). In several programs, the nature of mathematical numeracy was emphasised in the method classes (e.g. E20, E42).

A compilation of literacy and numeracy experiences from various programs includes: why literacy needs to be taught (E4); study of language difficulties (E37); study of the relevant documentation (E14); writing lesson plans and units of work.
that incorporate strategies from the literacy/numeracy documents and outcomes (E14, E38); reading processes (E24); close exercises (E24); how to teach writing and listening skills (E10, E24); technological literacy (E24, E35); presentation skills (E10); reading in science (E35); the study of work samples and assessment criteria for literacy assessment tasks (E27); creative writing (E31); creative ways of getting students to understand and apply information in texts (E1, E2, E30); and in-school workshops on mathematics and science literacy (E5).

The Bachelor of Teaching (7-12) at the University of Tasmania, was notable because students were required to tutor children on literacy and numeracy problems, and develop literacy/numeracy packages based on recent newspaper articles (E29). Their use of newspaper articles to provide numeracy experiences is described in Case Study 11 (Chapter 7).

**The exposure of teacher education students to school projects and programs designed to improve student outcomes in their method area**

Students were involved in a variety of school-related mathematics and science programs. These include: the Siemens Science School (e.g. E37); the Australian Mathematics Challenge (e.g. E18, E36); the Science Talent Search (e.g. E36); Australian Science in Schools Week (e.g. E36); the Mathematics Talent Quest (e.g. E1); Waterwatch (e.g. E29); gifted education programs (e.g. E36) and mathematics and science clubs (e.g. E18, E24). In addition, students also had involvement with professional associations (e.g. E1, E26, E34, E39), curriculum bodies (e.g. E26, E28, E34, E38) and conferences (e.g. E36). In the Bachelor of Teaching (7-12) at the University of Tasmania, students were involved in a Landcare project which had links to the science faculty and schools, and which involved in rich tasks, such as press releases and a professional development portfolio (E29). This project is further described in Case Study 12 (Chapter 7).

**The links between the teacher education program and business/industry**

Interviewees in almost half the programs described links to the wider, non-school community. Most of these involved centres of ‘informal’ learning such as museums, science centres, wildlife sanctuaries, zoos, aquariums, field studies centres and national parks. Students either visited these sites to study their educational facilities, or worked as volunteer education officers in them (this was especially common in Queensland programs, in which 20 of the 100 days of field experience may be spent in non-school settings). Interviewees stated that these experiences, helped to give students a broader view of science education, enabled them to work with different age groups of learners, and enabled them to become aware of the potential of different locations for teaching mathematics/science, and how to use them as teaching resources.

In some programs, students had experiences in professional scientific sites such as laboratories (e.g. E6, E25), mines (e.g. E9) and science-related industry (e.g. E32). These, however, were not common.

Two of the programs contained other noteworthy examples of community involvement. Students in the Graduate Diploma in Education at the University of
Adelaide did projects on mathematics in the workplace or mathematics in sport and recreation, in which they contact a local business and reported on their everyday business applications of mathematics (E27). Students in the Bachelor of Education – Secondary at James Cook University presented their ideas on how to use graphics calculators in lessons, and the makers of the graphics calculators then sponsored some of them to attend state conferences (E20).

Other innovations
Interviewees in about half of the programs described how they had integrated information technology into particular subjects, or into the program generally (e.g. web-based materials, chat/discussion facilities, electronic journals and CD-ROMs). For example, mathematics students in the Graduate Diploma of Education – Secondary at the University of Western Sydney, had website support covering mathematics issues and discussion groups, as well as access to the virtual conference held annually by the professional association (E14). The programs at Charles Sturt University had a strong on-line profile, including articulation with HSC On-Line and the development of competencies with audiographic telecommunications packages (E5, E6).

Challenges
The most common difficulty described by interviewees was lack of funding. The effects of lack of funding included pressure to reduce contact hours with students and to move towards mass lectures rather than tutorials, difficulties obtaining resources such as classroom materials, library books, and modern equipment such as data loggers, lack of permanent staff (who were needed to establish ongoing relationships with schools), and lack of funding for school placements (so the amount of teaching practice was less than ideal).

Another challenge mentioned was the difficulty in changing the students’ views of teaching and learning. For example, many of the science and mathematics students had been taught by ‘chalk and talk’, rote learning, transmission approaches when they were at school, so they needed to develop a more student-centred and motivational view of teaching. A related problem was the difficulty in identifying high quality teachers who used innovative strategies in their classes, and placing the students with them for teaching practice (many practicum teachers were still using transmission approaches, which conflicted with what the students had been taught at university).

A further issue was lack of students in the programs. Interviewees commented that not many people were interested in teaching mathematics or science, so attracting talented, flexible students into the program was a challenge. One commented that, although there were numbers of talented mathematics graduates who were immigrants from Asia and Eastern Europe, these people often struggled with the culture in Australian schools.

Having the students’ content studies in another faculty created some timetabling problems (especially with regard to the timing of practicum blocks) and communication difficulties. Lack of control over the discipline content, and the time given to discipline content were also raised as issues.
6.4 Secondary technology teacher education programs

There were 14 program descriptions for secondary technology education, and these are presented in Appendix F. Each program description concentrates on one particular ‘focus program’, but information about other, related programs at the same institution is also briefly presented (under ‘Other Programs’).

6.4.1 Summary of findings

Only 14 institutions were involved in secondary technology teacher education (these are listed in Appendix F), and half of these were located in NSW. Nine of the institutions had an undergraduate program (but there were no undergraduate technology programs in South Australia, Tasmania or Victoria). All the undergraduate programs were four-year Bachelor degrees, with the exception of the double degree program at the University of Newcastle. These programs typically had enrolments of up to twenty in each year. Most of the programs were less than five years old.

Eleven of the institutions had graduate programs for technology – seven one-year programs and five two-year programs were identified. These programs typically had less than twenty students.

In the sections below, the numbers in parentheses refer to the program descriptions as listed in Appendix F.

Nature and level of content studies

Most of the undergraduate programs had their content studies in non-Education faculties/schools, such as Engineering, Surveying, IT and Multimedia, Naturopathy, Engineering, Design, Science and also TAFE. In some cases these providers had developed subjects specifically for these students (e.g. F5), but usually they were a selected sequence of general offerings. One interviewee commented that the students’ involvement with these other faculties was beneficial because it gave them a broad university perspective. On the other hand, two programs had all or nearly all of their discipline content delivered within Education (F9, F14) and explained that as this was a specialised degree, there was no specific faculty for the discipline studies, so the Education faculty still offered them.

In nearly all of the programs, the discipline studies comprised a design core (or design and technology major) and either one or two specialisations to be chosen from areas such as agriculture, food technology, industrial technology, engineering studies, textiles and design, and information technology. For example, in the Bachelor of Education (Technology and Applied Studies) at Charles Sturt University, students had core studies in computing, materials, design and marketing, then chose a major and a minor from agriculture, computing, food technology, industrial arts and textiles (F3).

Students in the graduate programs had previous qualifications in a wide range of discipline areas. These included degrees in areas such as food technology, design, information technology, media and agriculture. Industry credentials such as a trade certificate and several years of industrial experience (e.g. in carpentry, building, or
automotive) were also accepted in several programs. The Bachelor of Education (Further Education and Training) at the University of Southern Queensland, was a four-year undergraduate program which only accepted students with industry experience. In this program, each student had an individualised course of study designed for them, which built on their past qualifications and experience (F10).

Some of the graduate programs were unusual in that they included some discipline content, particularly in workshop skills (e.g. F13, F14). In the Bachelor of Education (7-12) at the University of Tasmania, technology students who did not have a prior degree did a one-year full-time bridging course which covered woodwork, metalwork, technical drawing, design, photography, automotive technology, computing, food and textiles, which was completed as a prerequisite (F12).

**Articulation between content studies and pedagogical studies**

Interviewees stated that the development of the technology programs had involved a lot of cross-faculty consultation. This had occurred through the development of special subjects and/or through providing supervision in workshops or on projects (e.g. F7). However, the tailoring of subjects to education students was not always seen as desirable, because students were expected to become educated to a professional level rather than a school level (F4). However, in the Bachelor of Technology Education at Griffith University, the content studies were Education offerings. This made it possible to integrate content and pedagogy, and lecturers modelled the types of teaching behaviours they wanted the students to adopt in schools (F9).

The Graduate Diploma in Technology Education at LaTrobe University, had noteworthy links between the TAFE components and the university components. Students with a trade background were able to start their program at the TAFE, so they were in a more familiar environment and could build their confidence for their university studies (F13).

The Bachelor of Technology Education at Southern Cross University, had a strong philosophical approach, which combined innovation, research and foresight through integrating science, technology and design (F4).

All the programs contained at least two curriculum method subjects, which were Education offerings. These subjects provided a close articulation between discipline and pedagogy because they focussed on the transfer of discipline knowledge into classroom situations. In some programs there were one or more subjects for the junior syllabus and others for the senior syllabus in each technology specialisation, but in other programs there was a more generic focus such as planning, programming and assessment. Several programs had introductory units which focussed on the nature of technology, the technology workplace or an overview of the range of disciplines in technology (e.g. F9, F12, F14). For example, in the Bachelor of Education (Specialisation) at the University of South Australia, technology students had an introductory subject which aimed at dispelling stereotypes of what technology and technology education are, then five other curriculum method subjects, some of which had a theoretical focus and others having a practical focus (F11). The Bachelor of Teaching/Bachelor of Design and Technology at Newcastle was noteworthy for the quality of the school experiences which were a component of
the curriculum method subjects – these experiences involved observations, team teaching and mentoring senior students in Technology and Applied Studies (F5).

The integration of teaching theory and practice
Arrangements for practicum were not unlike those for the secondary mathematics/science programs. Undergraduate technology programs typically had up to 20 weeks of practicum, which often included both dispersed days and blocks. In some programs, students also had school experiences in their other education subjects. Some interesting innovations included:

- In the Graduate Diploma in Technology Education at LaTrobe University, practicum was in four small blocks over the two years, so students could build their teaching skills steadily, and the timing of these blocks was by individual arrangement with each student, because of their work commitments (F13).

- In the Bachelor of Education: Secondary Teaching (Design and Technology) at the University of Canberra, students had a one-hour professional experience tutorial each week, which often involved guest lectures by teachers and visits to schools to observe teaching models (F2).

- The internship in the Bachelor of Education – Secondary at Edith Cowan University was noteworthy because the better students were placed in schools in which there were vacancies in design and technology, and were in paid employment for six months as they completed their internship, research project and professional diary (F14).

Skilling teacher education students in practices to develop literacy and numeracy in school students in relation to these content areas
Arrangements for literacy and numeracy were not unlike those for the other secondary programs (ie. literacy and numeracy were covered either in special subjects, or in curriculum method subjects, or in other general education subjects).

The exposure of teacher education students to school projects and programs designed to improve student outcomes in their method area
Interviewees did not mention any specific school programs that related to technology.

The links between the teacher education program and business/industry
There were industry placement components in several of the programs (e.g. F2, F3, F4, F8, F9, F10). These varied from one to six weeks in duration and involved observations and work in, for example, the hospitality industry, manufacturing industry, construction industry or the computing industry. These experiences were commonly associated with the TAFE or VET component of the programs.
Some programs also had innovative design projects which involved industry links. For example, in the Bachelor of Technology Education at Griffith University, students contacted an industry or community organisation and constructed a project for them, such as designing and making facilities for the disabled (F9). Similarly, in the Bachelor of Education – Secondary at Edith Cowan University, technology students were involved in designing and making furniture for a local primary school (F14).

The BHP retraining program at Newcastle was a different type of link in which BHP workers were retrained as technology teachers under a Recognition of Prior Learning (RPL) agreement (Case Study 13 in Chapter 7).

Challenges
The interviewees for the technology programs typically described how technology education had moved away from traditional approaches that were based around specific content areas like woodwork and metalwork, and skills acquisition for a specific vocational niche (although several of the programs did have a strong vocational education component alongside the technology component). However, the interviewees also described a number of problems that they had experienced as a result of this change.

Firstly, there was some controversy about what technology education programs should and should not contain. This had created disagreement between program developers and government accreditation agencies. This schism also extended to students and schools - some students were coming into the programs wanting to teach woodwork or textiles and had not realised that technology education now has a much different emphasis. Similarly, school personnel sometimes asked technology students to teach woodwork and metalwork during practicum, even though these components were not in the students’ previous degrees.

Secondly, there is a huge range of potential specialisations in technology (from agriculture to engineering). This meant that there was no directly applicable discipline degree, so it was often difficult for students to identify entry pathways into the profession. Some interviewees felt that potential graduate students may therefore have been lost to the profession because they may not have realised that they had an appropriate qualification. It also meant that it was difficult for teacher education programs to cover all the specialisations. The question of how many options to give the students, and what depth of content to give them, was an important issue for the program developers.

Thirdly, some of the graduate programs admitted students with industry credentials and experience rather than university degrees. These students did not have a very academic background, and sometimes struggled with university level assessment tasks, so they needed additional classes in academic writing skills (e.g. F13). Conversely, those students who came into the programs with degrees in (say) media, architecture or engineering were often lacking the workshop skills in woodwork or metalwork which they may need in schools.

Fourthly, it was not uncommon for students in these programs to be studying in one or even two other faculties (or TAFE) apart from Education. Giving these students a sense of belonging to each institution/faculty and avoiding timetabling clashes between them were also raised as issues.
Lastly, this is a new area in schools, and some interviewees mentioned problems in getting suitably qualified, full-time staff to be involved in the programs (although others were happy using casual staff who were full-time teachers) and finding appropriate sites for practicum experiences.

6.5 Middle school and P-12 teacher education programs

There were five program descriptions for programs in which all graduates would be qualified to teach in middle schools, or in both primary and secondary schools. They are presented in Appendix G. Each program description concentrates on one particular ‘focus program’, but information about other, related programs at the same institution is also briefly presented (under ‘Other Programs’). Three institutions offered programs for middle school teacher education (University of Queensland, Flinders University and the University of Tasmania). These comprised two undergraduate programs and two graduate programs. The P-12 programs (one graduate program and one undergraduate program) were located at Deakin University and Victoria University.

In the information below, the numbers in parentheses refer to the program descriptions as listed in Appendix G.

6.5.1 Summary of findings

Nature and level of content studies undertaken

Students in these programs were able to choose to specialise in secondary mathematics, science or other secondary learning areas. For the mathematics or science specialisations, the graduate programs required some science or mathematics in the previous degree. The undergraduate programs contained science/mathematics studies, which were general offerings of the science faculty up to either Year 2 or Year 3 level (they varied considerably). In two of the undergraduate programs students also did primary discipline subjects in mathematics/science, which were Education offerings (G2, G5). The Bachelor of Behavioural Studies/Education (Middle Years of Schooling) at the University of Queensland was notable in that the primary discipline studies were fully integrated with the education studies, through the use of rich tasks (G1). This program is further described in Case Study 3 (Chapter 7).

Articulation between content studies and pedagogical studies in the preparation of these teachers

The programs typically had separate curriculum methods studies for the primary mathematics, primary science and secondary specialisation(s). These subjects were often the same or similar to those for the mainstream primary and mainstream secondary students. For example, in the Bachelor of Teaching (Primary and Secondary) at Deakin University (G4), students did one primary science education subject, two primary mathematics education subjects and four secondary curriculum studies.
(one for each of their majors and minors at junior and senior level). Some of these subjects were offered in school-based mode, in which students worked with small groups of children every week.

**The integration of teaching theory and practice**

The programs typically had 18-22 weeks of teaching practice. In the Bachelor of Education - Four Year Preservice (P-12) at Victoria University, students had 26 weeks of practicum, which included components in both primary and secondary schools (G5). In this program, students spent every Tuesday of every week in schools, and also had short blocks of teaching practice in each year (the program was linked to 160 schools each week, and staff members were allocated to schools to create working partnerships).

**Other terms of reference**

Students in these programs were typically doing some of the same subjects as the mainstream primary or secondary students. Consequently, there were no new science/mathematics/technology innovations with respect to literacy and numeracy, school projects, or links to the wider community, which have not already been mentioned with reference to other programs. For example, interviewees mentioned activities involving newspaper links, tutoring in literacy, experiences in museums, zoos and other community education programs, and the Siemens Science Festival.

**Other comments by interviewees**

There were favourable comments about the quality of the students in the middle school programs. One interviewee noted that the program attracted students who were forward-looking, adventurous in their thinking, and amenable to new ideas (G3). Another described anecdotal observations that their classroom practice was of high quality after completing their method studies (G2). It was also noted that those graduates who went on to teach in secondary schools would have a solid background in the student-centred approaches used at primary level.

Another stated advantage of these programs was that they would help ease the critical shortage of mathematics teachers in schools by freeing-up the teachers with full mathematics qualifications to teach at senior levels of high school.

However, it was also mentioned that not many students were choosing the science/mathematics specialisations in middle school programs. One reason given was that there is not a good career path for teachers who are restricted to the middle school years, even though these are critical, formative years in children's development.
7. Case studies

7.1 Introduction

The purpose of the case studies in this chapter was to provide more detailed description of selected innovative programs, as well as to provide enriching and corroborating input from students and teachers involved in the selected programs during 2001.

The case studies also provide more detailed snapshots of contemporary approaches to program development in Australia. This detail may better inform those embarking on the development of new programs, or those involved in the review of existing programs.

7.1.1 Selection of case studies

In Chapter 6 it was found that most of the teacher education programs did contain innovative aspects worthy of closer study. The selection of a small number of programs for case studies was therefore a difficult process, and in the end more programs than initially planned were included.

The final list of 13 case studies was decided upon after consultation between the project directors and the project advisors (internal and external) and after reference to the submissions from professional bodies and deans. The case studies are listed below under the project terms of reference.

Nature and level of content studies

Case Study 1. The Bachelor of Education (Junior Primary and Primary) at the University of South Australia, with a focus on its strong technology content and integrated mathematics/science units for primary education students.

Case Study 2. The Bachelor of Arts (Education)/Bachelor of Science at Edith Cowan University, with a focus on its science discipline studies, which include subjects in which secondary education students are allowed to modify their assignments to focus on the educational implications.

Articulation between content studies and pedagogical studies

Case Study 3. The Bachelor of Behavioural Studies/Education (Middle Years of Schooling) at the University of Queensland, with a focus on the integration of content and pedagogy through the use of rich tasks.

Case Study 4. The Bachelor of Education (Primary) at Central Queensland University, as an example of attitude change in a primary science content/methods unit.
The integration of teaching theory and practice

*Case Study 5.* The Knowledge Building Community (KBC) program at the University of Wollongong, with a focus on its school-based, problem-based approach to primary teacher education.

*Case Study 6.* The Bachelor of Teaching (Primary) at Northern Territory University, with a focus on its constructivist approach to practicum.

*Case Study 7.* The Bachelor of Science/Bachelor of Education (Secondary) at Murdoch University, with a focus on its school experience program with school-based supervision.

Differences in teacher preparation between different types of programs

*Case Study 8.* The Master of Teaching at the University of Sydney, with a focus on its problem-based approach in an end-on masters degree for secondary education.

*Case Study 9.* The Peer Tutor Program at the Royal Melbourne Institute of Technology University, as an example of a non-Education course which has links to schools.

Skilling teacher education students in practices to develop literacy and numeracy in school students in relation to these content areas

*Case Study 10.* The Bachelor of Teaching (Secondary)/Bachelor of Science at Deakin University, with a focus on its ‘Numeracy across the Curriculum’ unit.

*Case Study 11.* The Bachelor of Teaching (7-12) at the University of Tasmania, with a focus on its literacy and numeracy tasks linked to a newspaper website.

The exposure of teacher education students to school projects and programs designed to improve student outcomes in their method area

*Case Study 12.* The Bachelor of Teaching (7-12) at the University of Tasmania, with a focus on its Landcare project involving inter-faculty links and rich tasks.

The links between the teacher education program and business/industry

*Case Study 13.* The Bachelor of Education (Design and Technology) at the University of Newcastle, with a focus on the retraining of BHP employees.
7.2 Case studies on the nature and level of content studies

7.2.1 Case study 1

**MATHEMATICS, SCIENCE AND TECHNOLOGY STUDIES IN THE BACHELOR OF EDUCATION (JUNIOR PRIMARY AND PRIMARY) AT THE UNDERDALE CAMPUS OF THE UNIVERSITY OF SOUTH AUSTRALIA**

**Rationale**

This program was selected for case study because of its innovative content studies. The original telephone interviews indicated that the Bachelor of Education program at the Underdale Campus of the University of South Australia had two aspects of interest (Appendix D, Program D27). Firstly, the program contained a suite of 7 technology subjects, which would allow graduates an option to become technology specialists in primary schools. Secondly, the program contained a core sequence of four mathematics and science education courses, which modelled how to integrate these two content areas. Factors contributing to the selection of this program were: firstly, primary technology had been identified as an area of need by professional bodies (Ch. 5.3.2) and in the research literature (Ch. 4.3); and secondly, interdisciplinary units and integrated approaches had been recommended in deans’ responses (Ch. 5.2.2) and in the research literature (Ch. 4.3).

One part of this case study focuses on the technology education component and the other focuses on the integrated mathematics/science component. Our thanks to Denise MacGregor (the lecturer in technology education) and her students, whose descriptions of the technology component are paraphrased below. Our thanks also to Mike Chartres, Kathy Paige and David Lloyd (lecturers in mathematics/science education) and their first year students, whose descriptions of the mathematics/science units are presented in the second section.

**1) The technology component**

Technology in primary schools

Technology education is about engaging students in developing creative and innovative solutions to problems, using a range of materials and using their thinking skills.

In South Australia, the primary syllabus is concerned with ‘What is technology?’ as well as the technologies of fabric, information and communications, materials technology (including hard and soft materials) and cooking. The syllabus emphasises both materials and processes, so the learning that occurs through the process, as well as the outcome itself, are valued. The new framework also has an element of critique, which involves looking at the global impact of technologies.
Children may be given a focused practical task to enable them to develop a particular skill (e.g. using a hot glue gun) then this skill is used to address a more open-ended brief. This would typically have just a few constraints in it, and the children would produce a multitude of outcomes. This is in contrast to traditional craft activities, in which children are given a template to work from. Some good examples of design briefs are as follows:

- At one school, children were concerned with the amount of rubbish around the edges of a local lake. With their teacher they designed garbage bins, which were then sent to the council. The council implemented some of the designs and placed bins around that area.

- A group of year 6/7 girls designed a BMX track. They made a plan and a three-dimensional model, and pointed out some constraints. These were submitted to council and a BMX track was the outcome.

- One teacher took her students every week to visit senior citizens in an aged care home, and she decided to make something that they could remember the visits through. The kids decided on a theme of 'memories'. They asked the older people about their special memories, and they made a quilt to represent them. They designed the patterns for the quilt, and used the skills of stitching and fabric technology. The quilt was presented to the home.

- Our students have worked with children in schools to design and make such things as puppets using a range of materials (infants), a launching pad for a bottle rocket, kites, water filters and shows rides.

Description of the technology education subjects

Each of the following subjects is a one-semester offering. The first subject is compulsory for all students, but the others are taken as a suite of subjects, by students who wish to specialize in technology education. They are taken sequentially, so they build on previous knowledge.

‘Technology and the Arts’ is the core subject, which gives students a broad range of ideas about what they can do in schools, to engage students in technology. It is intended to give all students the confidence to teach this subject in schools.

‘Imagineering – Creative Construction’ is a first year subject, which focuses on being creative in construction. It covers basic safety, joining techniques, storybook stimulus (e.g. if the children are reading ‘The Three Little Pigs’ they could design a house that would not be knocked over; or if they were reading ‘The Three Billy Goats Gruff’ they could design a way to get the goats across the stream without waking the troll). The students also make a D&T website. The software ‘Inspiration’ is used to map concepts in the design process.

‘Materials for Design, Make and Appraise’ is a first year subject (semester two) which involves design, make and appraise activities involving a wide range of materials (including wood, metal and plastic). Students also work with industries such as ‘That’s Not Garbage’ to produce advertising, which goes on their web page.

‘Technology and Us’ is a second year subject which focuses on technology from a range of perspectives, including culture, society and environment. Students study the use of technology by traditional aboriginal cultures (e.g. the building of shelters, or hunting technology) though interaction with the museum and the aboriginal
adult college. Students study resources used in aboriginal education and are required to develop a unit of work. Each unit of work is sent to the aboriginal education unit, which must certify it before it will be used in schools. The students also work with two special schools to develop teaching aids to support the learning of children with disabilities. In this process, the special children come to the campus and work with the students. The final products are taken to the school and presented (e.g. sensory teaching aids such as a puzzle in a frame, or games with lights and buzzers).

‘Information Highways’ is a third year subject, which focuses on ICT. Students create a newsletter using desktop publishing software, then transfer it onto a web page. They use ‘Appleworks’ to produce paintings and drawings, and ‘Photoshop’ to produce a magazine cover which integrates two pictures together (using scanners and digital cameras). For each software program, the students cover the fundamental skills as well as the educational uses. For example, they use ‘Powerpoint’ to make a presentation, ‘Flash’ to develop an animated storybook, and ‘Imovie’ to make a short drama which they script and edit themselves. The students also visit schools to see what children are doing with software products, and develop a unit of work that incorporates ICT and the reasons for doing so. At the end of the semester, the students’ products become part of a design portfolio, which they link to a website. Groups of students also transfer educational materials into on-line format for children in remote locations.

‘Technology through Invention’ and ‘Technology by Design’ are fourth year subjects which focus on curriculum and programming. They include an in-school component, in which students teach technology to all the classes in a school for a period of five weeks. At the end of the five weeks the students hold a mini expo which is intended to advertise technology in the wider community. For example, students have held displays of children’s work in shopping centers, or in school halls, with student explainers present. The intention is to inform the community of what technology education is (many people think it is just computers). Students also work with the Technology School of the Future (part of the Hindmarsh Digital Precincts) to make programmable working models. These models involve the use of cams, hydraulics, pneumatics, electric circuits and gears, which students have learnt about in the first two years of the program. The School of the Future then puts the models on their website as examples of what can be done.

As part of the program, students have also worked with ‘Statewide Recycling’ and ACI (glass) to research the systems in the industry, then made a three-dimensional model or interactive models to represent the system, which was put on display at the industry.

Groups of school children come to the campus quite regularly, and the third and fourth year students teach them and evaluate the lesson (which also serves as professional development for the teachers).

The students’ views

The students (four females and one male) commented that they liked technology as a learning area because, it focused on hands-on activities and skills for learning (e.g. problem solving and communicating), it was fun for children to do, it had a future focus, it complemented and enriched a thematic approach when integrated with
other learning areas, and it allowed a variety of learning styles. One student commented,

I think it's a subject that is really open for success as well. The kids feel successful at it. They might not be able to spell, but when they do design and technology there's all these other ways of communicating. All these other skills that they learn. Usually without even realizing it they are integrating so many different subjects into it anyway, so they are benefiting from all areas. You can spend a big chunk of time on it without feeling I'm not giving as much time to language or whatever.

Students liked the suite of technology subjects in the program because it regularly involved experiences with real children, either in schools or on campus. For example,

I love the way that when you go into the school, the children are so excited when they hear they're doing technology. You get a great result from every student practically.

They also valued the links with the School of the Future, and the hands-on focus in the classes at university. One student stated,

As part of our classes at uni we do a lot of making and hands-on stuff. So we experience how to do it was well, and that helps us know what to do when we get on to these practical teaching experiences. We're not just sitting and listening to someone, we're engaging in it. We enjoy that and it makes you confident in it.

Some of the activities the students mentioned were as follows.

We just did some wishing wells. And they just worked out really well with a pulley system. They were fantastic and they worked. We had them do the design. They had to list everything they wanted, so it could be brought in for the next lesson. Some of them stuck little stones around it [the well] or used papier mache or cardboard, popssticks. Anything really that they could get their hands on they were allowed to build with.

We did lots of bridge making. They practised looking at different structures using the 'K'nox. And then the kids just went crazy. They made these bridges which opened up. [They made them out of] straws, paddle pop sticks, cardboard, toilet rolls, boxes, plasticine. We generally use junk material, for the cost effectiveness.

There was a whole school theme on India, and we made Indian buildings with the year ones. We made the Taj Mahal and it was fantastic. The kids knew a lot about India by the end of the teaching.

With my year 6/7s I just did pneumatics and basically set them a task where they could use two syringes and they could build whatever they wanted. Some would have a look at the ideas that I brought in -- a mouse coming out of a hole, something popping up. And then you had the boys who did their cannons that shot out, and some volcanoes with lava. So that worked really well.

With my year 5s the theme that they were focusing on for the term was "water catchment areas". So I built into that the task was to investigate an animal that lived in a water catchment area, and they had to make a pneumatic system around that. So some kids had frogs coming off the lily pad. There was a
massive range – even things like yabbies. That was really good and they just loved it.

[The infants] did ‘Mary, Mary quite contrary' and designed gardens. They went out in the garden and they got dirt, rock and little dried flowers and designed this big garden and then they wrote sentences about what they did and how they did it and why they did it like that.

I did circuits and switches with year 2/3s and they went off and showed at assembly. They were turning the switches on and off and they had a ball. They figured it all out for themselves. The fun thing was that they enjoyed trying to blow up the globes. It was a really good learning experience – they kept adding batteries, which cost us a bit in globes in the end.

They had a day where they displayed all their work and parents and people from the community came in. Some kids designed a playground. A conveyor belt – the challenge was to get an egg from one spot to another without it breaking.

The students also mentioned some issues to be addressed in technology. These were, the lack of Australian resources for technology and design, the fact that many adults and teachers saw technology as being information technology only, and the lack of continuity between primary and secondary in this learning area.

(2) The mathematics/science component

The rationale for integrating mathematics and science

Lecturers have several reasons for integrating mathematics and science:

Firstly, students come into the classroom with an undifferentiated view of the world, so the program connects with where they are rather than where the teacher is.

Secondly, the recent research in both primary science education and primary mathematics education is based on complementary constructivist views of teaching and learning mathematics and science. This research base provides a strong and consistent foundation for challenging and developing students’ understanding of how children learn mathematics and science and how teachers can support this learning.

Thirdly, by putting mathematics and science together the program enables students to participate in a structured sequence of three full-semester courses spread over four of their eight semesters in the program. The mathematics and science education team work with students over four semesters, whereas if we saw them just for science we would see them for one semester only. This gives us more chance to make real changes and to challenge and develop students as beginning teachers over three years of their program.

Fourthly, the sequence of four mathematics and science education courses is structured around three recurring themes. The first is about children learning mathematics and science (we take a social constructivist view as much as possible); the second is the classroom practice and teachers teaching mathematics and science; and the third is the mathematics and science vehicles we choose to use to place the first two themes in a practical context (we continually refer to these themes in our workshops). Having four semesters to strategically place these
themes and link them with the students’ first, second and third teaching practicums is a big advantage.

Fifthly, each member of the mathematics and science education team work in the practicums, and there is a mathematics and science teaching requirement in each practicum, that links to the students’ workshop sequence and the three themes. We actually see the students in lots of different ways and believe this supports students to make specific connections between their understanding and their emerging classroom practice.

Sixthly, we can identify the big ideas across mathematics and science (like sorting and classifying by attributes, and the idea of pattern) together with working mathematically and working scientifically. The sequence of courses encourages students to explore the big ideas in mathematics and science, and working mathematically and working scientifically from both topic specific perspective and from a broad perspective. It challenges students’ perceptions about what mathematics and science are (our students do not come to us confident as mathematicians or scientists). In our workshops, we encourage the view that learning mathematics and science involves working collaboratively, communicating in a variety of ways, engaging with and challenging ideas, interacting with their environments, peers, communities, others’ ideas and a wide range of resources, and involves taking risks and making mistakes. Students’ questions and experiences can be valued, which is aimed to change their views of mathematics and science. Having them for four semesters gives us more opportunity to change their attitudes towards teaching mathematics and science. By the end of the program, the students leave very confident to deal with these two areas. (FIRST YEAR STUDENT COMMENT: The focus has shifted. Initially when you thought of teaching you’d think that you’d have to know everything, whereas now it’s about you learning alongside of your students as well)

However, mathematics and science content are not integrated all the time in the courses even though the understandings about teaching and learning mathematics and science within a constructivist paradigm is consistent. Students need to be able to understand many of the key aspects of mathematics and science to support their understanding of how and what to integrate, so the program does spend some time just exploring aspects of mathematics or just exploring the aspects of science when choosing specific content vehicles. We want students to recognise what is mathematics and what is science, and we also want them to see how they can complement each other.

We try to make our approach to teaching and learning mathematics and science explicit. For example, we explain which curriculum strands we are integrating, and why we have chosen them. However, we also point out that other combinations are possible, and that some topics just don’t fit easily into an integrated theme. We also point out that what an investigation may look like from a science perspective may be quite different to that from a mathematics perspective. For example, the notion of fair testing to answer a science question or hypothesis is certainly a part of working scientifically. The idea of fair testing doesn’t make sense in mathematics, where the focus may be more about answering a student generated question or exploring a conjecture after students’ explorations.

Although the students are expected to teach mathematics and science in schools, during their practicums, we don’t force them to integrate. The second year students
are encouraged to teach the two topics separately (one mathematics, one science), but in third year they can choose to teach either an integrated unit (which most of them do) or a separate mathematics unit and a science unit. This has more to do with the students confidence to integrate where appropriate and the much longer third year practicum offers more time to explore an integrated topic. They often find that they want to integrate because it makes their job easier. The schools that work with our students are positive and interested.

The mathematics and science education sequence also aims to develop a more positive disposition towards mathematics and science, and teaching mathematics and science within the students. Student surveys indicate that by far most of the students who begin the Underdale program dislike mathematics and science, have little confidence with these two disciplines and in the main had undertaken the minimum required in mathematics and science in their senior secondary years. Our sequence presents mathematics and science differently to what students have had in the past. As future R-7 educators, it’s just as important for the students to develop positive dispositions towards mathematics and science as it is to know for example, what a fraction is. The mathematics and science education team’s research is beginning to show a significant shift in attitude with the students as they progress through the sequence. (FIRST YEAR STUDENT COMMENT: I myself didn’t enjoy maths and science in primary school, and I think combining them is a way to make them more enjoyable, as a whole together and as a way to remove that negative focus that kids have when it comes to maths and science.)

Strategies for integrating mathematics and science

Key Ideas

Sometimes we use a key idea to integrate mathematics and science. For example, we spend three weeks on the idea of sorting and classifying based on attributes, properties and characteristics. The students are asked to sort a range of resources and materials from everyday or ‘found’ materials and objects such as leaves, shells, fasteners, containers, packets, boxes, housing advertisements, to structured curriculum materials such as geometric objects and fraction kits. They are asked to separate the objects into groups. They identify attributes which have a science focus or a mathematics focus, then select one attribute to sort materials, after which they prepare a display. Another activity students undertake to further explore the concept of attribute or property involves removing their shoes, exploring and then choosing suitable attributes to compare shoes and eventually identify specific shoes using a self constructed dichotomous key for the shoes they have worked with. (Students may choose mathematical attributes such as the number of eyelets, pattern on the sole, aspects of size, or science attributes such as colour, material the shoes are made from, or the intended function of the shoe). Also, students might have a specific look at dichotomous keys for science, which we then linked back to a mathematics topic such as quadrilaterals and do a dichotomous key for them. The students explore how sorting and classifying are similar in science and mathematics, and the relationships between them.

Similarly, we look at the key idea of ‘patterns’ from a very broad sense. We look at patterns in the natural environment (e.g. cycles of day and night, life cycles) and also mathematically (e.g. measuring plants as they grow). (FIRST YEAR
STUDENT COMMENT: *A lot of the stuff does go hand in hand. And everything is becoming cross-curricular anyway, so with the lines between subjects becoming blurred it's natural for maths and science to gel together I think. So it works quite well.*

The key idea of collecting and organizing data is also followed throughout the program.

**Themes**

Alternatively, we sometimes use a theme to integrate mathematics and science. For example, one topic in second year is ‘Nature’s Realtor’, where students adopt a tree on campus, and they use measurements and explore measurement strategies to describe the tree’s size and aspects of space strand to describe its location. The science focus involves exploring the interdependence between plants and animals within that tree’s small environment. This is one topic within the sequence that models for students how children can undertake mathematics and science outside the classroom, and one strategy to plan for and resource authentic experiences. The students do compass work using maps, they measure distances on the ground, estimate the height of a tree, estimate the number of leaves on the tree, and they measure the changes in the tree’s shadow throughout the day. They describe the location of the tree to a prospective buyer, who happens to be small animal that is looking for a home. The students identify the physical structures of the tree and their functions, the animals living there and why they live there. After two and a half workshops (approximately five hours) of exploration and investigation the students produce a display, which summarizes their findings in the form of an advertisement for an animal to live in the tree. The students then use each others’ adverts to locate and visit trees adopted by other groups in the class, test their validity, and give feedback to that group (as a form of peer evaluation).

Similarly, in third year we have a theme of ‘Bodies’ in which the students look at human physiology (the bones and organs of the body). This theme is then linked with the measurement strand of the mathematics curriculum where the students explore measurement concepts (e.g. ratios of parts of the body, surface area and capacity) and measurement strategies such as direct comparisons, direct measurements and indirect measurements. At the time of this workshop sequence, the students are in their practicum school one day per week so they are able to implement a body measurement activity with their group of children. (FIRST YEAR STUDENT COMMENT: *I find that a lot that I do in maths relates to science and vice versa, so it would be good to relate it to each other, especially in a primary school environment. I think it will benefit their learning.*)

In the ‘Soils’ topic, the students further explore and use an interactive teaching sequence (which builds on children’s prior knowledge using their questions and investigations). As a prior knowledge experience, the students are given six samples that could be soils, and they describe them as either soils or not soils and provide explanations as to why they think this. They also have some soils that they have brought from home. The students use their soils to explore a wide variety of attributes of soils (e.g. porosity, colour, size and texture of particles, pH etc) and the students choose four or five attributes which interest them. They then use available resources to find out about these attributes, and apply them to the soils they have brought in. They collect, organise and represent data in a suitable way, and undertake a variety of measurements. They then take the role of forensic scientists.
We propose that someone has stolen a lecturer’s red wine collection from a home. The students have soils samples from the feet of four suspects and samples from the scene of the crime. They have to use the techniques they have developed to test the soils and come to a conclusion about who should be charged with the crime. They present their evidence in a courtroom-style situation. This topic contains aspects of comparing attributes, the science of soils and the mathematics of measuring attributes and organizing data to identify patterns and relationships with a particular focus on working scientifically and working mathematically. From this, as with all of the mathematics and science vehicles, aspects of teaching and learning are explored. For this topic, the teaching and learning foci include, children’s questions and planning and programming. (FIRST YEAR STUDENT COMMENT: We have lots of fun. We do lots of primary activities where we’re interactive and working with materials. They give us good ideas about how we learn, and therefore how the students will learn.)

Non-integrated topics

We have found that while we can make the links ourselves, it takes the students much longer to do so. So some topics have just a mathematics focus or a science focus, because otherwise there would be too many ideas for the students to engage with. We don’t want to muddle it for them.

We use an interactive approach in the science topic ‘electrical circuits’, starting with the prior knowledge activity of what’s inside a torch (the students draw an annotated diagram of what they believe is inside a torch and how it works, then they are given a torch to pull apart). (FIRST YEAR STUDENT COMMENT: What we’re doing is really practical and it’s stuff that’s really pertinent to everyday life activities.) Similarly, the ‘Animals’ topic is mainly science. The students begin by exploring their concept of what makes an animal an animal, explore children’s alternate concepts and then observe a wide variety of invertebrates and vertebrates with a focus of physical characteristics and function, behaviours and adaptations. An aspect of the teaching theme within this topic is the integration with literacy where students use their observations to compose descriptions as poems. (FIRST YEAR STUDENT COMMENT: A couple of weeks ago we got different animals in. They had a blue tongue lizard, guinea pig, fish, bopping mouse. That was good fun. We had 15 minutes just to observe what the animal does. First we had to write down what we knew about the animal. We came up with some questions that we’d like to know about it. That motivated us to go and research, to actually find out answers to questions. Then we did a presentation on it. After that we went through with the lecturer how you get the children to explore and come up with their own questions because that’s what motivates them to find out more.)

An example of a mathematics topic would be that of ‘Proportion’. The students indicate that they know about fractions, division, percentages and ratios, but they often can’t recognize the connections between them. The big picture of proportion hasn’t happened for these learners even though they have successfully completed schooling. This topic is introduced with a division perspective and as a prior knowledge experience, the students are given a collection of straws and are asked to equally divide their collection of straws as many ways as they can. They choose the number and divide the straws into that many equal groups, when there are straws left over they discuss how to cut up the leftovers, so the notion of equal sharing can happen whether you have remainders or not. The students then begin to further
explore their idea of division and equal sharing through representing fractions in a wide variety of different ways using everyday found materials. The students choose a fraction that interests them and represent it as a mass, a capacity, a distance, a surface and a time (not using any representation of time - an informal time).

Issues and challenges for integrated programs
Firstly, the people working together need to have a common philosophy. It's actually easier and less time-consuming to work separately, so it helps if the team members are passionate about it as well. However, working in a team has been a really positive experience for us. We have planning time, where we work collaboratively and develop shared understandings. The students know they will get a slightly different perspective from each of us, but we make sure we rotate between groups over the four semesters.

Secondly, you need to give other members of the faculty/school an understanding of what you are trying to do, because you will need to negotiate such things as timetables, links with practicums and workloads for students. The advent of a new computer timetable system has caused some problems because it does not recognise or enable you to easily address integration across courses.

Thirdly, you need to communicate with the schools to work out what things the students will need support with.

Fourthly, you need to communicate with the students about what you are trying to do. Their impression is that they have had mathematics and science ‘done to them’ rather than ‘done with them’.

Fifthly, trying to get the program resourced (e.g. for interactive and resource rich activities) while we all have heavy teaching loads is also an issue. Our contact hours are a bit higher than usual because of the way we teach in workshops, but we don’t think we could do it in another way (e.g. giving a mass lecture about collaborative learning in mathematics would be hypocritical).

7.2.2 Case study 2

CONTENT STUDIES IN THE BACHELOR OF ARTS (EDUCATION)/BACHELOR OF SCIENCE AT EDITH COWAN UNIVERSITY

Rationale
This program was chosen for case study to focus on the teaching of mathematics/science discipline studies for secondary education students. The original interview summary (Appendix E, Program DescriptionE40) indicated that a number of discipline lecturers had an interest in teacher education, and for example, some students were allowed to modify their discipline assignments to focus on the educational implications. It was decided to focus this case study on the characteristics of high quality teaching of discipline studies, from the point of view of both teacher education students and discipline lecturers. Factors contributing to
the selection of this program were; firstly, science deans had emphasised the importance of modelling best teaching practice in discipline content courses (Ch. 5.2.2); and secondly, the literature review had indicated that relatively little is known about what teacher education students learn in their science courses (Ch. 4.2).

The methodology for this case study was significantly different to that of the others. In individual interviews, secondary mathematics/science education students were asked to name discipline lecturers whom they had found to be particularly valuable, and were also asked to describe the teaching characteristics of those lecturers. Several lecturers were named, and two (Annette Koenders and Adrianne Kinnear) were contacted and subsequently interviewed about their teaching. Our thanks to Robin Groves and Grady Venville for facilitating this process. Unfortunately, due to the Ansett collapse it was not possible to visit the campus, so all the interviews were carried out by telephone.

**Characteristics of high quality teaching: the students’ views**

The six students identified a number of different science and mathematics discipline lecturers who had displayed high quality teaching. They also described the lecturers’ characteristics which they had valued most highly. Those characteristics are described below, roughly in the order of the frequency with which they were mentioned.

The students valued lecturers who provided **clear explanations**. The students explained that clarity was enhanced when lecturers began the explanation at a basic level, then built up in a sequenced series of steps. These lecturers explained things using relatively simple terms, and were willing to repeat themselves or explain it in different ways if necessary. The following is a representative statement, concerning a chemistry lecturer.

> He managed to break everything down. He used to explain it really slowly and clearly, went over it quite a few times, and made sure everyone knew it really well. Being able to talk in the students’ language - there’s a lot of terms in science that the students have never even heard before, so you’ve got to be really aware of that and explain what you’re saying really well.

The students valued lecturers who were **approachable and helpful**. The best lecturers learnt the students’ names, treated them as individuals and encouraged students to see them if they had problems. The following statement refers to a biology lecturer.

> She learnt everyone’s names. She just knew what stage everyone was up to and what type of help everyone needed.

The students valued lecturers who were **enthusiastic**. The students explained that enthusiasm was not only evidenced by a lecturer’s voice and body language, but also by the extent to which they were willing to do a bit more than what was normally required. The following is one statement about a biology lecturer.

> He brought a lot of resources into the class as well, so he’d obviously put in the time outside of what would normally be expected to teach the course. He taught the course with a passion.
The students valued lecturers who involved the students in group activities and discussions. The following is a representative statement concerning a mathematics lecturer.

He got everyone involved, by directing different questions to different people, and if someone has answered a question [he would] ask the class and ask individuals ‘Do you think this is right?’ He wouldn’t ever give you the answer until everyone understood it.

The students valued lecturers who talked about high school teaching and related the content to high school teaching. The following are representative statements, referring to a biology lecturer and a mathematics lecturer.

He understood that some of us were doing education and in his lectures he made what he was trying to teach us relevant to the [high school] course. He showed us how it relates to it, which was really useful.

He was talking about how we have to not teach something because we want to get paid for it, we should teach it because we want to know the content and it’s something that we want to do, otherwise this is not the place to be. He used to tell us that he doesn’t like teachers who teach mathematics using an overhead, because he preferred them to be more involved with the students.

The students valued lecturers who used humour. Students mentioned that some of their lecturers included jokes or cartoons which were relevant to the content, and that this helped to create a light and friendly atmosphere.

He had ‘Simpsons’ cartoons relevant to chemistry at the end of every lecture. I was in first year then and that made him my favourite teacher.

The students valued lecturers who gave good feedback to the students. The students appreciated lecturers who provided informative feedback and regular feedback throughout each unit rather than just at the end. The following quote refers to a biology lecturer.

She gave great feedback on all of our assignments. We got pretty much a written page on where we could improve [and] where we’ve gone wrong.

The students valued lecturers who made an effort to motivate the students. The students explained that interesting choices of topics or the use of unusual stories or examples would arouse their interest.

He always talked to the students to motivate them to want to learn mathematics. A lot of the students really enjoyed calculus even though it’s a hard unit in general. He would always start of with a small historical introduction.

He started the course off, before any of us knew him, showing a video of a sheep decomposing with maggots eating it, and kind of led in from that. Right from that moment he caught everyone’s interest.

The students valued lecturers who used variety in their teaching. The variety came from incorporating different types of teaching approaches or activities throughout a lecture or throughout a unit.

Her [biology] lectures were varied. It wasn’t very much just copy these notes off the board. She might show a video, or even just simple things like just going from talking to showing some overheads, or handouts.
The students valued lecturers who referred to the real life applications of the content. Some lecturers did this by organising field trips, while others related the content to everyday life experiences or to their experiences in professional laboratories.

He tried to show you how the maths could actually be used, what it could be used for in real life. Instead of actually giving you a formula to work on and practise, he’d pose a problem, then as a class you’d work out the formula to solve this problem, like different things like bus routes, and will you get wetter running in the rain or walking in the rain?

The importance of high quality teaching in discipline studies

It was clear from the interviews with students, that almost all of them had copied teaching strategies which they had seen their discipline lecturers use. In other words, when the education students taught in schools during their teaching practice, they had a tendency to try to emulate the characteristics which they admired in their discipline lecturers. The following were typical comments.

Making sure I know everyone’s names and being a really friendly face is something that really stands out in my mind and I’ll probably endeavour to do when I’m in a classroom myself.

I have actually mirrored some of her teaching styles in the way I’ve taught on teaching practice. She probably would have an influence on me when I go out to teach science in a school, from basically the way she teaches, sort of a group-based thing rather than an actual expository teaching style.

She kept her lectures varied and she was quite clear, and didn’t assume too much prior knowledge, which is something that I try to do when teaching.

His enthusiasm towards teaching is a huge thing, and it’s come through in me so I definitely try to be enthusiastic about what I teach, so that my students can see that.

It’s the variety of teaching that made it so effective. That’s one thing that I really need to put into my teaching, and it’s something that he’s helped me with.

These comments indicate that a teacher education program can be enhanced when the science/mathematics discipline lecturers model high quality teaching practices. This allows the education students to not only learn the discipline content but also provides opportunities for them to observe and learn effective strategies for the delivery of content in high school classrooms.

Teaching approaches of identified lecturers

The following two sections focus on particular lecturers and their approach to teaching discipline content. Their comments are paraphrased, and are supplemented with quotes from their students.
Interview with Annette Koenders

The units which involve education students

I teach education students at first year level, the two units of introductory biology are ‘Origins and Evolution of Life’ and ‘Form and Function in Biology’ and I have written and coordinated these units. I also teach some of the education students in the third year unit ‘Comparative and Environmental Physiology’.

Teaching practices

I try to be very student-centred and my teaching is very specific to the students at this university. I try to infect students with my enthusiasm for the subject. I really try to relate the subject matter that I teach to the students’ personal lives. I try to give examples that students may have encountered in their personal lives. I try to tell anecdotes. I try to tell students about funny things that I’ve encountered when I’ve done research projects. I try to make it a very personal experience — the experience of biology — that it’s all around you. You can see a lot of these things when you just walk down the street for example. I always try to draw on personal experiences, to make students aware that looking through a biologist’s eyes is a really exciting thing, and you can do it at any time of the day. You don’t need to go to university or read a book in a laboratory to do it.

STUDENT COMMENT: I like the way she lightens the atmosphere of the room. Obviously she still carries a lot of heavy content but she keeps it as a light atmosphere, which is good I think. Chucks in the odd joke every now and then and sort of reminds you that it’s not all deep doom and gloom.

I also focus on imparting learning strategies to students, and making them more independent, self-motivated learners.

STUDENT COMMENT: She used to engage the class in a lot of group activities and discussions, which was really good, especially in units such as biochemistry and genetics, which were quite hard. She used to engage in a lot of small tutorial groups, to try to open up the concepts and try to get everyone to understand what was going on.

I try to create a really supportive learning environment where students can feel safe to try things without fear of ridicule, but at the same time I also try to maintain high standards, so I do demand a fair bit from my students. Every semester I organise a sausage sizzle for the students to meet each other and the academic and technical staff informally.

STUDENT COMMENT: Every term she arranges a science faculty barbecue, and arranges all the different years to go. She’s brought everyone into a group. Science as a faculty and everyone working together and hopefully able to ask other people for help. Even with the first years, after the barbecue they’re attached a lot more to the university. More confident to walk up to a third year or a fourth year and get their advice.

I also make myself very obviously available to students. I encourage them to contact me with their problems and although I’ve got about 100 students in first
year, I also go into all the labs regularly, so they can see me outside the lecture theatre. I also encourage students to come and see me or phone me or email me, and we usually can work something out. I try to present an image that I’m ready to listen and ready to consider.

**STUDENT COMMENT:** She was just generally a very open sort of person and a very approachable person. You could just put your hand up at any time and say something or make a comment, and she’d have a discussion about that and then come back to what she was doing. She wouldn’t fob you off. It was really good.

The other thing I have really focussed on is using technology in an appropriate way to enhance student learning. I’ve developed a virtual laboratory which has been implemented successfully, and I am also developing units for on-line delivery. Flexible delivery is one of the strategies of the university. I think it’s an interesting area to work in because it’s not as straight forward as we thought initially. You have to be very careful how you use it.

**Challenges for my teaching**

The biggest challenge is time. When you really focus on learning strategies then that takes time away from learning other things, and trying to strike the balance is quite difficult.

The other problem is a lack of infrastructure and that is not a problem due to this university - I think it’s something due to the federal funding of tertiary education. There is a big move towards flexible delivery and the use of technology in education but the funds usually seem to be lagging behind. I’ve got the technology to create the teaching environment, but there is not the funding to have enough computers of a high enough standard for students to make full use of the facilities.

**Interview with Adrianne Kinnear**

**Teaching practices**

I teach the final year ‘Advanced Ecology’ unit, which presents ecological knowledge as a continually changing, evolving body of knowledge. What we understand about the real world is only as good as the observations we make, and only as good as the models we think we can make from those observations. So I try to get across the idea that these are the ideas we have today about how the natural world operates, but they’re only as good as the observations we’ve made, and next week we might make some more observations which actually throw all those models into doubt. It’s the idea that knowledge doesn’t stay the same. To me this is more interesting than just presenting ecology as a series of facts that are written in stone.

I deal with the content in an open-ended, problem-solving way. I might take a piece of research which my students have done, which goes against current ecological theories or models. We look at the raw data (e.g. the succession of mites in a series of rehabilitated forest plots) and discuss what kind of pattern they are showing and what kind of model if any, this pattern fits. If it doesn’t fit any of them then, why not? I’m trying to get them to understand the model through application.
The laboratory/field component deals with real world contexts and takes the students through the whole process of the design and gathering of ecological data, its analysis and its presentation. For example, throughout the semester we do a series of early morning trapping surveys of a local bandicoot population.

STUDENT COMMENT: She certainly does a lot more than you would normally expect from a lecturer. She’s arranged for us to be going out and counting the bandicoot population in a local reserve. Doing a lot of field trips and seeing that up with government departments. She’s arranging a lot for us and she’s explaining it in such a way as what would be needed if you were a scientist working in that field. Sort of setting the benchmark for that.

I use lectures, guided discussion and group discussion. For example, the students get into groups and share their answers to what they’ve done over the week. They share ideas and come to a group idea about what the answers to that problem could be. Then we use class discussion to put all those ideas together, so at the end they get a generic answer to that kind of problem. So we’re developing sets of ways of approaching things.

STUDENT COMMENT: She’s very approachable. She’s keen to sit down with us and just talk about things outside of the class. She provides morning tea before the class. She’s trying to make it a very sociable kind of event as well. She puts on a kettle and brings in a pack of biscuits.

Considering education students

When the students finish the unit, I hope they’ve got a much more enthusiastic appreciation for the natural world, because as teachers, that’s what they have to instil in the kids. If they’re not enthused and interested and confident about what they can do then they’re not going to feel confident in the classroom.

I would also like the education students to see that having knowledge beyond what they are teaching is important. Almost all the activities that we do in class, with the exception of the bandicoot project, can actually be done in a secondary classroom - you just change the level of the content.

I offer the education students alternative major assignments where possible, based on the same field and class work, and try to continually help them reflect on the higher order learning they are doing and how and why it is relevant to them as teachers. For example, this year, the education students do exactly the same data analysis and interpretation as their peers, but have the option of:

(i) doing their first assignment (the epifaunal communities of marine algae) as a paper written for ASTJ (the Australian Science Teachers’ Journal) centred around its use as a classroom activity; and

(ii) doing their second assignment as a poster (on the aquatic communities of a nearby lake) which provides a resource they can use in the classroom.

STUDENT COMMENT: She said to the three of us [education students] that we could do it in such a way that whatever we produce is a resource for next year. Which has been good. We’re doing a poster on the epifauna inside Lake Joondalup at the moment, and the three of us are going to do it as a food web — a big poster about food webs. Doing a resource like that I can see how we could use it next year and in the future.
Challenges for my teaching

It’s a real challenge to get the students thinking at a higher, problem-solving level. The challenge is to make sure that you are not leaving some of them behind, and to get them into that new way of thinking about content. That’s why it’s important that we share ideas and everybody in the class ends up with a way of approaching the problem - a way of learning.

7.3 Case studies on articulation between content studies and pedagogical studies

7.3.1 Case study 3

INTEGRATION IN THE BACHELOR OF BEHAVIOURAL STUDIES/BACHELOR OF EDUCATION (MIDDLE YEARS OF SCHOOLING) AT THE UNIVERSITY OF QUEENSLAND

Rationale

This program was chosen for case study because it is an innovative middle school teacher preparation program. The initial interview indicated that the program integrated content, pedagogy and curriculum through the use of an integrated curriculum and rich tasks (Appendix G, Program Description G1). The program is a four-year dual degree and as yet, there are no students in the Bachelor of Education component because the first intake was in 2001 and the B.Ed. does not begin until the third year of the program. A graduate entry version of the program will commence in 2002 and a small group of students who began the Bachelor of Behavioural Studies in 2000 and were eligible, opted to join the dual degree in 2001 and will complete their education studies in 2002 and 2003. However, for the purposes of this study it was intended to view it as an innovative program which is still in the process of development.

Our thanks to Donna Pendergast (Program Director, Middle Years of Schooling) and Diane Mayer (Director of Teacher Education) whose comments are paraphrased below

Development of the program

Our philosophies for the program have been influenced by three major factors: New Basics, middle schooling principles, and the ‘learning to teach’ literature.

The influence of New Basics

Traditional teacher education programs are usually organised with discrete courses focusing on discipline content, educational psychology, pedagogy, curriculum
methods and so on. Similarly, school curriculum is organised by dividing it into separate key learning areas such as English, Mathematics and Science. However, the New Basics approach of Education Queensland is an alternative way of organising curriculum in schools. The proposed New Basics curriculum in Queensland is organised in themes:

- Life pathways and social futures (Who am I and where am I going?)
- Multiliteracies and communications media (How do I make sense of, and communicate with, the world?)
- Active citizenship (What are my rights and responsibilities in communities, cultures and economies?)
- Environments and technologies (How do I describe, analyse and shape the world around me?)

The New Basics curriculum approach aims to prepare students for the new work environments and new community settings of the future. It emphasises integrated, overlapping and authentic experiences, which will provide opportunities for children to apply their learning in the real world. Rather than just adding new components to old programs (and thereby creating overcrowded curricula) a New Basics approach aims to replace existing curriculum structures (e.g. Key Learning Areas) with new curriculum organisers.

At present, there are 37 schools which are trialing New Basics throughout Queensland, and these are being monitored through a longitudinal study.

In the Bachelor of Education program, we have adopted the idea that it is possible to reorganise the teacher education curriculum, so that learning to teach is more authentic, relevant and integrated than in the more traditional segmented programs. However, although we are informed by Education Queensland’s New Basics themes, we have not adopted these specific themes in our program. Rather we have drawn on the New Basics approach as a conceptual framework.

Middle schooling principles

Many schools in Queensland are developing middle schooling programs, sometimes as sub-schools within P-12 campuses, sometimes across primary and secondary schools which are geographically close, and sometimes within existing secondary campuses. Amongst other things, we have drawn from the principles of middle schooling outlined by the National Middle Schooling Association in the USA, as well as the 1996-1998 National Middle Schooling Project in Australia managed by the Australian Curriculum Studies Association and funded by the Commonwealth Government. The main middle schooling principles, which have informed our program development, are as follows.

Integration. Adolescent children need the real world applications of what they are learning. Separate mathematics and science subjects for example make it quite difficult for the children to bring the content together in a real, authentic way. We are modelling this by integrating content from different learning areas.

Flexible Learning Pathways. Appropriate learning pathways will be negotiated with the students, based on their prior knowledge and the identification of areas they need to develop. We will be asking students to identify their main area of weakness in
their previous studies, and to concentrate on this area in their tasks for each semester. For example, in the art and science course, there may be a student who already has a strong arts background, so that person will focus on science (but will also involve aspects of the arts). Students will be rewarded based on their improvement in that area.

**Authentic learning and assessment tasks.** Each rich task (see below) will require students to draw upon a range of learnings in different areas, to solve a real, applied problem. As much as possible, students will be in school and community settings.

**Teamwork.** In middle schools, teams of teachers are often responsible for groups of children. This provides continuity for the children and allows them to build relationships with teachers (the typical secondary school timetabling structure of a 40 minute lesson with one teacher then moving on to another teacher, does not seem to suit these children well – they need time to build relationships with particular teachers). In a middle school team there would typically be about three teachers to 70-80 students, and a class may go for one whole morning. All the teachers would be responsible for all those children, but within that, each teacher would also take their areas of expertise. We will be trying to model the same thing here by having the teacher educators working in teams. To support this, the education staff have been selected to represent a range of specialist areas, and they are also working with the other faculty staff and teachers in schools.

**Negotiated Curriculum.** We will be working in areas of students’ interest. This is in contrast to traditional teacher education curricula which often focus exclusively on developing generic knowledge and skills deemed essential for teaching in a wide range of contexts. For example, if the topic was ‘Travel’, rather than saying, ‘It’s really important to understand these principles of travel, therefore we’ll teach it in this way’, students might say, ‘I’m really interested in one particular aspect of travel’, so they would research, investigate or carry out an activity associated with that, and achieve the necessary learning in the process of doing it. This does not mean open negotiation, because there is direction and guidance, but there is flexibility in the students’ activities. We will be modelling negotiated curriculum with our students in this program, as they work towards their rich tasks.

**Use of new technologies.** We recognise that there has been a change in the way that students process information. Teachers of the future will need to be able to use the range of technologies available in productive ways, as an integrated part of their professional lives. We will include flexible delivery mode with the students, because we believe that it is becoming an increasing reality for classrooms.

The program will also draw from the ‘learning to teach’ literature, which, amongst other things, emphasises the importance of developing discipline content knowledge with curriculum and pedagogical knowledge. Typically, traditional teacher education students study their discipline content first, then the pedagogy and curriculum, and there is little integration. We aim to integrate content knowledge, curriculum knowledge, and pedagogical content knowledge development for all key learning areas within a number of ‘Frame’ subjects.

**Rich tasks**

A rich task is a major piece of work that integrates a range of learning areas and provides the opportunity for students to demonstrate their learning, and involves
higher order thinking, critical thinking, and reflective practice. Each semester, there
will be one rich task, which drives the semester, and all the other components will
be linked to the task. Each rich task will be a large project in which students engage
with other students, teachers in schools or people in the community.

Over the two years of the B.Ed., students will cover content from each of the Key
Learning Areas. In semester one the emphasis will be on SOSE, and the rich task
will focus on that area (the students will come from a background of studies in
society and environment, so they will have a strength there). The next semester, we
will introduce them to science and the arts (see below) but they will also use SOSE
from their previous semester, so their rich task will integrate these three learning
areas. In the third semester they will add the other four Key Learning Areas,
including mathematics and technology, but the rich tasks will also involve the
previous three learning areas. In this way, the key learning areas develop in a spiral
way building on each other as the program progresses. Throughout the sequence,
the students will learn how to learn by using rich tasks, and in the final semester,
they will design their own rich tasks, so they will then be able to replicate this
strategy in the classroom.

The science component
The mathematics component has not yet been fully developed, so this section will
focus on the integrated science course instead.

The ‘Frame 2’ subject is a one-semester course which has an arts and science focus.
It will be located in the second semester of the B.Ed. (ie. in the second semester of
year three of the full dual degree program) and will represent half of a full-time
semester load. It will involve a range of activities such as lectures, tutorials, case
studies, small group work and workshops. It will have three integrated components:

1) curriculum innovations for the middle years, which will carry through from
their previous studies in the program;

2) the arts and science key learning areas, which will include content modules
(including the absolute essential minimum knowledge in science for graduates
to teach at grade 6-7 level) and the specific pedagogical practices for that
knowledge (we are currently working with the science faculty and school
teachers to develop this content); and

3) the rich task, as follows.

The rich task for Frame 2 has a community focus (the mathematics component will
appear in Frame 3, and the mathematics rich task will have a classroom focus). The
rich task for Frame 2 is, “Students will show that they are able to identify a
community issue of concern and participate in developing an initiative within a
defined community to address that issue. They will identify possible contributing
factors, including policies, rules, social attitudes and behaviours, and will
communicate with target groups about potential strategies for intervention. They
will develop a means of communicating with a specific audience about their strategy
using a small range of visual and written material, along with an oral presentation.”

Students may choose to do this task individually or in pairs or small groups (by the
end of the program, the students must have demonstrated their ability to work both
individually and in teams).
The students at this stage will already have a strong background in SOSE, and a
developing background in science and the arts. They will be expected to draw on all
these areas for their rich task. For example, there might be a local community
which has a concentration of migrants and they are struggling with (say) growing
vegetables. Students need to identify the appropriate vegetables for this area, the
practices involved, and how to prepare food from these vegetables. The students
would actually work with the real community or a team from the community that is
doing this.

Comments about developing an innovative program
The biggest difficulty is encouraging people to think conceptually differently about
teacher education. Initially we spent a lot of time meeting with various stakeholders
to talk about how things might be done differently, and to get people (both in
schools and within the university) to consider teacher education differently. Our
program logo is ‘Reform, Rethink and Transform’ and that’s underpinned our
development process. Until we get our first cohort of graduates, it will be our task
to continue to promote the philosophy of the program, then our students will begin
to act as ambassadors for the program.

When you are trying to do something which is different from a traditional or
accepted approach, it is necessary to have a really well-grounded philosophy or
conceptual framework to provide the justification for what you are doing.
Otherwise you can end up changing from one thing to another as you respond to
everyone’s demands and preconceptions: everyone wants something different from
you.

In addition, the time needed to set up links, negotiate with other faculties, and
conduct meetings is very demanding. It takes a lot of time to build trust, and to
develop the feeling that we are all professionals working together to prepare better
teachers, rather than feeling threatened by reform and innovation.

Another difficulty is that we have had no specially dedicated middle years of
schooling teacher preparation model to work from. It would have been useful to
have been able to look at another program which had already tried such
innovations. It is exciting and pioneering, but also scary.

One example of a potential challenge within the program is the negotiation of
learning pathways. This is a complex area which requires a lot of flexibility from
staff and students. It is recognised that students will have different strengths and
weaknesses, and these will need to be mapped throughout their program. This will
be a complex task, but as many of the students will have similar backgrounds, many
of them should be focusing on the same or similar areas. However, the graduate
entry students will all be unique, and the identification of their strengths and
weakness will require more input from us. Tracking this will be a challenge.

On the other hand though we have, through many meetings, developed strong
group cohesion. We work extremely well as a team. There are no leaders and no
followers, and we’ve had the luxury of a new campus and putting a new team of
staff together (we suspect it wouldn’t have been so easy in an established campus
with an established education staff). Even though we are teaching other programs,
in this Middle Years of Schooling teacher preparation program we have had the
luxury of 12 months developing the program before begin teaching it.
7.3.2 Case study 4

SCIENCE ATTITUDE CHANGE IN THE BACHELOR OF EDUCATION (PRIMARY) AT CENTRAL QUEENSLAND UNIVERSITY

Rationale

This program was chosen as an example of attitude change in a primary science education program. The original interview (Appendix D, Program Description D19) indicated that there was a transformation in the attitudes of the students because of the constructivist-based, classroom-oriented teaching approach, which was used by the science methods lecturer. The purposes of this case study were to describe the techniques used by the lecturer to achieve attitude change, and to confirm that attitude change had occurred in the students. Factors contributing to the selection of this program were: firstly, professional bodies had emphasised a need for primary education students to be excited and motivated in science (Ch. 5.3.2); and secondly, the literature review had indicated the importance of developing positive attitudes in these students (Ch. 4.2).

Our thanks to Ken Appleton, the science methods lecturer, whose comments are paraphrased in the following section, and to his students, whose interview responses are also presented below.

The interview with the lecturer

Course structure

I teach in the ‘Science Curriculum and Pedagogy’ unit in the Bachelor of Education (Primary). This is a compulsory curriculum methods subject, which is normally offered as two hours of tutorial each week for one semester (there are 24 hours of face to face contact). However, this year I taught the subject in a ‘sandwich intensive’ mode, in which there was a two-day intensive session before the semester started, then one class during the semester, and the last three classes were in a school. The two-day intensive session was intended to provide an introduction to the science syllabus outcomes, giving the students worked examples on a science topic, and showing them how to plan a science unit for their school visits. The one class during the semester was mainly to check the students’ planning for their science teaching unit. In the school, the students worked in pairs. Each pair was allocated to half a class, and they were required to teach a unit of work (the topics were negotiated with the classroom teachers) of about five hours duration. There was also an introductory one and a half hours for the students to get to know the children and identify their existing ideas on the topic. By the end of the semester, the students were expected to have developed an understanding of issues such as learning theories, the nature of science, curriculum integration, curriculum outcomes and gender in science. They were also expected to be able to plan, implement and evaluate a science unit that articulated with aspects of these issues.

I tried to model a range of different teaching approaches. One example is the ‘interactive approach’ in which the students engage in activities on a topic, raise questions to which they would like to find answers, and then work towards finding
the answers. This encourages open-ended investigations that have a lot of student ownership.

The students’ attitudes

Most of our students would have some reservations about teaching science. Many of them had bad experiences in high school, which have turned them off science, made them fearful of it, and made them feel that they don’t know enough science to be able to teach it. The students initially feel that science is a body of knowledge that they have to transmit to kids, and because they don’t have a good grasp of that body of knowledge themselves, and haven’t been successful themselves in science, they therefore could not teach it.

The students' experiences of science in high school were typically of cookbook style laboratory work (if they had any laboratory work at all), the teaching of definitions, a lot of memorisation, and a lot of textbook work which had no meaning to them outside of the classroom.

Some previous research with my graduate students suggests that if the students don’t start to teach science within the first few weeks of beginning teaching, they will probably become locked into a habit of not teaching science at all. One of the key things we need to do in the methods course is to try to turn their attitudes around, so they feel comfortable with teaching science, and will do so when they begin teaching.

Strategies for achieving attitude change

One of the things that seems to have the most impact on peoples' attitudes is success or failure. Success is likely to create attitude improvement, so I try to give these students successful science experiences and successful teaching experiences in science. I try to give them success in actually doing some science themselves. I portray science as investigative science, using hands-on, minds-on science activities. Also, I don’t believe that you have to cover all the topics in science in order to create confidence - my previous research has indicated that if students have success in one or two science topics, they develop confidence in science as a whole.

The students must also have success in teaching science in school, using hands-on activities. I developed the sandwich intensive mode so as to allow students an opportunity to teach a hands-on science unit using the new outcomes-based syllabus. They have half a class of kids rather than a full class, and they work in pairs to support each other, so they have a greater chance of success. I deliberately do not assess their teaching, so the experience is relatively risk-free from that viewpoint.

I'm very conscious of the fact that if I fail somebody, they're probably going to be turned off teaching science but, on the other hand, you have to set standards. Consequently, I let them have multiple opportunities to achieve the outcomes of the course, so they are more likely to have success in passing the subject.

Secondly, I always tie the science content to pedagogical issues (e.g. when we are investigating magnetism we discuss how you could explain to kids what a magnetic field is, and what analogies could be used). The integration of discipline content and pedagogy is important for promoting attitude change in education students (and
even their science discipline studies in the science faculty should hopefully take this approach).

Thirdly, I try to make the students understand that, if they have not been successful in science before, it wasn’t necessarily a personal failure of theirs. Students tend to attribute their failure to themselves, so I promote the idea that it was a failure of the teaching system. If the students can see that the way they were taught science in the past was not necessarily the best way to teach the subject, then they can realise that their past failure in science was not their fault (ie. their feelings of failure are shifted from themselves onto the system). I promote the idea that good science teaching should be based on constructivist principles (ie. in order to learn something we have to link the new information to what we already know, we have to consider students’ existing ideas, and we have to be aware that the classroom is a social environment).

Problems and issues

It should be noted that the strategies I use will not necessarily appeal to all students. One of the techniques I try to model is to not tell the students the answer straight away. Some students get frustrated with this because their model of teaching and learning is to regurgitate information for tests and assignments. When I don’t do this, they don’t like it.

In addition, attitude change is dependent on a high level of trust between the students and the teacher, but when you have large classes and large numbers of classes it is very difficult to build up the sort of relationship which will engender attitude change.

The interview with the students

Previous experiences and attitudes

One of the five students appeared to have been fairly neutral in her previous attitudes, but the other four expressed strong previous lack of interest in science, which linked to their experiences of the subject at high school. For example, the following are responses from three of the students.

I found science very boring at high school. I wasn’t interested. It was basically straight out of the textbook. [What made it boring?] The presentation. The teacher for the subject was not very patient. He didn’t like to repeat himself and if you challenged or questioned he didn’t want to go into any explanation. He basically had a recipe for any experiments we were supposed to do. There was nothing to get you interested or involved in the first place. He just assumed that we were all naturally interested in science, which some of us were, but most of us weren’t. We would rather be doing anything than science.

I didn’t find it very interesting because I had a lot of problems understanding it. I think what they wanted you to do was just to be able to memorise the textbook. [How did that make you feel when you couldn’t understand?] Hopeless, basically.

The science teacher was a really big guy and really took control of the class aggressively, and I must have annoyed him or he was having a bad day.
remember asking him something and he came down and yelled in my ear from this far away. I never said another word in science again. I passed the exam purely by rote learning, but it wasn’t relevant to me or to real life.

Present attitudes towards science

All five students indicated that they were very positive about science now, and that they were confident to teach it. For example,

I’ve always had science up there with maths — they’re both going to be really hard to teach. It [Ken’s course] just took away all the fear of teaching. Equipped with what Ken had shown us, I didn’t have any problems going out to teach science in the classroom. It was a really enjoyable experience for all of us, the children as much as ourselves.

From Ken’s course, I decided to do a science major. You have to have a major for primary, so now I’m doing science and maths. [So you’re now studying science in the science faculty?] Yes.

When I first saw science as one of our subjects I thought, ‘Oh, no. I can’t do this because it’s a science’. But when Ken got us through it I thought ‘Maybe I can. I’ll have a go’. But then at the end I really thought ‘Well, I can do this now’. Then when we went out on prac and they asked us to do a bit of science I loved it.

With watching Ken, it was just an eye opener. And it was exciting, the way he carried himself, and the way he challenged us with those discrepant events. I think if you can just get your students’ attention and make them want to be a part of learning about science, I think it will come easily. I think it does depend on the teacher and how they present themselves. I’m sure that I can do it.

It’s more relevant to me now. I’m taking a lot more notice now of things around me and just thinking about how things work and listening to things on the radio and TV. There’s the science show on Thursday night that I tape now.

Causes of the attitude change

The students stated that the attitude change was due to Ken’s course, and that there were many things within the course which contributed towards their attitude change. These included:

Ken’s enthusiasm:

You could tell he really wants to make a change for children in the future and starting with us. This is how he thinks that he can make a change and he really did model that. He had a real passion for it.

Discrepant events demonstrations (ie. demonstrations which have a surprising result):

It was a combination of different things, but to me, when Ken started each session he would have a discrepant event, and that would suck you in. Before you knew it, you are away and the lesson has started.

Ken’s modelling of teaching strategies:
Ken’s modelling of how you should go about teaching science, or interacting with the children in learning about science, was the most important thing. It was his enthusiasm and the fact that everybody’s answers are valued.

Valuing the students’ answers:

He kind of made everyone feel clever, just for having an answer even if it was wrong. It was like, you’ve had a think about it and you’ve come up with some sort of answer so you’ve done a good job anyway. So that was really good because you didn’t leave feeling that you were a real dodo.

Ken’s constructivist approach:

I really think by Ken’s attitude of a constructivist, that’s really changed my attitude. Because I know now how to go about teaching students. In the future I’ll be really interested with science.

Making science relevant to real life:

We were just on the go the whole time and we were really interested and the day flew. I started to think that I could learn science, and it wasn’t all just formulas and grids and graphs, it was real life relevant.

Having a chance to practice teaching science to children:

The teaching in class at the school. The kids just loved it. The teacher was very supportive of us as well. It made science interesting to teach. Then when we went out on prac straight afterwards I applied those same principles in the classroom. The children just enjoyed it because it was hands-on. It made me feel that I had really taught something and the children had taken it in and enjoyed it and I enjoyed teaching them.

Final comments

The students’ comments provided confirmation that the approaches used in Ken’s teaching had been successful. The interviewer gained the strong impression that there had been a very significant positive change in these students’ attitudes, as a result of Ken’s curriculum methods class. Furthermore, it was clear that the students had developed some quality learning experiences for school children. For example, one group demonstrated physical change by making chocolate crackles with their children. A second example is as follows.

We were making bread muffins in the frypan with the chocolate chips in them. The children were just so keen. When we lifted the lid there would be condensation inside the lid of the frypan, which would fall down and the water would sizzle inside the frypan. One of the children picked up on it and then we said ‘I wonder where that came from?’. So then all these ideas came forth about where the water came from. We explained in a simplified process and told the children we thought it was the liquid – remember the liquid we put in to making the bread? - that has since come out and evaporated and condensed. When you teach it that way, the kids want to ask questions.
7.4 Case studies on the integration of teaching theory and practice

7.4.1 Case study 5

THE KNOWLEDGE BUILDING COMMUNITY (KBC) PROGRAM AT THE UNIVERSITY OF WOLLONGONG

Rationale
This program is an alternative pathway for students in the Bachelor of Teaching/Bachelor of Education in Primary Education. It was chosen for case study because it has adopted a school-based, problem-based approach (Appendix D, Program Description D15). It was decided to focus on the initial planning and development of the program, as well as the program itself, because the story of how innovations are planned and developed is an important one. Factors contributing to the selection of this program were that PBL approaches had been suggested by science deans (Ch. 5.2.2) as well as in the research literature (Ch. 4.3).

Our thanks to Brian Cambourne (the program coordinator), Julie Kiggins and Brian Ferry, whose combined comments are paraphrased below. Our thanks also to the students and teachers who consented to be interviewed.

Initial development of the program

Purpose of the program
In 1996, we decided to develop a teacher education program that had closer links between theory and practice. Previous students had generally been supportive of the school experience program, but found it difficult to make the links to their on-campus lectures and tutorials. A more school-based program would help to make these links. It would also provide students with a good understanding of the culture of schools, and what teaching is really like on a day-to-day basis.

Background research and negotiation
We spent a lot of time negotiating with the schools, the local districts, the Teachers' Federation and the DET (Department of Education and Training). Before we even put pen to paper we had about 150 hours of meetings. We also reviewed the literature on problem-based learning (PBL). What came out of the review was that PBL hadn't been extensively tried in teacher education (it was mainly restricted to health sciences, medicine, dentistry and nursing). We hired a consultant from the University of Newcastle, because they had an excellent PBL program in medicine. She came down and ran three days of courses with us, and answered a lot of our questions.

The next step was to put a proposal together that the university, the DET and the Teachers' Federation would sign on. A small committee of us worked on that
proposal and then spent some time moderating it. We spent a year getting our final proposal together, so that all parties would sign on and agree. We argued that it takes a whole school to mentor a student, so the whole school has to be committed to it (all the teachers on the staff would be playing a role in informing these students - some of them as mentors, and some as informants, as in an anthropological sense). We had to work out a way of achieving that so that the schools and the Federation wouldn’t feel that conditions were being eroded, and in order to support us the DET decided to provide release days.

Release days and funding

The release days system operated on the basis that for every week that we had students in the school, the coordinator was given one release day. Up to this year the department has given us 120 release days, which costs them a lot of money, but it makes the schools feel that they’re not being asked to do this for free. Instead, they have a fund of release days that they can use any way they want to, and each school uses it differently. In addition, the university pays each school $20 per student per day, for supervising students, and each school then decides how they’ll spend the money. One school bought an air conditioner, another school bought curtains, and another decided to send the mentors who had the most students, off to an in service course. So we’ve tried very hard to make it a program where the schools feel that they own it - not just us.

One of the constraints on the program was that we couldn’t expect any more resources from the university. It had to be resource neutral, so we weren’t going to get any additional money for practice teaching. Consequently, we decided to run the KBC program only in those semesters where there was already a practicum scheduled for the B.T./B.Ed. However, instead of doing their practicum in a block, the KBC students would spend two days per week at a school for the whole semester. They would enrol in the same subjects as the mainstream students, but instead of attending mainstream lectures and tutorials, they would complete the requirements of the subjects by working collaboratively during their time at the school.

The first students

Then we planned our first cohort coming in. The dean gave us permission to enrol about 10 per cent of the new intake, which worked out to about 24 students. We thought we’d have them knocking the door down to get in, but eventually we had to go around and sell it to them. The dean envisaged that the first cohort would be an elite group of students, but it didn’t work out that way. Instead, they were a group of people who saw KBC as a way of organising time to fit in to their job, baby minding or partner. This turned out to be a good thing, because we could argue that we had a fairly average sort of group, and if KBC worked for them then it could work for all the students.
Problem-based learning (PBL)

Developing the skills for PBL

Because the students enrol in the same subjects as the mainstream students, they must show evidence of acquiring the same outcomes. The students are expected to negotiate with the university and the school to develop tasks which will allow them to acquire the knowledge for each of the subjects they are enrolled in. In other words, the students carry out action research at the school, which enables them to show that they have acquired the outcomes of each of their university subjects. In order to do that they have to develop the skills that are inherent in problem-based learning. Students have to learn to work as a community of learners who can negotiate, take responsibility for their own learning, and identify and solve professional problems. We have to provide opportunities and methods for them to reflect, and to be able to solve the group dynamics problems that they’re going to run into when they’re doing collaborative learning. Consequently, in their very first year, instead of going to mainstream lectures, they spend four or five intensive weeks ‘unlearning’ the competitive baggage that they bring from the HSC, and trying themselves out on becoming problem-based collaborative learners and becoming a knowledge-building collective. It’s very interesting to see the baggage come to the surface - the disagreements and the arguments that they have are all part of the process.

STUDENT COMMENT: Once we started it all, it was still a bit daunting. Like in the first week. We were evaluating how we were going through the first week and we both thought, ‘No, we don’t like it’, because there wasn’t that much structure. But the more that it unravelled, the more that I saw how good it was going to be to put the theory into practice. And I’ve just learnt so much within myself, and so much about working with others, that there’d be no way I’d ever look back regretting what I’ve done.

In the fifth week the students begin their two days per week in a school, and one compulsory day per week at university. The rest of their week is self-directed learning.

STUDENT COMMENT: That’s the beauty of KBC though, because you end up having the confidence to go and find the information.

Designing the tasks

By the end of first semester, the students are fairly good at taking responsibility for their learning and working collaboratively. For example, this year’s first year group all went to the very first lecture of each of the subjects that they were enrolled in for mainstream lectures. They got the handouts of the subject outline, listened to what the lecturers had to say, then came back and formed their groups. In their groups they studied the subject outlines, and identified what they were expected to learn by the end of the semester. They ended up with a huge list of outcomes for all the different subjects. When they deconstructed these outcomes they found that 30 per cent of the time, the lecturers were asking for the same thing, so they integrated across the subjects to reduce the time and pressure involved. That got them to about the end of the fourth week. Then they went to their schools, and they sat
down with the coordinating teachers and explained what they had to learn. Through negotiation they developed a series of assessment tasks which fitted in with the school program. Eventually what’s happened is that we’ve got students at four different schools who are acquiring these outcomes through quite different assessment tasks. For example, one group has put together a Power Point display which shows the main concepts and examples that they’ve seen in the classrooms, as well as information from teachers about how they deal with these concepts. Another group has done a ‘Burke’s Backyard’ video documentary in which you can write in for handouts if you want to learn more about certain topics. The mainstream lecturers are involved in the grading of students’ assignments, by checking off the outcomes for each subject.

STUDENT COMMENT: Now I think we are more in a routine of going out there and investigating and just pooling all this information and then finding the best way of presenting it - the stuff that you find relevant, that you’ve learnt.

TEACHER COMMENT: It’s a problem solving approach. That’s clear. You can see that through the assignments that are coming into the school. There’s a deeper dialogue of the learning that’s going between the teacher and the associate teachers [ie. the students] because they’re so used to that at the university level. They’re arguing backwards and forwards about the particular content at the university level, and that’s spilling over here.

Meetings at university
During the compulsory one day per week at university, the students meet in their KBC home room. This room is only for the use of KBC students, and is set up for them to give presentations and to display examples of their work. They deal with housekeeping issues, share their experiences in schools with students in other groups and discuss problems with their mediators.

STUDENT COMMENT: [The home room] It’s like our own little safety house.

Articulation with mainstream
During semester 2 of first year, the students do mainstream classes, because there is no practicum scheduled for that semester. The students come back into KBC in semester 1 of year 2. In third year they are mainstream in semester 1 and KBC in semester 2.

Of the original pioneer group of 24 students, there are 18 left, and they’re very cohesive, very collaborative, and they know how to take responsibility. For example, because we haven’t done a third year KBC internship before, the students and the schools and the university facilitators sat down at a day long meeting, and co-planned how they’re going to do this final session. As a result, the schools feel they own a bit of it, the students feel they own a bit of it, and we university people feel we own a bit of it.

Mathematics and science courses
There is a mathematics method unit, which students study in KBC mode because it is scheduled for a KBC semester. This includes an action research project in the
Schools, observing three children doing any area in maths. There are four school sites and there are six students in most of the schools, so there are two or three different mathematics projects in each school site. The science and technology subject occurs in a non-KBC semester, so the students are combined with the mainstream students for this subject.

STUDENT COMMENT: In all the subjects that we’ve done, we’ve tried to KBC them as much as possible, so in all of them they make you do group work, so we’ve stuck with our buddies.

School-based experiences

Purpose of the school experience

The program aims to provide the students with a good understanding of the culture of the schools. We had a lovely example of one of our girls who didn’t realise how long it took just to paste stencils into kindergarten workbooks. She said it took an hour and a half just to do that.

STUDENT COMMENT: You’re learning what the teachers are doing, you’re doing exactly what they’re doing, and you are following through the day as they would, doing lunch duties if they do those things. Everything that they do, you do as well.

TEACHER COMMENT: From the point of view of the teacher it’s just nice having extra people in your school and I’m very impressed with the way they’ve come in and they’re relaxed in the staff room, because that’s the culture from the school that they’re picking up.

Working with the mentor teacher

Of their two days per week in schools, students spend one day (or equivalent) with their mentor teacher. The definition of mentoring that the teachers like is, the role that a mentor plays is like being at home, going to the toilet and finding there’s no toilet paper - a mentor is the person you can yell out to and say, ‘Help’. The mentor teacher has the responsibility for facilitating the student’s teaching with small groups or whole classes for different subjects, and giving feedback. Students spend any spare time doing their assessment tasks.

STUDENT COMMENT: You’re taking notes, talking to teachers in the staff-room and the students, and gathering all this information. But at the same time while you’re in the classroom they’re showing you what to do, and they’ll throw you in and say, ‘OK, have a go and help you. Like, ‘This is what you’re doing wrong. This is what you’re doing all right.’ So it’s all coming together.

TEACHER COMMENT: I’ve had mainstream students this year as well, but you have a closer contact I think with the KBC teacher associates. You meet more and you have more discussions. You get to know each other.

Working with other teachers

The students are also there as a resource for the school. On the second of their two days per week they provide support for teachers in a range of different classes. The
students don’t do anything that teacher aides do, so they can’t photocopy, for example, but they can mark students’ work and they can take small groups.

**STUDENT COMMENT:** I feel so much a part of the school that I’m at, and I feel so much like a teacher. I can walk through the playground and some child’ll be picking up a rock, and all I have to do is look at him, shake my head, and he responds to that, because we are treated so much as associate teachers.

In return, the rest of the staff are what we call ‘informants’. They make themselves available to tell stories about teaching and learning in their own particular interest areas.

**STUDENT COMMENT:** The thing is, they want to help you. They want you to come to them, and they want to be able to share with you what they know. Like I know in my first prac, I went to the ESL teacher [and] the reading recovery. They all were just like they loved to have you and share what they knew.

**Interviewer’s comment**

The two quotes below, one by a teacher and one by a student, encapsulate many of the significant aspects of this program.

**TEACHER COMMENT:** The fact that they’re so used to problem solving and gathering information from other schools and looking at a broader level. They come in better able to do that and they seek out other teachers, which is a little confronting at times. Whereas in the traditional mode in my experience is that they see that particular teacher in that particular classroom, and they only get that particular piece of input. I think that’s been the strength. It’s a different school teacher, and they’re aiming to identify why things are happening the way they do. They’re better at asking and arguing about it.

**STUDENT COMMENT:** I actually made the comment to my mum the other day about how what I’ve done at uni I think has just stemmed from KBC. So if I came straight from high school to mainstream I would have gone through the motions - done what I had to do. But being in this group has really brought out the best in me, and I strive. I don’t hand in anything unless it’s my very best, and I think that’s only come from KBC. Like everyone brings out the best in each other.

### 7.4.2 Case study 6

**THE CONSTRUCTIVIST PRACTICUM IN THE BACHELOR OF TEACHING (PRIMARY) AT NORTHERN TERRITORY UNIVERSITY**

**Rationale**

This case study was chosen as an example of an innovative approach to teaching practice in primary education. The original interview indicated that this practicum has an integrated constructivist approach, in which students are required to choose
competencies to focus on during practicum and thus drive the learning process themselves (Appendix D, Program Description D17). It should be emphasised that the practicum as a whole has a much wider base than just a focus on the competencies. It involves, for example, a strong teacher-as-researcher focus, for which the students do action research and a school/community research project. However, it was decided to focus this study on the way the students choose their competencies. One of the factors which contributed to the selection of this program was the emphasis given to constructivist approaches in the research literature (Ch. 4.3).

Our thanks to Mike Grenfell and Lorraine Connell, whose comments are paraphrased below. Our thanks also to the students, and to Lorraine McGuire, the Assistant Principal at Manunda PS, for their interview comments.

The competencies

The competencies we use are those of the National Competency Framework forBeginning Teaching, which initially came from the Australian Teaching Council (now defunct). The competencies are grouped under the headings: (1) using and developing professional knowledge and values; (2) communicating, interacting and working with students and others; (3) planning and managing the teaching and learning process; (4) monitoring and assessing students’ progress and learning outcomes; and (5) reflecting, evaluating and planning for continuous improvement.

The full list is presented in the final section of this case study.

Introductory field experiences

In second semester of first year, the students are introduced to the full list of competencies (we also look at the historical aspect of where the competencies came from, and why we use them). The students are given booklets which provide details and anecdotal records of the competencies. The lecturers model how to use reflections and anecdotes to provide evidence for the competencies. The students also study case scenarios of how the competencies have been used.

STUDENT COMMENT: At first it’s overwhelming and then once you start the ball rolling it gets easier.

We acknowledge that some students may enter the program with some competencies, which they have developed in their previous lives (e.g. through tutoring or coaching). These students are asked to provide evidence for their development of these competencies, so credit may be granted them. Through this process, we value what the students can already do, and their future progress will provide further development of the competencies.

STUDENT COMMENT: I’ve been through another system where we get told ‘OK, this is what you’re being assessed on’, and they watch you teach. But I think for me this [NTU program] is more rewarding because I’m seeing how I’m developing and I’m assessing myself.
Following this process, the students have one week of field experience in schools. They are initially required to identify a competency with which they are totally unfamiliar (but not the advanced competencies such as programming). While they are out in field experience they work on that competency - they ask their teachers for comments about it and they do their own reflections, which are brought back to university and discussed at length. At this stage, the emphasis is on the first and second competencies (professional knowledge and values, and communicating and interacting).

STUDENT COMMENT: The first competency that I’m addressing is ‘the teacher recognises and responds to individual differences’ and that’s quite appropriate to the class that I have because we have such a diverse range of ability levels.

The practica

The first practicum is a five-week block in first semester of second year. Before the practicum starts, each student identifies five competencies which he/she particularly needs to work on (but these can be changed if they are inappropriate, according to the advice of the classroom teacher).

STUDENT COMMENT: I choose the ones I haven’t done and the ones that I have done previously that I could do better. I choose areas of my teaching that I’ve noticed need certain attention - areas that I’m not confident with that I really need to focus on.

STUDENT COMMENT: I enjoy the challenge. So the fact that the competencies were left to me to decide, I found that just encourages me to use my initiative, and I appreciate being treated in that way by the university.

By the end of the practicum the students are required to provide anecdotal records, samples of work as exemplars, and reflections from their journals, which are presented as a narrative report of their development of those competencies. The emphasis at this stage is still on the first two competency groups.

TEACHER COMMENT: We had a reflection session last Tuesday. They had all put something down in diary form. They had done their reflections in narrative form. They had responded to teachers’ comments about competencies.

STUDENT COMMENT: [One competency was] ‘The teacher encourages positive student behaviour’. I had a difficult class behaviourwise, so my teacher and I sat down and I developed a behaviour management plan for my time on prac, and I used that as evidence.

In practicum two (a four-week block in first semester of year 3) and Practicum 3 (an eight-week block in second semester of year 3) the students are not limited to five competencies, but they are advised not to choose too many. They are allowed to address their previous ones again if they would like to revisit them. However, the emphasis builds towards the higher competencies such as unit planning and assessment.

STUDENT COMMENT: Initially in the first prac, choosing competencies was about developing communication with students. Feeling comfortable and confident with that and then saying Where next? in my professional development. Moving on to planning and my programming, and now assessment.
Throughout this sequence, the university staff and school teachers continue to show students ways of providing valid evidence.

**STUDENT COMMENT:** You choose your best piece of evidence. One that really shows that you can do this to a high standard.

The students are not expected to develop all the competencies in the three years of the program. Instead, we take the view that these competencies will continue to develop throughout their lives as teachers – they don’t stop once they finish their preservice teacher education. At the end of the third practicum we encourage the students to identify competencies which will need attention in their first year of teaching. The students identify these and include them in their narrative reports. In fact, the departmental staffing officers now see this as an important part of each student's forward planning.

**STUDENT COMMENT:** By the end of our first year of teaching we should have evidence for all the competencies. A lot of the competencies are reporting to parents and things that we don’t get a chance to do on prac. So the time line is that you can achieve them by the end of your first year of teaching.

**Communication with the classroom teachers**

When the program was first proposed, the university staff worked extensively with the teachers in schools to inservice them on the process. Interestingly, it was the schools that insisted that we go there for long meetings, and who challenged what we were doing, who became superb at it. We mainly used collections of vignettes and case studies to help classroom teachers identify the competencies. We still spend an enormous amount of time in schools, talking to the teachers and visiting classrooms, so we get feedback from them and build up those relationships.

**TEACHER COMMENT:** In the past we have made comments to NTU about things that didn’t really work - things that were disadvantaging preservice teachers. And those things have been taken on board, so it’s been a long, close relationship.

One of the reasons for choosing this constructivist approach was to lessen, if possible, the amount of work that the teachers were doing, but we think it may have doubled it in terms of time, because of the amount of dialoguing that goes with the reflection and the development of competencies.

**STUDENT COMMENT:** My teacher helps me to get evidence, because we have to get two pieces of evidence that we’re actually attaining this competency. Every week she will write a couple of paragraphs in relation to my competencies, about what she’s seen me doing in the classroom and I can use that as evidence.

**TEACHER COMMENT:** They’re actually treated as colleagues when they come in. We don’t treat them as student teachers.

We have also noticed that there is sometimes more conflict than in previous programs. For example, if students feel that they are in a very hierarchical environment, and they’re not getting a chance to say anything, then they will do something about it. Whereas in the past they just put their heads down and became clones of the teachers.
STUDENT COMMENT: A lot of us have had some great experiences in our practicums and have had some great teachers to work with. That's made a huge difference.

TEACHER COMMENT: Their [students’] comments are very positive about the way that the program operates. The most important thing is that the students have to provide morning tea on the last day. That's traditional.

Challenges

The main problem we have found is that the teaching population is so transient up here that it is difficult to keep all the teachers in-serviced on the competencies. Also, we have to be wary of students who play the system, by choosing a competency that they can already do, but who pretend that they can’t.

Addendum: the National Competency Framework for Beginning Teaching

1. Using and developing professional knowledge and values.
   - Knows content and its relationship to educational goals.
   - Understands the relationship between processes of inquiry and content knowledge.
   - Understands how students develop and learn.
   - Active in developing and applying professional knowledge.
   - Operates from an appropriate ethical position.
   - Operates within the framework of law and regulation.
   - Values diversity, all students have right to learn.

2. Communicating, interacting and working with students and others.
   - Communicates effectively with students.
   - Develops positive relationships with students.
   - Recognises and responds to individual differences.
   - Encourages positive student behaviour.
   - Responds to role in the team responsible for students’ education.
   - Works effectively with teachers, ancillary staff and others.
   - Works effectively with parents and others responsible for the care of students.
   - Communicates with school support staff, the profession and wider community.

3. Planning and managing the teaching and learning process.
   - Plans purposeful programs to achieve specific students learning outcomes.
- Matches content, teaching approaches and student development and learning in planning.
- Designs teaching programs to motivate and engage students.
- Structures learning tasks effectively.
- Demonstrates flexibility and responsiveness.
- Establishes clear, challenging and achievable expectations for students.
- Fosters independent and cooperative learning.
- Engages the students actively in developing knowledge.

4. Monitoring and assessing student progress and learning outcomes.
   - Knows the educational basis and role of assessment in teaching.
   - Uses assessment strategies that take account of relationships between teaching, learning and assessment.
   - Monitors student progress and provides feedback on progress.
   - Maintains records of student progress.
   - Reports on students progress to parents and others responsible for the care of students.

5. Reflecting, evaluating and planning for continuous improvement.
   - Critically reflects on own practice to improve the quality of teaching and learning.
   - Evaluates teaching and learning programs.
   - Plans to meet longer-term personal and school goals.
   - Develops professional skills and capacity.

7.4.3 Case study 7

TEACHING PRACTICE IN THE BACHELOR OF SCIENCE + BACHELOR OF EDUCATION (SECONDARY) AT MURDOCH UNIVERSITY

Rationale
This program was chosen for case study as an example of an innovative secondary mathematics/science practicum. The original interview (Appendix E, Program Summary E42) indicated that each teaching block was linked with a major or minor curriculum method unit, and that university supervisors were located on-site in schools. One of the factors which contributed to the selection of this program was that the literature review had indicated the need for university supervisors to have more impact in practicum, so as to make stronger links between theory and practice (Ch. 4.4).
Our thanks to Cal Durrant, the coordinator of secondary school experience, who described the program to us. The comments of one mathematics/science student were also quoted and paraphrased, to provide ‘One Student’s Story’ of experiences during practicum. Due to the Ansett collapse, these interviews were carried out by telephone.

**Features of the teaching practice**

‘Introduction to Teaching’

In the unit ‘Introduction to Teaching’, which occurs in second semester of first year, the students do two weeks of school experience - one week in a primary school and one week in a high school. These are about one month apart and are intended to give students an understanding of what happens in primary and secondary schools, and to give students an opportunity, early in the program, to decide if teaching is for them. Each student is assigned to a particular teacher and mainly does observations of teacher-student interactions, classroom management, programming, lesson preparation, and integration. However, each student is also required to teach one class in a primary school and one in a secondary school. In these lessons, the students work in pairs to present the lesson (to provide support for each other).

The students keep a journal for this unit, and also attend tutorials and lectures, which cover teaching and learning strategies.

Other practica

In third year, the students have a two-week experience in May, which is linked to their minor teaching area. The vast majority of students do a science as a major and maths as a minor, or vice versa. The students teach in their minor teaching area and have specific tasks which relate to this area (these tasks relate to observations, lesson planning, resources, and programs). In the past, students have had assignments for their curriculum method subject which have had to be carried out on prac, but this caused problems for part-time students who may not have done the subjects concurrently, and it overloaded the students. The schools also did not react positively to these assignments because they preferred the students to concentrate on their teaching. They are required to teach at least 16 hours over the two weeks, although some students may teach up to 24 hours, depending on the advice of the cooperating teacher. The students do their curriculum unit for their minor as either a prerequisite or a co-requisite for this block.

In fourth year, the students have another two-week session in May, which focuses on their major.

The university supervisors

All the supervisors are ex-teachers, and most are retired heads of department, or principals or deputies, so they have a broad experience base. Most of them have had the role of supervisor for several years and have demonstrated sound judgement in situations that have developed in schools. The age gap between supervisors and students can sometimes be a problem initially, but most students
find them easy to get along with, and respect their opinions. The supervisors have meetings on campus about a week before each school experience session, to meet the students and run through the requirements. They then go to the schools, meet the teachers and discuss the details and requirements with them.

The Murdoch caravans

In the typical two-week sequence, the supervisors are expected to be at the school for the whole teaching day, and are either based in the staffroom or in a caravan located in the school grounds. There are about a dozen caravans scattered around at various schools. Each one is set up as a mobile office, containing equipment such as a blackboard, whiteboard, photocopier and overhead projector.

While there are advantages to having these caravans at schools, such as providing a central location for the supervisor, and a university site in schools, there are also the disadvantages of it providing an escape to a mini university site rather than the students staying with the teachers. Especially in high schools, the students are therefore encouraged to spend most of their free time in the relevant staff room.

The role of the supervisor

In each school, there are about six to eight students in various learning areas (mathematics, English etc). About three times each week, the university supervisor runs lunchtime tutorial/discussions in the caravan. These cover generic issues such as programming and classroom management. One issue is that, because the supervisors are not necessarily subject specialists, the supervisor may not be familiar with the specialised content of the lessons, especially at senior high school level. Because of this, the classroom teacher is usually required to comment on the specialist content, and the university supervisor comments on the generic aspects of the lesson.

For each student, the supervisor observes one to two lessons in the first week and at least two lessons in the second week. At the end of the block, the supervisor, cooperating teacher and student meet to grade aspects of the student’s teaching as Outstanding, Competent or Not Yet Competent. Students are awarded a pass/fail rather than a grade. Because the practicum is not graded, the supervisor becomes a source of support (a shoulder to lean on) for the students, and is able to step in when ‘brushfires’ begin to develop. The supervisor becomes a liaison person for the university and is able to ‘pour oil on troubled waters’ when necessary. This method of supervision allows a rapport to develop between supervisor and student (although this doesn’t always happen in practice).

The Assistant Teacher Program

The Assistant Teacher Program (ATP) is a 10-week session in the third term of the fourth year. Students usually teach in their major teaching field. By the end of the ATP the students are expected to be teaching a full teacher’s load, so the teacher has time to do some professional development. The teachers still have a duty of care however, and are required to be close at hand. Students are awarded a grade for this session, so it more intense.
The university supervisors are not permanently located in these schools, and have less contact with the students than in previous sessions. The ATP is usually held in the same school as the students were in for their second block, so there is continuity, and they do not need a settling-in period because this was done in the two-week session about a month before. The students already know the cooperating teacher and have developed a rapport with that person. The supervisor is often reappointed to that school as well. However, the supervisors and schools are different to the ones the students had in their school experience program and their first teaching block, so they have a broad range of experiences.

The main difficulty with this session is that there is no teacher payment for it at the moment (in contrast to the previous teaching blocks). This is particularly an issue for external students who are located interstate in which case the teachers do expect to be paid for this supervision.

One student’s story

Hi. I’m a student doing a Grad. Dip. at Murdoch. My major is in science and my minor is in maths. This is the story of my prac experiences this year.

The ‘Introduction to Teaching’

One of the things about Murdoch is that in the ‘Introduction to Teaching’ you’ve got to do a week in primary school and a week in high school. Besides a whole lot of enjoyment, the main thing I got out of it was a realisation of the huge task that those poor primary school teachers have got to achieve. I think they have nine areas that they have to teach, and a real eye opener for me was the huge amount of work that they have to do and the diverse range of things that they have to teach. It was a really awe-inspiring experience, because you got to see the spectrum of what actually kids have to learn. It’s so hard to go back and think, what did I do when I was in grade four or grade five? It was a very broadening experience to see what they had to do.

In the two weeks at high school we were only required to do a 30-minute session [of teaching] but a few things came home to me. One was the diversity of students in a high school classroom, even in a streamed classroom. I had a low-level Year 10 maths class who didn’t know how to read digital time. I was stunned. The challenge was to try to bring myself to a level where I could try to communicate to them how to understand this. Also, I was given the task of introducing negative numbers, which is quite a difficult concept at any level. Primary school seemed like a lot of fun but high school seemed so much like business.

The whole experience was actually good for me because I was a little bit less confident in myself, thinking, is this the right path for me? But being able to get out and get hands-on and being able to deal with the kids and make friends with them and develop relationships with them was a really enjoyable experience.

Links between theory and practice

There are a few weeks of lectures to begin with – you have five or six different lecturers and you go to different topics, and you’re talking and making notes. At the time it mightn’t seem relevant, which is quite common in university, but when you
go out there in the prac you start seeing it. I remember this lecturer talking about this assessment method and then you’re seeing it in use. Another lecturer talking about classroom behaviour, and it was exactly what the lecturer was talking about. It really concreted the ideologies that the lecturers were trying to get across because we could get out there into the classroom and see it all happening. Even as an observer, you could see that the teacher would do this and the expected response would occur.

**Major and minor pracs**

We did two two-week pracs. I did one in maths and one in science. I completed my minor studies before I went on my minor prac, and my major studies before I went on my major prac, so that was helpful and well thought out.

In the two pracs I mainly became familiar with what I’m supposed to teach. This is the difficult thing for me. It’s very hard for me to go back and start thinking about how much I’ve got to teach in a 45-minute session. You’ve got a bunch of 13-year-old kids in your classroom - how deep do you go with your negative numbers?

The other thing I liked about these pracs was being able to try all different sorts of techniques. I had a science lesson where we had to review ‘Matter’ and the kids were pretty bored with it and I’d only been in the classroom a couple of days. I thought, all right let’s make a game of it. They all got into groups and each person made up a little speech about a certain section, so then they all got to the front of the class and they thought, well this is a bit more like drama or English or something like that, and they gave a presentation. They really got a lot of enjoyment out of it and thought, this is not like normal science. The way I want to teach is to make it fun, especially in the lower years. Also, maths is such a difficult thing especially for young people (‘What am I going to need this for?’) so I try to bring as much hands-on as possible.

**Sessions in the Murdoch caravan**

In the earlier pracs we [students at that school] got together with the uni supervisor at lunchtimes and morning tea. To hear other people’s stories: ‘I did this, and this is the methods and the technique and the strategy I used’. And the supervisor might say ‘All right, but that’s not a very good one, and I advise everybody not to use that method. What you should try is this.’ And it was just like a learning curve. Huge. It was great because we all bounced ideas. Sharing and learning. And that’s the way Murdoch has designed it. At one stage, we got a bit scared that we were isolating ourselves from the other staff because we spent all our morning teas and lunches in the Murdoch caravan. We’d all just go in there and eat our lunch and talk about this, that, and the other experience. It was really good.

**Rapport with supervisors**

Ninety-nine percent of the time I had a very good rapport with the supervisor. I was able to make contact with them when I needed. I’ve had three different supervisors (I was lucky I struck the same supervisor twice in two different pracs). This particular supervisor was very good - she made herself available up until the
wee hours of the evening if I ever needed to ring her and talk to her or ask her questions. It was very good for me to have this person to tap onto.

My last prac was in a pretty low socioeconomic area, and the kids there were having problems with drugs and crime. I even had policemen coming through my classroom and collecting kids. Which was a bit disturbing for me, but for them it was an everyday occurrence. To get the kids to stop hitting each other was a task in itself, let alone trying to teach them something. So I had quite a few problem kids - I think in one class I had eight kids with ADHD. The uni supervisor just came up with strategy after strategy. I had all my books and I said, ‘What if I try this and what if I try that?’ I mean she didn’t just feed me with a spoon. She constantly was saying, ‘Oh, no. That mightn’t be a good idea in this situation’ or ‘Yes, that sounds good. Give it a try.’

She wasn’t a maths or science person, but that didn’t matter. It was the strategies and the behavioural problems I needed help with.

The Assistant Teacher Program

In this last prac we were almost independent. I didn’t get to see my supervisor often - I think it was once a week over six weeks. There was one other student in my school from my university and we got together for a bit of bonding and self-efficacy, which mostly occurred in the car park before and after school.

7.5 Case studies on differences in teacher preparation between different types of programs

7.5.1 Case study 8

PROBLEM-BASED LEARNING IN THE MASTER OF TEACHING AT THE UNIVERSITY OF SYDNEY

Rationale

That this was a distinctive type of program was clear from the initial interview (Appendix E, Program Description E12). It was also a pioneering program in the sense of being the first of its type in the nation. Its distinctiveness compared with the graduate entry diploma and bachelors degree programs made it a clear candidate for a case study, particularly with the recent growth in masters courses for teacher education. Aspects of the teaching approach, involving problem based learning and collaborative groups with a case studies focus, were also attractive to us. This program had also been identified as innovative by one of the responses from professional bodies (Ch. 5.3.2).
**Background**

The Master of Teaching at the University is a two-year postgraduate degree in teacher education, which commenced in 1996 as the first two-year postgraduate course in teacher education in Australia. Students enrol in a Bachelor of Teaching for the first three semesters during which they take coursework and two short (four and five week) sessions of practicum. They can exit with this degree, but around 95 per cent of students complete the additional semester of internship as a conditionally qualified teacher and the required post-internship conference to complete the M. Teach. The degree involves an issues-centred, case study based curriculum including collaborative group work, with an emphasis on problem-solving strategies. These represent a main focus of this case study.

**Interview with a method lecturer**

The case study included an interview with an academic staff member responsible for teaching in science method, Tony Sperring. We commenced with a discussion of broad aspects of the program.

The degree is offered as either a primary (K-6) and secondary (7-12) program, but with a common core of courses. In the primary program, mathematics and science and technology are two curriculum areas. Included in the secondary program, students can take a double major in science, mathematics or technological and applied studies, or two (or even three) disparate single teaching method areas.

Despite competition with one-year postgraduate programs of teacher education offered by other institutions, the demand for the masters program is reasonably strong, with an overall intake of around 200 per year. The only change noticed recently has been an increase in the primary cohort (currently ~75) compared to the secondary cohort (currently ~125). Perhaps the measure of the change is given by the fact that the last Dip.Ed. program for science at Sydney attracted 37 students, whereas the peak in the M Teach for science to date is 27.

The internship is the major part of the masters program, although coursework in the second year is slanted towards supporting this. During the internship each student is mentored by an experienced teacher, with academic staff visiting as an advisor to ensure that the internees meet their stated roles and responsibilities. The report written by the mentor is like that which would be written by a Principal/Faculty head on a new teacher after the first year of teaching, and thus less structured than the pro forma reports used for each Practice Teaching session. Students are assessed as ‘satisfactory or unsatisfactory’ for the internship and may be withdrawn from the internship if their performance does not meet the stated criteria.

The masters component, where they are placed out in a school, has been arranged as a HECS fee-free component. A range of partnership schools, with which special arrangements including in-service activities for teachers operate, are used primarily, but other schools may be used and there is the opportunity for interstate or even overseas internships.

Typically, at least twenty students are preparing each year as science teachers and a slightly smaller number as mathematics teachers. Some students choose the program because they like the idea of doing a longer preparation for teaching; some have an allegiance to Sydney U. through their earlier degree; and some see the value
of a masters qualification in a competitive marketplace, particularly as an ‘edge’ for getting into the private school system.

Graduates of this degree in science, mathematics and technology have in previous years tended to end up disproportionately in the private school system, partly because ‘it’s been a seller’s market in science’, but more will be entering the public school system this year.

Distinctive features of the program

When the program was initially set up, there was a conscious effort for it to be ‘not just a longer Dip.Ed.’

There was an attempt to recognize that the traditional kind of lecture delivery, ‘tips for teachers’ kind of in-servicing arrangement wasn’t the way to go in the changing environment. A lot of work was done to try and put students in a situation where they looked at real cases in the school system as it currently is, rather than those drawn from the memories of lecturers from their days as teachers.

The core cross-curriculum program Study 1 has been a focus for a lot of development work based around real cases. The program also aims to get students to themselves explore case studies when they go out into the schools, to author their own cases, and to develop an action research project, which involves them in looking at certain issues while they are in practice teaching and later on in the internship.

The course was developed, as far as possible, to be seminar- and laboratory-based rather than lecture-based, although there are still key theme lectures in some parts of the program. They have also focussed very much on small group work, trying to get students to design projects of interest to them and to explore issues from that viewpoint rather than a set curriculum. The program in science is ‘an evolving and flexible one’, and the student-centred focus is clear.

In any year, it won’t be the same order of activities … because it will evolve and shift and change depending on the cohort of students involved.

This places a demand on academic staff to remain flexible and be able to address issues as they arise, which reflect the students’ prior background in science and the sort of experiences they’ve had. The majority of students, perhaps no less than 90 per cent, enter the program directly after a prior first degree, although some are returning after a period in the workforce. Some students may hold an honours or even research postgraduate qualification in science, but this number is small.

Sorting out a way of making it possible to complete a higher qualification in science while doing this program is something that has been considered as worth addressing. From 2002, it will be possible for Sydney University graduands to complete the 4th year of their B.Sc. Honours studies (over two years rather than the normal one year) whilst doing the B.Teach. or M.Teach. program.

Students are placed in a situation where they have to take up an issue, explore it, find out for themselves and report back. The program is, overall, putting the responsibility onto the student, treating them as a masters level students and not as students in the final year of an undergraduate program.
Problem-based learning

The move to a problem-based approach was driven by a number of factors, including the belief that:

*the old Dip.Ed.s were essentially giving our answers to yesterday’s problems. If we wanted people to develop as life-long learners and develop a professional attitude towards teaching, they ought to see it as more than just a craft you learn once, and then you’re set for life. We’re trying to encourage the notion of on-going reflection on practice.*

A lot of emphasis is placed in the course on people being reflective on the kind of things they are exposed to, reflecting on their own experiences, writing those reflections and discussing them with their peers, and reporting back on them. The program development involved deep consultation with practising teachers regarding their recent experiences and current incidents and issues. Building on model case studies, students are required to find and develop their own case studies.

*There is a focus on the philosophy that genuine learning comes out of genuine situations and problems.*

During the initial *Study 1* component of the program, students are not separated according to their discipline allegiances at all. This component runs for the first six weeks, involves no specialist curriculum material, but included six visits out to different schools. It is built around seminar-based discussions, introducing them to the concepts of problem-based learning, case-based learning, and collaborative learning. This is an intensive introduction, and the change in style is ‘a bit of a shock to a science student’. The very first time the science and mathematics students meet as a discipline cohort is in week seven, during a two- or three-day off-campus ‘camp’.

The issue of whether anything can be ‘missed out’ in this flexible, student-centred program was raised. It was suggested that the flexible program was inherently harder, as it was harder to drive the whole thing.

*On occasions, not everything flows out of a problem that is realistic, and then you have to go to the literature and go through the process of setting some fairly traditional topics.*

As far as possible, triggers or starting points for discussion are sought through the program. The program is fairly well supported by both research-based library material in the main library and by a curriculum library in the faculty. Regular culling of library material is making things more difficult. A fairly extensive web-site supports the program, including a facility for message-board and chat-room discussions. Science and mathematics students seem more amenable to this approach, being much less technophobic than those in areas such as humanities.

Students in the sciences attacking the problem-based learning approach get no detailed pre-preparation, but are ‘led gently’, through ‘brainstorming’ in groups which report back. Only if the groups don’t come up with appropriate or reasonable answers are suggestions for ways forward or resources worth consulting made by the lecturer.

*The tension is always between me ‘knowing’ the answers and telling them, or me holding back and letting them discover for themselves.*
Intentionally, students are put in situations where they don’t rely upon the lecturer. This is probably easier to do with graduates then it would be with commencing undergraduates.

The science core course is built around giving students a small teaching task, which they do very early on without a lot of guidance. The kinds of things that happen in those teaching tasks are then taken apart and analysed.

Of course you see initially a lot of traditional standards, such as using the overhead projector. Things that are not appropriate for school situations are then discussed. Gradually, students pick up on the kinds of messages that have been coming at them.

Incidents that have been reported in the paper or other media, or reported back by students during internships, are examples of the way a case study may be developed for new students. All the time, new ‘real’ cases, as distinct from those already in the literature, are being sought. Occasionally literature cases are used, if considered necessary. Case studies revolve around an incident being explained, and then students being required to decide how they would deal with it themselves. The developing new school syllabuses of recent years have also been the basis of cases and discussion, directed to how students would develop new programs to reflect the new syllabus, and the implications of the new programs. To varying extents, science, mathematics, and design and technology use similar approaches.

Students are divided up into working groups of four to six people as collaborative working groups. These are not ‘constant’ groupings, and may vary from task to task and perhaps even session to session. For one of the big pieces of formal assessment due at the end of first year, they work for an extended period in a group of three or four on a particular school-based topic, developing a unit plan for a particular year class. Beyond the Study 1 component, students work in method-based groupings. Mixing of students taking different teaching methods happens not deliberately but by default, since half of science students are taking two distinct methods (science-mathematics, science-geography, or science-language, for example).

One target sought is to push them out of the role of being apprentices and more into the role of having to make decisions themselves and analyse the material coming to them more critically and more reflectively.

I say to my students, there’s a plethora of material out there – that’s not the problem. The problem is sorting the good from the bad, and creating good and not bad [material].

Other aspects

The change from the Dip.Ed. to the M.Teach. program at Sydney coincided with moving from a new to an old building, by serendipity. This permitted redesigning the laboratory used for science, including flexible furnishing and introducing the ability to work with computers in the laboratory. In this new environment, new modes of teaching, beyond the lecture followed by laboratory approach, are possible. Most of the materials used are now on the web-site and, along with the internet, is accessed directly by students during teaching sessions. Students become familiar with using computers in an everyday fashion.
Undergraduate double degree programs in science and education have also recently commenced, and students in their third year will be streamed in with the masters students for science curriculum work while still doing their science studies. This will introduce new and as yet unknown issues.

The greatest problem with the masters course at present is simply somewhat lower enrolments than would be preferred; a cohort of at least thirty, rather than in the twenties, would be best. With a slightly higher cohort, the opportunity to run a greater number of specialist curriculum-specific electives would exist. For example, in the past five years, the physics and earth science specialisation has only been able to be run once; at present, only biology, chemistry and senior science specialisations are run every year. The consumables and minor equipment budget is also dependent on student numbers, which obviously affects what can be sustained and achieved.

Relationships and interactions with the Faculty of Science are good, and the Dean of Science is supportive. Some joint teaching of courses exists, and restructuring of the primary teachers science program in a course with components of all the enabling sciences is an example of the cooperation.

Interview with students

Three students who had just completed the masters program this year were interviewed; in fact, this interview was held on their final day in the program. Each had a different background: one was a Sydney science degree graduate; another was a combined degree graduate from another university; the third was an engineering graduate from another university with professional workplace experience. The first two had both taken science method in chemistry and biology, the third had taken combined mathematics/science method. All expressed strong, positive support for the program they had undertaken. They saw themselves, through this particular masters course, as being prepared as ‘the leaders in tomorrow’s schools’, with the expectation of going on to subject master or principal positions in the future. They saw this as an exciting concept.

Students came to the degree through different paths:

- I was an engineer. … I didn’t like the way things were run. … The companies were run just on money, and I just didn’t agree with that. I was tutoring kids, I liked that, thought I had a talent for teaching and decided to go in for teaching.
- I was doing a double major in chemistry. I thought ‘I don’t want to work in a lab all my life, … It just doesn’t challenge me.’ I wanted to work with people, and I decided ‘Teaching was me.’ … I didn’t want to go to another uni, I wanted to stay here.
- I wanted to learn teaching skills because I thought they would be helpful for the rest of my life [whatever I did]. … I heard that there was a new course here that was really good, and I really liked the idea of two year’s training. I thought I’d be better trained, and I really loved uni, so I wanted [was happy] to stay.

Students recognised that the program ‘pushed’ a particular educational philosophy. They didn’t think this was necessarily a bad thing, but saw it was just one viewpoint amongst a suite of possible approaches. The need to run a program under the cover of an overarching philosophy was appreciated, but some reflected on whether there
were other facets of teacher education they could have experienced. This was not a negative comment, but just a reflection on the possible ways a teaching program could be approached.

Reflections on the program of study
Students readily identified cooperative learning and group work as things they particularly liked about the course. The absence of strong competition between students that the pass-fail mode created was supportive of the group approach to teaching and learning. Students were more willing to help each other and work cooperatively. The pass-fail nature of the course added to the enjoyment of the course after more competitive science or engineering degrees. As one student said:

*At first I thought 'Wow, I'm only going to do the minimum – I only need to pass.' But after a while you think 'I really need to know this stuff,' and you learn for the sake of learning – which is quite nice!*

Learning how to deal with likely situations in the classroom was thought to be one valuable outcome of the case studies examined in the course. In fact, students would have preferred even more of a case study approach:

*They definitely work – I'm sure they work.*

They felt they got a lot of tips and information from staff, and thought them very helpful.

*The lecturers were great – they were really supportive.*

As a whole, when I compare it to my engineering degree where there was just no relationship built between students and lecturers, [I can say] here it's different, much better – and these guys can actually teach!

Students thought the whole first semester of the course was heavy on theory, which downplayed the practical aspects of teaching.

*It was really hard to see how what we were learning was going to be correlated with classroom practice. We came out thinking 'I'm going into [classroom] prac, I've got no idea what I'm doing, I haven't prepared well for this'.*

After the first session of practicum, however, some students saw more relevance in the first semester of work. As one student reflected on the overall practicum approach in the degree:

*There's progressive development in the course. There's two prac sessions each four weeks long, and before you do the first prac you get to observe a few classes in different schools. It's not just 'throw you in at the deep end and that's it'.*

Students noted that as part of the first practicum session they also had three days in their host school before they started teaching, getting to know it, seeing the students, and familiarising themselves with the program. This assisted their transition. The second session left them more on their own in terms of preparation, but, as one student noted, they could draw on the experience from the first practicum session.

The final semester internship proved a generally popular activity and was highly valued as an experience by all students.
At first I thought – it’s ten weeks, I wish it was four. But when I got into it, it just flew; it went really, really quickly – and then you didn’t want to leave in the end because you got so used to the staff and the kids.

The amount of practical teaching involved was appreciated, particularly the opportunity to spend a whole term in a school. Looking back on the highlights of the degree, one student thought of:

*mainly the prac teaching – they were good times.*

The opportunity to experience a range of school environments was also appreciated:

*The other experience was going to different schools – we went to a really, really elite private school and then to a small public school. The difference in the resources and the way things occurred in the schools was an eye-opener.*

One student thought that perhaps the only downside to the two-year program is the extra financial demands placed on students by the length. This was particularly felt by the time of the internship; according to those interviewed, a few students dropped out of the masters and took the bachelors degree instead simply due to personal financial problems. The coordinator reported that 16 of the 2001 graduates took the B.Teach, whereas 172 completed the M.Teach. (there being a separate weekend mode for overseas trained teachers specifically enrolled just for the B.Teach.) and that typically around 90 per cent of those doing the course completed the full M.Teach. program.

With backgrounds in science or engineering, where they said they were used to a faster pace of learning, there was a general view that the program could be compressed into three semesters, while retaining the same amount of practical work, and still be successful:

*I think that the amount of [formal] learning could effectively have been done all in one year. I feel it dragged out.*

While instruction on classroom relations and management and teaching strategies was included in the course, and was considered really helpful, the amount of time spent on this aspect was not considered sufficient by the students interviewed. It was thought that the case studies provided some help with regard to this, but didn’t probe these issues too deeply. They recognised that this aspect comes with experience, but they felt they needed more formal/directed work on classroom management issues in addition to that raised in the case studies.

Students had chosen to complete the masters degree for a number of reasons, including:

*I didn’t feel competent after one and a half years to go straight into a full load teaching. I really wanted more practical experience.*

However, one student thought they weren’t necessarily prepared for the demands of a full teaching load, as even in the internship they worked on a reduced load.

*There’s this pressure on you to come up with a perfect lesson every time. I don’t think that’s realistic. To plan those perfect lessons takes a lot of time, and it just doesn’t happen immediately.*
The science coordinator defended the 60 per cent-of-normal teaching load as an essential part of the internship, and necessary to allow students to complete their other coursework.

We want to give students the opportunity to experience real, unsupervised teaching and also to reflect on their experiences and critically appraise their preparedness to cope with the demands of an extended period of teaching without the level of support provided in a practice teaching session. If they had a bigger load they wouldn’t have the opportunity for meaningful reflection and self-analysis, nor for their work on their action research projects (for Pass candidates) or honours projects (for Honours candidates), which are a part of the internship.

Nevertheless, students generally were comfortable with their ability to perform well as teachers when they commenced teaching full-time. This confidence came in part from the extended experience of the internship. Further, wider ‘world experience’ of being slightly older as graduates when they started training, even possibly including some other prior work experience in a different field, assisted them in being confident of their ability to teach and handle children.

I never thought I was going to go on to a teaching career, but I got into it, and I love it. I can’t wait [to start teaching].

Another student suggested that:

The confidence I have in teaching comes from the prac, as opposed to the things I’ve actually learnt in classes. I don’t think I was well prepared for the teaching experience from the lectures, but I don’t know how possible that is. You’ve got to be there, you’ve got to experience it.

Overall, the nature of the final semester was clearly attractive. For the extra investment of time and personal effort they acquire a masters degree ‘which looks better’ than a bachelors degree, and they get much more classroom experience and the opportunity to reflect on their experiences. The students didn’t consider they would be doing any additional study at least for a few years, but likely would consider doing something else later. They thought it was time to get out and earn some money. As regards further study, one student concluded:

That’s what teaching is anyway – learning new things every day.

The students felt better prepared for teaching as a result of their two-year program, and more likely to remain in teaching long-term.

If I like it I’ll stay. I don’t think that I won’t like it, but it’s just that there are a lot of other things I want to do. But in the end I might say I’m happy in teaching, why change.

This would seem one outcome a successful program would hope to achieve.
7.5.2 Case study 9

THE PEER TUTOR PROGRAM AT THE ROYAL MELBOURNE INSTITUTE OF TECHNOLOGY

Justification

The Peer Tutor Program is not a formal teacher education training program, nor even a course within such a program. However, it was selected for a short case study because it has relevance as a course creating links between non-education students and schools, providing education experiences for students who may be considering later teacher training. Thus it also has a role in developing attitude change amongst science undergraduates in terms of later training as a teacher. It is an example of a number of such programs that have developed from within science faculties in several universities. The program at RMIT has received support for several years from the Science in Schools initiative of the Victorian Government, and is based on the STAR program established earlier at Murdoch University. One of the factors contributing to the selection of this program was that science deans had described the importance of these types of 'project subjects' and the creation of collaborative links between schools and university science faculties (Ch. 5.2.2).

Background

This case study included interviews with the Dean of Science, Prof Mal McCormick, program coordinator Mr Nick Besley, and program lecturer, Dr John Farrell, as well as a student who had completed the program. Printed information pertaining to the course and written student comments were also available.

In concept, the program sets out to foster interest in science and technology amongst primary and secondary students by the placed 'peer tutors' acting as role models for further study in these areas. Although developing interest in science amongst school students is the declared aim of the program, it has the secondary effect of developing amongst the peer tutors a raised interest in science and technology teaching as a career. Anecdotally, about 20 per cent of undergraduates who have participated in the program at RMIT have gone on to take a Diploma of Education. However, as the program coordinators note, it is hard to see whether the program has changed their attitude significantly or whether they had a prior interest in teaching as a potential career in any case. Some students have suggested that they took the subject to see if they might 'like' teaching; others take it as an interesting and worthwhile elective.

Students in Science at RMIT are involved in a 'context curriculum', which includes a requirement for them to take two special one-semester context curriculum courses/subjects outside their major discipline area at second or third year undergraduate level. The Peer Tutor Program course is now an elective in this group.

Students who choose this optional subject are placed in a school class, the majority in secondary school classes. They are not involved directly in teaching, but more as a 'scientific teacher's aide', assisting individual students, answering questions,
checking student work, demonstrating experimental science, or any task the participating teacher deems appropriate.

**Program organisation**

The way the course operates was discussed first, in particular, the role of the school and teachers in the course was seen as a key aspect. The part played by the school was recognised as central to the success of the program:

> The program relies heavily on the cooperation and goodwill of individual teachers within schools to provide an effective experience for the peer tutor and for the students.

Teachers in schools must agree to participate in the program and must timetable the activities to fit in the teaching program. However, they provide limited advice to the peer tutors, since their role is otherwise mainly as a host. Some schools have chosen to participate in the program for several years, suggesting that they value the involvement. However, individual science teachers in schools are a primary and key contact, and their agreement is a core to program success. These same teachers also effectively provide the placement ‘content’ for the programs through their choice of involvement of the peer tutors. A certain amount of reliance is placed on the tutors’ initiative to seek amendment to the tasks if they feel they are inappropriate or too restrictive.

The program is adaptable to student preferences. As one staff member said,

> The program is very flexible for participants. They can be placed in city or regional schools, and may suggest and even assist in organizing their own placement.

Typically, peer tutors in metropolitan schools attend schools for half a day a week for a period of about eight to ten weeks. For regional placement, an intensive placement is more likely to be organised. Special placements are also organised; for example, a student with cerebral palsy was placed in a special primary school, working with students with the same disability; further, foreign students have also been accommodated, including with placement within the TAFE system. The effective operation of the program demands a deal of consultation and organisation, including with schools, which is a major task of one of the Faculty of Science administration staff. Participants usually focus on their own discipline major when in the school environment, e.g. mathematics, chemistry or physics.

Matching peer tutors with science classes in primary schools has proved difficult because science is often integrated intermittently into the teaching program, although successful placements have been arranged (for example, five out of 18 placements in Semester 1, 2001, were in metropolitan primary schools). Of secondary school placements, the majority has been in assisting junior science or mathematics classes, although placements as diverse as assisting senior psychology or advanced mathematics have been made. Where schools have been reluctant to take peer tutors, it generally relates to their strong and major commitment to hosting student teacher practicums.

At a regional level, students may be placed in an individual school for a number of days, performing essentially the tasks of the metropolitan placements, but in a concentrated timespan. Alternatively, they may participate in a ‘travelling show’
format, in which they present a ‘Magical Science Show’ to students and participate in workshops to explain the science behind the observations. In the words of one country science master, it was ‘good for kids to meet young people who had pursued science beyond Year 12’; another described the program as ‘a very valuable event’. Participating peer tutors also felt very positive about the activity, gaining enhanced basic leadership, organisational and public speaking skills.

**Program content**

The program is centred on a single one-semester subject. It involves a briefing and training session prior to placement. This compulsory session focuses on peer support; discussions about placement and likely scenarios, classroom dynamics, and the learning experience. Discussion of ways in which to draw out students in a class environment is included. Concerns the peer tutors may have about the placement are addressed with ‘hypotheticals’, designed to offer students ways of dealing with possible scenarios. This includes discussion of what they can do in situations where the host teacher is not providing effective activities. The time provided is short, but the object is classroom awareness and not teacher training. Faculty of Science staff carry out this preparation. There is recognition that this aspect of the course could be extended and improved, and there are plans to include a staff member from the Office of Transition (responsible for the ‘first year experience’ program) in the future. A debriefing session is also held following the placement. Assessment in the program is based on a journal recording the placement experience and a formal written report. There is no site assessment, with the assessment directed towards reflection and reporting skills. The subject assessment is graded in the usual manner.

**Staff and student perspectives**

It was noted that not only extraverted students choose the peer tutor program. Some appear motivated by the view that they wished they had had this type of support in primary and secondary school, and wish to be involved in providing it to others.

An academic teaching in the program noted that he was teaching science communication, and saw using mentoring as a better, or at least a different, way of teaching, which lead to his involvement in the peer tutor program. Enthusiasm for the program from Faculty staff was clearly high; in fact, is probably essential to maintain it effectively.

One student who has completed the program identified a desire to improve her communication skills as a key factor in choosing the course, while also noting a parental influence on her choice. Her classroom experience was with Year 9 and 10 students, and involved assisting in practical classes. A value for the high school students, in her opinion, was that:

> They felt more comfortable in speaking to me and didn’t worry so much about asking silly questions.

For this peer tutor, the experience was very positive; teachers in the school were welcoming and supportive, the in-school program was well structured and planned, and overall she now feels she is a better communicator. During her placement she
developed and demonstrated a small practical experiment, which also provided some exposure to occupational health and safety considerations during the exercise. However, it was noted that not all peer tutors had as positive an experience, as there is a deal of reliance in the program on the initiative of the host teacher and peer tutor.

The program has consistently achieved ‘very positive and even enthusiastic feedback’ from students participating as peer tutors. One student interviewed reflected on the personal satisfaction in seeing,

*faces light up when shown the exciting and fun aspects of science,*

and other positive feedback of this type certainly suggests that participants valued the experience.

In general, enhanced communication skills, and meeting the challenges of preparing for and presenting before an audience seems to be common outcomes. It is apparent that participants feel largely positive about their school-based experiences.

This, albeit restricted, ‘taste of teaching’ clearly offers a way of developing in science undergraduates a positive feeling towards teaching as a potential career. Obviously, the program has objectives beyond providing a ‘teaching experience’; the peer tutor program is firstly about ‘selling’ science to students, and secondly about ‘selling’ the institution presenting the program. However, in an environment where there are shortages of science, mathematics and technology teachers, the value of these programs would seem high and their role highly appropriate.

7.6 Case studies on skilling teacher education students in practices to develop literacy and numeracy in school students

7.6.1 Case study 10

THE ‘NUMERACY ACROSS THE CURRICULUM’ COURSE AT DEAKIN UNIVERSITY

Justification

This course was chosen as an example of a compulsory numeracy subject for secondary students. The original interview (Appendix E, Program Description E30) indicated that students conduct research on numeracy in schools and the community and deliver their findings in multidisciplinary presentations.

Our thanks to Susie Groves for information at a preliminary interview and to Helen Forgasz, for providing the information in this case study by emailing her responses to our follow-up questions. Responses are presented below under sub-headings relating to questions posed.
Discussion of the course

Reasons for the subject creation

The cross-curricular nature of numeracy is one of four ‘common understandings’ included in the report Numeracy = everyone’s business (Numeracy Education Strategy Development Conference, 1997). In particular, it was suggested that ‘all teachers in all subject areas accept responsibility for the development of numeracy’ (p. 88). It was recognised that this may be an ambitious goal, but that it was consistent with expectations nationwide with respect to literacy. In the report, it was suggested that ‘all teachers need to recognise the numeracy demands within learning areas and subjects and deal appropriately with them by taking opportunities to develop and enhance students’ numeracy within the learning area and subject’ (p.88). To assist in achieving these aims, it was recommended that the Australian Council of Deans of Education report what was happening in pre-service and in-service courses.

In the report, Preparing a Profession (Australian Council of Deans of Education, 1998), it states that graduates of all initial teacher training courses should not only be numerate themselves, but should also understand the contribution of numeracy to education and daily life, and be able to identify and respond to pupils’ numeracy learning needs. This report and its implementation in Victoria through the Guidelines for the evaluation of teacher education courses (Standards Council of the Teaching Profession, 1998), led to the introduction in 1999 of a compulsory unit Numeracy across the curriculum for all Deakin University students in the final year of their secondary teacher training course. (A similar unit in literacy was also introduced).

The course in outline

The stated objectives of the unit are to enable students to:

• understand the nature of numeracy and its scope and role in everyday life;
• develop their personal numeracy skills;
• recognise the role of numeracy and its inherent demands and opportunities within their areas of specialisation;
• develop teaching strategies to discern and respond to individual students’ numeracy learning needs within these areas.

All students studying to be secondary teachers, no matter what their teaching method, take this course. The course is taken in the final year of their studies.

The students study a range of topics through weekly lectures (one hour) and tutorial sessions (two hours) — average group size of about 30 — for the original course in 1999 are shown in the table below. The course has changed minimally since that time.
## Course topics

<table>
<thead>
<tr>
<th>Lecture</th>
<th>Tutorial (Workshop)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numeracy = Everyone’s Business</td>
<td>What is numeracy?</td>
</tr>
<tr>
<td>• Literacy = more than reading &amp; writing</td>
<td>• Startling statements!</td>
</tr>
<tr>
<td>• Numeracy is more than arithmetic</td>
<td>• Thinking broadly about numeracy</td>
</tr>
<tr>
<td>• Numeracy is everyone’s business</td>
<td>• Administration</td>
</tr>
<tr>
<td><strong>Numeracy Across the Curriculum — Some Examples</strong></td>
<td><strong>Numeracy in a Reading &amp; Writing Class</strong></td>
</tr>
<tr>
<td>• Quick examples of numeracy in everyday life</td>
<td>• Sample GAT (test) writing task on Greenhouse Effect — example of numeracy demand</td>
</tr>
<tr>
<td>• Examples of numeracy demands across the curriculum</td>
<td>• Spread of Cane Toads — example of numeracy opportunity</td>
</tr>
<tr>
<td>• Exploring social science issues</td>
<td></td>
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<tr>
<td><strong>Numeracy in Everyday Life — Some Aspects of Personal Numeracy</strong></td>
<td><strong>Numeracy Across the Curriculum &amp; Personal Numeracy 1</strong></td>
</tr>
<tr>
<td>• Interpreting graphs &amp; data</td>
<td>• Work in groups to discuss results from Assignment 1 &amp; plan presentations (half session)</td>
</tr>
<tr>
<td>• Examples of statewide testing &amp; what the results say</td>
<td>• Personal numeracy 1 — interpreting graphs &amp; data</td>
</tr>
<tr>
<td>• What is a benchmark?</td>
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<tr>
<td><strong>Personal Numeracy 2 — Number Sense</strong></td>
<td><strong>Numeracy Across the Curriculum &amp; Personal Numeracy 2</strong></td>
</tr>
<tr>
<td>• Calculators vs mental computation vs paper &amp; pencil arithmetic</td>
<td>• Groups presentations 1 (half session)</td>
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<tr>
<td>• Estimation</td>
<td>• Personal numeracy 2 — developing intuitive understanding of decimals</td>
</tr>
<tr>
<td>• Thinking strategies</td>
<td></td>
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<tr>
<td><strong>Personal Numeracy 3 — Measurement &amp; Chance</strong></td>
<td><strong>Numeracy Across the Curriculum &amp; Personal Numeracy 3</strong></td>
</tr>
<tr>
<td>• Understanding the metric system</td>
<td>• Groups presentations 2 (half session)</td>
</tr>
<tr>
<td>• Estimation &amp; benchmarks</td>
<td>• Personal numeracy 3 — measurement &amp; chance: the underlying concepts</td>
</tr>
<tr>
<td>• Chance — conceptions and misconceptions</td>
<td></td>
</tr>
<tr>
<td><strong>Professional Numeracy Demands in Secondary Teaching — An Example</strong></td>
<td><strong>Final Session</strong></td>
</tr>
<tr>
<td>• Scaling of VCE (year 12) scores</td>
<td>• Elaboration of professional numeracy examples from the lecture</td>
</tr>
<tr>
<td>• Effect of the GAT (General Achievement Test)</td>
<td>• Aspects of personal numeracy as requested by students</td>
</tr>
<tr>
<td>• Obtaining the ENTER (University entrance) score</td>
<td>• Student evaluation of unit</td>
</tr>
</tbody>
</table>

In 2002, however, the weekly lecture will be dropped. There will be a three hour tutorial each week. The course content will be adjusted accordingly — lecture content will be absorbed into tutorials. Further minor changes will be in response...
evaluation comments from students. Student feedback over the three years that the
course has run, as well as a persistent pattern of dwindling attendance at lectures as
the semester progressed lead to the decision to abandon the lecture. Tutorials were
well-attended throughout.

Assessment

The assessment items for the unit consisted of two assignments, the first
contributing a total of 45 per cent of the marks, and the second 55 per cent.

It should be noted that students are required to purchase the Reader for this course.
The Reader is comprised of a range of articles that cover the topic of numeracy
across the curriculum in general, and articles that highlight specific numeracy issues
within the eight key learning areas. They are directed to the readings at appropriate
times during the course. The readings provide background for the two assignments.
They are encouraged to read more widely and to surf the Internet for information –
we provide them with a list of useful URLs to begin their explorations. Until a new
edition of the Reader is put together, handouts of a growing collection of
contemporary readings are distributed.

The two assignments are reproduced below from the students’ Unit Guide for the
subject.

Assignment 1

Your task for Assignment 1 is to research the numeracy demands and opportunities
in one of your teaching methods. If mathematics is one of your teaching methods,
you will need to focus on your other area of specialisation for this assignment.

This assignment consists of three parts, as described below.

Part 1: (Approximately 750 words — 15 per cent).

Students are required to complete either part a) or part b). The wording below is
the wording provided to students:

a) In your own area of specialisation, select one of the following and analyse it in
terms of the numeracy demands and opportunities it exhibits:
   • a curriculum document — e.g. the draft Curriculum Standards Framework II;
or
   • a secondary school text book; or
   • a professional journal or magazine.

Write a brief report of your analysis. Make sure you clearly state your area of
specialisation and include a full reference of the material you are analysing.

OR

b) Observe a lesson in your area of specialisation and document the demands and
opportunities for numeracy in that lesson

AND

Interview a secondary teacher in your area of specialisation and document their
views on the demands and opportunities for numeracy in this curriculum area.
Prepare your questions in advance, but be flexible when conducting the actual interview. Tape record the interview so that you don’t need to take notes.

Write a brief report of your observation and interview and your conclusions about the role of numeracy in your area of specialisation. Make sure you clearly state the area of specialisation and provide all relevant information (e.g. the year level of the class observed). Make sure also that you include direct quotes from the teacher to illustrate your points.

*Part 2:* *(Approximately 750 words — 15 per cent).*

Conduct an interview with one of the following about their perceptions of the numeracy demands in the workplace:

- a secondary teacher;
- someone in the workplace outside a school;
- an employer.

Prepare your questions in advance, but be flexible when conducting the actual interview. Tape record the interview so that you don’t need to take notes. Use your tape recording to help you write a brief report of the interview and your conclusions based on the responses. Make sure also that you include direct quotes from the teacher to illustrate your points. Make sure you clearly state important background information about the person you have interviewed, such as their occupation and details about their workplace. Do not include any identifying information — e.g. use first names only. Do not include your tape recording.

*Part 3:* *(Equivalent to 750 words — 15 per cent).*

During the workshop in week 3, you will be placed in groups of four and will be given time to discuss your findings from parts 1 or 2 of this assignment.

As a group, select one or more issues to highlight in a ‘pithy’ (TV grab style) report to the rest of your workshop. These presentations will take place during weeks 4 and 5. The maximum time allowed for each presentation will be 10 minutes. You should make sure that you including adequate time for questions and discussion from the rest of the class within your allocated 10 minutes. At least two members of the group should present the information. Any handouts, overhead projector slides, graphs, etc., used in the presentation should be made available to your lecturer.

**Assignment 2**

You have been appointed to Grassy Knoll Secondary College starting in February 2001. The new Principal is aware that Numeracy is an issue which will be receiving increased attention. As a person who always strives to be at the forefront, she has decided to appoint you the newly created position of Numeracy Across the Curriculum Officer at the school.

As part of your job, she has asked you to prepare a school numeracy policy and make a presentation to the parents at a special Literacy and Numeracy Information Evening she has organised for early in term 1 — the new Literacy Across the Curriculum Officer will also be making a presentation based on the school literacy policy which he is developing.
Prepare an outline of the school numeracy policy. Include a statement indicating what you believe numeracy to be and why it is important. Make sure you indicate how teachers in at least three curriculum areas (other than maths and including one of your own areas of specialisation) can be involved in numeracy across the curriculum — give examples.

Your assignment can be presented in the form of a written essay or as a presentation in any format you choose (e.g. a video, a PowerPoint presentation, etc). Regardless of the format, it should show evidence of wider reading than just the articles from your Reader and include appropriate references.

(Equivalent to 2000 words — 55 per cent).

In seeking information about what interesting assessment tasks, projects, etc the maths/science/technology students do for this subject, the deliberate mixing of students from different majors was identified. The tutorial groups are comprised of students taking the full range of teaching methods; so too is the mix of students for the small group presentations. All students do the same tasks and nothing different is done by the maths/science/technology students.

Strategies to enhance individual numeracy skills

This has probably been the least successful aspect of the course. Attempts were made to raise awareness of assumed/expected numeracy skills in the various key learning areas through presentation of pertinent examples in lectures and working through others in tutorials. As the students’ own numeracy skills varied widely, some students found the examples very simple; others had extreme difficulties. Another difficulty was as a consequence of the mix of students in classes. Having students from all key learning areas in each tutorial group meant that any example drawn from one key learning area would prove irrelevant or uninteresting to a sizable number of students. We did not want to have homogenous groups as we believe that the students would not learn of the range of numeracy demands and opportunities for teachers in other discipline areas. We attempted to exploit these apparent difficulties to advantage. We put it to the students that they were likely to encounter similar difficulties among their own students. We emphasised that there was no simple solution to dealing with a range of skill levels and interests in the one classroom.

Strategies for overcoming number phobia

The team initially involved in developing the unit was acutely aware of this issue and its consequences. It was taken into consideration in devising the course content and the assignment tasks. It has turned out not to be a major problem with our students, all of whom are training to be secondary teachers. It is much more likely to be an issue with those in primary teacher training courses. With our large number of students, there are sure to be a few who do suffer number phobia. Throughout the course, we use a lot of examples from newspapers and from students’ own everyday experiences to illustrate numeracy demands in daily life, how well many already deal with them — often unaware that they are doing so — and hence that numeracy is ‘everyone’s business’. In so doing, we believe we are indirectly challenging some of the fears. When we discuss the examples, we expose the numeracy demands present to which, in many cases, people respond.
automatically and appropriately. In other words we highlight numeracy skills that the students may not previously have recognised that they had.

Students’ opinion of this course

In the evaluation of the course, we invite and encourage constructive criticism of all aspects of the course – content, structure, lecturers/tutors, assessment, etc. This year it was noted that, at the beginning of the course, students were more aware of the relevance and importance of numeracy than previous cohorts. This, we feel, reflects the concerns evident in the educational community at large. In their evaluations, they commented negatively about the lectures – a consistent pattern over the three years. Their criticisms focussed on the overlap between lectures and tutorials and, because of the poor timetabling of the lecture, why they were not attending. As mentioned above, the weekly lecture has been abandoned for 2002.

The students spoke highly of the assignments. In particular, they noted how much they had learnt in the preparation of the group presentations, the interviews with teachers or employers, and in trying to develop a school-wide policy for Numeracy across the curriculum. The relative weighting of the components of the assignments will be re-assessed in light of comments received.

Things staff like about this subject

I am particularly pleased to be involved with teaching this course. I like the subject per se. I think it has been a timely inclusion into the secondary teacher education program. I have always believed in the interdependence of disciplines and the importance of bringing this to the attention of my students – whether at the school of tertiary level.

With respect to this particular course, I believe the assessment tasks to be particularly pertinent. Student comments, as noted above, echo these sentiments. Interestingly students commented that this was the first time in their tertiary courses (including education courses) that they had been assessed on a group ‘product’. I believe the content as outlined above is very appropriate. I enjoy the flexibility of being able to adapt the content to current, contemporary issues and concerns.

Problems encountered and solutions employed

(The questions of what problems were encountered and how they were solved were asked to provide information to help other people who may wish to set up a similar unit.)

I believe I have already covered the main difficulties we have encountered with various aspects of the course and the ways in which we dealt with them.

I would strongly encourage others to include detailed evaluation forms, and allowing classtime for students to fill them out. It is important, I believe, to invite students to comment on the good aspects of the course and to be constructively critical. It is also important to act on their valid criticisms and build on the outlined strengths.
7.6.2 Case study 11

NUMERACY IN THE BACHELOR OF TEACHING (7-12) AT THE UNIVERSITY OF TASMANIA

Rationale

This program was chosen for case study as an example of an innovative numeracy project. The original interview (Appendix E, Program 29) indicated that students used a website which linked to a local newspaper, and developed numeracy experiences to be used in schools. One of the factors contributing to the selection of this program was that the literature review had indicated the importance of developing authentic numeracy experiences in which mathematics is presented in real life contexts (Ch. 4.6).

Our thanks to Jane Watson (the mathematics education lecturer), Rod Boucher (the education services manager at The Mercury, Hobart) and Jonathan Moritz (a PhD student in mathematics education at UTAS) all of whom were interviewed about the project. Our thanks also to the five secondary mathematics education students whose interview comments are quoted below.

The website


The ‘Chance and Data in the News’ website is a joint venture between The Mercury and the University of Tasmania. The site presently contains about 200 newspaper articles which were collected from The Mercury and other News Limited Newspapers throughout Australia. Attached to each article is a series of questions for students as well as a teacher discussion section and an index of related articles. The teacher discussion section raises some pedagogical issues, which link in to the student questions. Many of the articles are supported by images from the newspaper (graphs, pictures or diagrams which have been scanned from the original article). The articles are grouped under the mathematical subheadings, Data Collection and Sampling, Data Representation, Chance and Basic Probability, Data Reduction, Inference, and Numeracy. The articles may also be accessed under other subheadings such as crime, diet, entertainment, environment, gambling, gender differences, health, traffic, sport, humour and smoking. An example of an article, with its related student questions, is appended below.

The articles are selected and put onto the site by Jane and Jonathan, who check The Mercury (and other newspapers to a lesser extent) on a daily basis. The articles are cut out and scanned in in their original form, so they have an authentic newspaper feel to them. Jane also writes the student questions and teacher discussions which appear with each article. The Mercury provides the website itself, some editorial promotional support, and some support through fliers in schools. The big advantage of using the Mercury website however, is being able to put the actual newspaper articles on line without breaching copyright.
The website provides a way for teachers to tie maths in with literacy, and with current affairs issues, by using the daily newspaper. The aim is to make mathematics relevant and fun by looking at how it is applied in real life.

How it is used in the teacher education program

The website is used in the mathematics curriculum unit in second year. As well as the secondary mathematics education students, students who are enrolled in primary and middle school programs also use the website. This year, the students had three tasks, as follows.

Firstly, they were required to go out and find a newspaper article themselves (they were given a model from the Mercury website) and to create a poster which displayed the article, with some questions and an explanation of how they could be used in the classroom. In other words, they had to find an article and mimic what was in the website. This assignment was assessed and given back to them with suggestions and comments. The purpose was to give the students experience at recognising an appropriate article and writing questions themselves, rather than just relying solely on the Mercury website.

As a hurdle requirement, the students were required to review the questions written by their colleagues and comment on them via WebCT. The software program WebCT was chosen because it offered a simple way to have restricted access to on-line discussions. Only students enrolled in the course were able to access the materials, so it provided an opportunity for the students to find their article and do their questions in a safe environment that wouldn’t be viewed by outsiders. Jane responded to their comments, also via WebCT.

The second thing they had to do was to use an article and questions in their teaching. They developed a lesson plan, and taught it as part of their internship, towards the end of their second year. They were allowed to use articles from the Mercury website for this teaching if they were more relevant to the school curriculum at that time, or if they would be more motivating to kids. They were not restricted to using their own chosen article in their teaching, although a lot of them did.

The third task was to write an evaluation of that lesson. Some interesting things came out of these evaluations. For example, the middle school students reported that every day, for a week or two afterwards, the kids would bring in newspaper articles and show the teachers what they had found. A few students reported that the kids didn’t believe it was maths, so that led to a debate in the class.

Student comments

The following are excerpts from students’ interview comments about the program.

- It puts numeracy where it should be – in the everyday world.
- It brings in a new dimension into the maths, and it essentially integrates it.
- It gives some practical application for what you’re doing in the classroom. They [kids] can see in a real world context what’s going on.
- It’s something innovative and it’s something the kids haven’t seen. It’s a lot about taking a risk. Because it’s new, you don’t know what is going to happen.
and how it’s going to go, so if it goes all right or really good then you’re more prone to taking more risks in your teaching.

You can see application of maths. It’s not just knowing whether or not a kid can do a procedure, it’s actually seeing the application, which is really important. There’s just so much maths in the real world and they don’t see it in the real world. They see it as numbers on a page, but it’s more than that; it’s everywhere. That’s what I want to give to kids.

Examples used by the students included:

Recently there was an article about logging old growth trees, and on the front of The Mercury they had a picture of the casino and an old growth tree and we (with grade 8) did ratios of the two. It was just a really nice visual clue.

The cartoon said, ‘Crime is down by 8 per cent’ and then the fellow is holding this fellow up and saying, ‘Give me 92 per cent of your money’. That was really good to discuss about percentages.

I used a collection of articles (grade 9) to show how graphs are represented in the newspaper. We looked at pie charts and the different ways they were represented (like the idea of using a roulette wheel divided up to show how much money people were spending on gambling). We also looked at line graphs and bar graphs about population, and picture graphs, and also there was an unusual bar chart which was made out of a football which was segregated out. A lot of the kids in the class are into AFL football, so they really got interested in that. It was an introduction into how we represent information.

I went through all the articles and found all the places where newspapers had misrepresented mathematical data, and got the (grade 7) students to just start thinking a bit more critically about what newspapers print, what the correct representation should have been, and how newspapers do influence their point of view. That seemed to work pretty well. It took them a while to appreciate what was going on, but once they did, that’s when the questions started coming. They started making their own graphs that would be misrepresenting other data, and then presenting what the correct one would look like and making the difference between them.

Problems and issues

The focus is on numeracy, and there are many newspaper articles relevant to the topic Chance and Data. However, newspaper articles are less useful for advanced topics such as algebra, trigonometry, factorisation or calculus.

At this stage, there are probably not many social science or health teachers who know that the site exists. One of the challenges is to find the time to go to their conferences and tell them about it, as a way of fully integrating it into other learning areas.

Some types of articles become dated when they have been on the website for a while, so their usefulness decreases.

Another problem is the question of whether kids in schools have computer access to the website. Although there is an increased number of computers in classrooms in recent years, it’s still not easy for a maths teacher to put the whole class on-line,
and the students often end up using photocopies of articles. The idea is to get the kids aware of what’s in the newspaper so they start bringing them in themselves.

Addendum: an example from the website

Space Rock Closes in on Earth

An asteroid 1.5km wide is heading for Earth—and is due to arrive on October 28, 2028.

Scientists say the chances of the massive chunk of space rock colliding with Earth are tiny. But uncertainties in the measurements of its orbit mean scientists cannot rule out a collision.

They certainly expect it to come closer than the-Moon, which is about 386,000km away.

In fact, their best estimate is that the asteroid will whiz by at a mere 42,000km.

Astronomer- Dan Green, of the Harvard-Smithsonian Centre for Astrophysics in Cambridge, Massachusetts, admitted: "Right now one has to say that Earth is within the error bars."

This asteroid is not as large as the one that scientists believe hit Earth 65 million years ago, killing two-thirds of all life, including the dinosaurs.

But it is thought to be the largest object known in human history to have passed this close to Earth.

The asteroid, designated 1997XF11, was found in December and its newly calculated orbit was announced yesterday in the email version of the International Astronomical Union Circular.

There is no internationally adopted plan for what to do if an asteroid is seen on a collision course with Earth.

Many astronomers and space enthusiasts have come up with detailed proposals in the past, ranging from zapping an approaching asteroid with a laser beam to blowing it up with nuclear explosives.

An asteroid 1.5km across could strike Earth with enough force to wipe out a quarter of the human population, say scientists.

Most of the damage wouldn't come from the impact itself but from the dust that would
be kicked up into the atmosphere, blocking the planet from the sun's warmth. Odds are that an impact of that size occurs about once every 300,000 years. Right now, the asteroid is moving away from Earth about 80,500km/h. Scientists already know that on October 31, 2002, the asteroid will take an early swing by Earth at a safe distance of 9.6million km. Astronomers are now planning more observations of 1997 XF11, and are looking to see whether the asteroid shows up on older photographs of the sky. "The accuracy and precision of that orbit should improve every time we find something," said Eleanor Helin of NASA's Jet Propulsion Laboratory in Pasadena, California. Ms Helin heads another project to locate and track near-Earth objects. Any new observations would help, but it would take some time for astronomers to calculate the precise orbit. The closest recorded asteroid-Earth encounter occurred on December 9, 1994, when a very small asteroid passed within about 105,000km. There are several groups of scientists now working to find and follow objects that could one day threaten Earth.

**Space rock closes in on Earth**

Student Questions for this article

1. What fraction or percentage of the distance to the moon, is the asteroid expected to come to the earth?

2. How far does the asteroid travel in a day?

3. How do you think the scientists calculated the 'odds' near the end of the article?

4. Why do you think scientists wanted publicity for this story?

Teacher Discussion for this article

This article is an example of scientists providing a study to the media with a purpose. In this case one suspects it is to attract attention, and perhaps funding of "early warning systems". It is difficult to imagine the distances but students might draw a solar system drawn to scale and indicate where the asteroid's path would take it in relation to the earth, moon and sun.
The odds reported at the end are in unusual form and raise a question as to how they might have been calculated.

There are several opportunities to discuss fractions, distances, time and rates from the numbers provided in the article.

7.7 Case study on the exposure of teacher education students to school projects and programs

7.7.1 Case study 12

THE LANDCARE PROJECT IN THE BACHELOR OF TEACHING (7-12) AT THE UNIVERSITY OF TASMANIA

Rationale

This case study was chosen as an example of a high quality link between a school project or program and a teacher education program. The initial interview (Appendix E, Program Description E29) indicated that secondary mathematics/science students in the Bachelor of Teaching (7-12) at the University of Tasmania were involved in a Landcare project in a local gully, then go on to work with schools on Landcare projects. One of the factors contributing to the selection of this case study was that the literature review had indicated the importance of school projects which have authentic, real life contexts (Ch. 4.7).

Our thanks to Natalie Brown (Faculty of Education) and Tania Stadler (Faculty of Science) whose comments are paraphrased below, and to the secondary science education students who agreed to be interviewed.

About Landcare

Landcare can be viewed as another way of doing environmental education. It is a community based movement but has been supported in the past by state and federal funding. In practice it often consists of community groups dotted around the rural areas and the towns. These groups meet once per month to do some rehabilitation work on a particular area that they have decided to take responsibility for. Schools have become more and more involved in Landcare because the children can work on their little bit of bushland and start to look after it and develop a sense of ownership and responsibility. Landcare originally started out as an agricultural movement but it has grown to be much more than that. It now has a whole community, whole catchment approach. It encourages the whole community to join together at catchment level to take responsibility and take action.

One of the aims of Landcare is to get young people involved in the projects, and Tasmania has been quite innovative in Landcare education. Landcare education officers are employed through funding from the Natural Heritage Trust, and this funding supports Tania’s involvement with the project. The Landcare project
within the teacher education program is therefore a joint venture between the Faculty of Education and the School of Geography and Environmental Studies (within the science faculty).

**Landcare in schools**

There are a number of different approaches to implementing Landcare in schools. Some schools have taken a whole-school approach. For example, some schools are heavily involved in the swift parrot project. The swift parrot is a threatened species, and this project has involved school children in planting blue gum trees on the migratory route for the swift parrot and looking at ways to reduce parrot deaths (e.g. from collisions with glass windows in buildings). There have also been interactions between city and country schools with the tree planting.

At other schools, individual teachers take the Landcare project and implement it with one or two particular classes.

In Tasmania, there is a new curriculum initiative, the ‘New Essential Learnings’, which is similar to the New Basics model in Queensland in that it emphasises authentic learning experiences. One of the advantages of Landcare is that it fits quite nicely into the sorts of aims of the New Essential Learnings. As a result, a number of secondary schools have picked it up as a vehicle for delivering the NELs and several other schools have recently expressed interest in adopting it. Other schools have recognised its value in keeping kids interested in science by taking them outside and getting them to do hands-on things. They often find that it interests kids that may be disenfranchised by traditional science classes.

**Why we use Landcare in teacher education**

We thought that Landcare offered an opportunity for our education students to get hands-on experience in authentic learning in science. It would help our students to understand that you don’t need to go far away from the school, and you don’t need to spend a lot of money, in order to provide kids with science learning in a real life context. There are a lot of really good activities you can do in the school’s backyard. It also offered the students an opportunity to meet people from a range of community organisations, and to see the things that they do, so it was encouraging them to make links between the schools and real community groups.

Landcare projects generally have the advantage of integrating different science disciplines (e.g. the biology of plants and the chemistry of water). However, the way we use Landcare also offers the opportunity for the science students to work with SOSE (Studies of Society and Environment) education students, to learn from each other, and to learn to integrate the two areas. For example, the water quality surveys were chemistry based and would be a new experience for SOSE students, who could however, help the science students to understand the political and historical aspects of the project.

In summary, our main aim is to give the students some understanding of Landcare, and confidence to implement it in schools in creative ways. One spinoff of this project is that it also helps to set up positive links between the university and the local schools.
How we do it

The project is part of the second year science curriculum methods subject. The Landcare component has three main phases - the students firstly learn about Landcare, then they implement it in a school, and finally they prepare a resource portfolio. These are described as follows.

Learning about Landcare

Our idea is to allow students to have hands-on experience in all aspects of a typical Landcare project, including the surveys, site preparation and weeding, just as the students in schools would have.

We picked Lambert Gully, which is an area of bushland located in an urban area close to the campus. There is a stream going through it, but the gully has been invaded by blackberries and other garden plants. However, it is an important site because it is a refuge for a number of threatened species, such as the swift parrot, the forty-spotted pardalote and the eastern barred bandicoot. A local Landcare group is actively involved in working in the gully.

We took the students there and firstly did some orientation activities which they could use with children to familiarise them with the site. Then they found a patch which needed regenerating and did plant surveys, including weed surveys, to work out which plants needed to be removed and which types of plants should be planted. The students pressed plants, made herbariums, collected seeds and studied how to propagate them. They also cut blackberries (which wasn’t a very popular activity!) and did water quality testing and bird surveys.

STUDENT COMMENT: I know that most of the class were very negative to begin with, and we saw it as almost a waste of time - How is this going to help me to become a better teacher? But at the end you can see that it’s been a very positive, productive exercise.

We had experts from a number of organisations including Waterwatch, the NPWS, and Greening Australia who came in and taught the students how to do these things. We also had support from the Hobart City Council, which was excellent because they provided a bush crew to help supervise some of the weeding sessions, and they were there for the tree planting.

STUDENT COMMENT: To see the modelling of our lecturers in terms of what they were doing with us, and to see how they had pulled in resources, people from outside, to do much of the actual teaching for the project. They were quite comfortable in saying to us that they didn’t have the skills or the knowledge but they could find it for us. So that was good in that it gives you the confidence to know that I don’t have to know everything - I can go out and find resources and bring them in to the classroom, or take the kids to the resources.

The experience thus allowed the students to physically work on the site as well as gathering information on appropriate techniques. The other part of the project was a celebratory media event, which involved students in media releases and tree planting, so the whole experience was a rich task which followed exactly the sort of things which they could do in a school with the kids.

Implementing Landcare in schools
The students are expected to implement a Landcare project or activity in a school. They are put together in cross-curricular groups of four to five students (each group has some SOSE and some science students) who are expected to work together on the project, then each group is allocated to a school.

STUDENT COMMENT: It was really good to go outside and use the school environment as part of our teaching area, but it was also a safe way to learn it. If you’re out there with five other student teachers and something goes wrong then one of you can go and deal with that and you’ve learnt that lesson.

We have five schools involved in the Hobart area. Each group is required to negotiate with the school as to when they would go to the school and exactly what they would do with the kids (we felt that this process of negotiation would be a valuable experience for the students).

The time the students spend in schools is not part of their practicum - some of it is time taken from their science curriculum method subject, and some is their own time. This year the students spent two full days in their schools (our time was limited but we would like to build on it in future) and did a variety of activities. One group initiated Landcare in their school by taking children to Lambert Gully, showing them what had been done and then replicating the activities on another patch of ground that the school owned. This set the Landcare project in place, to be continued by the teachers. Others went into schools where there were existing Landcare projects and ran specific activities with the kids.

STUDENT COMMENT: We took a group of 15 girls on the excursion with us. We went to Lambert Gully reserve and had someone come in from the city council and talk to them about the history of the site. They collected weed samples to start a herbarium on weeds and did some water sampling at different points. We looked at community use of the site and the different values which the community may have for an area. [How did the kids respond?] They were positive. Just to actually know that it was there was a whole thing on its own.

In all of these cases, the students were expected to use Landcare activities to encourage active citizenship, to allow the kids to have hands-on involvement, and to present science content in an authentic context. They were expected to take the students outside the classroom to experience a particular environment and provide a real life context for science learning.

STUDENT COMMENT: The interesting thing about it was that because we weren’t their teachers, we got to relate to them on a level that was a little bit different to what we’ve seen on our prac. They all responded really positively to it, and it was really good to relate to them as a class group but not as ‘the teacher’ - on a first name basis and we were working with them. It provided a bit more of an insight into how these kids were operating as a group.

STUDENT COMMENT: And it was with students who normally wouldn’t engage with science in the classroom. These kids were really engaged with quite detailed science in terms of what is happening in the water and why do these fish die in these circumstances, even to the point where there are some introduced species of trees which are polluting the water with their leaves, because it has an impact on the oxygen content in the water. So you’re getting into some really heavy science with kids who normally wouldn’t be interested or engage in it. I saw those sorts of things as being really good.
The resource package

The students are required to produce a Landcare resource package. This package is intended to be useful and relevant, so next year when they go out teaching they will be able to refer to it. The resource package is intended to include such things as, suggestions for orientation activities, notes on site preparation, flora and fauna surveys, notes on classification and identification of native plants and weeds, instructions for how to press plants, water quality testing guidelines and notes, seed collection and planting strategies, lists of contact persons and networks, media releases and lists of resources. It should also contain programming ideas such as, a model for implementing a Landcare project with a class, ideas about motivating kids, and lesson plans.

STUDENT COMMENT: That was part of the purpose, for us to establish our own contacts and resources. We now know where to go when we have to do that sort of thing and we will be doing it.

The resource notes should be written in such a way as to be understood by someone who isn’t a scientist, because many of the people who work on Landcare projects in schools are not scientists (that’s why it was really important that we had input from the SOSE students as well).

STUDENT COMMENT: It showed me how to integrate across subject areas across curriculum. It’s looking at resources in a different way and looking at things in the community as resources, rather than just going to books.

Problems, issues and challenges

The time constraints of a university course make it difficult to see all of the projects through (like cutting down blackberries) and you really need extra support to do that, so it was important to work in conjunction with other organisations such as the council. The council can see the benefit of it because their aim is to maintain that area of bushland. It’s also important to tie in with Landcare groups and tell the students what Landcare groups do, so it’s augmenting the work that the Landcare groups do, and benefits them.

An important problem is the demise of the Natural Heritage Trust, as they provide the funding for Landcare. The funding is used to support Tania to coordinate the program, and to pay for people to come in to teach various aspects. It makes it easier when there is a project officer who can set up initial contacts, make links and liaise with schools.

Another issue was that different schools had different expectations of what the education students would do. Some of them thought that our students would come in and run the whole program. Others already had the programs going and just wanted extra hands on deck. As a consequence, students going to different schools had quite different experiences. This made the sharing session a valuable part of the program.

Choosing the right time of year is also an important issue. If you want to do tree planting and seed collection, you’ve got to plan it for the appropriate time. The timing of the visits (once a week or twice per week for a shorter period of time) is one of the tricky things which depends on the seasonal timing.
7.8 Case study on the links between the teacher education program and business/industry

7.8.1 Case study 13

RETRAINING BHP EMPLOYEES IN THE BACHELOR OF EDUCATION (DESIGN AND TECHNOLOGY) AT THE UNIVERSITY OF NEWCASTLE

Rationale

This program was selected for a case study because it represented an innovative link between an education program and a major industry. It was also selected as an example of teacher education in secondary design and technology (Appendix F, Program Description F5). The program is characterised by extensive use of RPL (Recognition of Prior Learning) and school-based discipline studies.

Our thanks to Kath Grushka, the coordinator of design and technology education at the University of Newcastle, and to several of her students, for consenting to be interviewed.

Co-ordinator’s description of the program

Program development

The BHP steelworks at Newcastle closed down about three years ago. During the years preceding the closure, the company developed a ‘Pathways’ approach, which supported the retraining of workers who were to be declared redundant. The Pathways was open for all employees to go into any career path - it wasn’t specifically for teaching. However, some BHP people were interested in teaching, so this developed as one of the pathway options that employees could choose. The teacher education program itself was collaboratively developed by the University of Newcastle, BHP and the DET (Department of Education and Training, NSW).

The program developed was a two-year Bachelor of Education (Design and Technology) degree. On completion of the program, students would be qualified to teach a Design and Technology core, Industrial Technology as a senior curriculum, plus wood, metals, technics, technical drawing and electronics in the junior curriculum, and Metals and Fabricating (Vocational Education). These areas were chosen because most of the BHP students were from the metals industry, so their best curriculum niche was Design and Technology (Industrial Technology), and because of their industry experience they were well suited to vocational education as well.

Entry requirements

Most of the redundancy people had a trade background (rather than a university degree) so a Recognition of Prior Learning (RPL) approach was agreed upon in collaboration with the DET. It was agreed that a minimum qualification attainment
must be certificate 3 trade, plus students must have significant industry experience in an area relevant to the teaching area they wish to enter, and plus they must demonstrate the capacity and ability to continue lifelong learning. Each student was assessed on the balance of these three aspects. There was no UAI entry - students had to apply directly to the faculty, who assessed them using RPL.

These entry requirements are still being used as new students currently enter the program, but we have also introduced a scale between the certificate 3 level and the degree level, which allows students to gain credit in the program according to the Australian Qualifications Framework model.

Student intakes
About 60 students took up the offer in the first round, about four years ago, and another 20 came on board at later times.

Our policy was to also make the program available to the wider community (not just BHP), so we now have what we call a ‘community program’ which accepts students from a wider range of industries. So far, we have had 150 graduates, about half being from BHP and the rest were from any other industry in the community, as long as they satisfied the RPL entry requirements. Consequently, the program is now much wider and also includes food technology and computing. We believe that this model is capable of being applied across all curriculum areas, including mathematics and science.

Program delivery
The first two years of the program were delivered part-time because the BHP was still operating, but students became full time after that. The first year was interesting because we had to design a program around shift work. We went and taught on site (in BHP) because it was easier to use lunch hours and between shifts on site, than for the students to come to campus then go back. The Education went to the industry.

The program normally takes two years to complete, but in response to political agendas and teacher shortfalls, we also have an 18-month program which has an extra semester fitted in. This version now has its first full fee paid scholarship students beginning.

Program content
The degree comprises 320 credit points. Students may be given a maximum of 130 credit points of credit. Students complete 175 credit points of education and the rest is discipline studies.

Most of the BHP students were metal workers, so they receive training in their areas of other materials weakness, which are woods and plastics. They also do core design and technology studies, which focus on design processes, design projects and curriculum. Most of these discipline subjects contain both content and methods, which are integrated. They are taught by high quality classroom teachers and delivered in schools. The use of school classrooms assists rapid enculturation (this enables students to appreciate for example, the huge difference between an industry workshop and a school workshop, in the equipment available and the skills
levels taught.) Getting the students into schools as quickly as possible has proved to be a very successful strategy.

About one third of the program consists of these integrated discipline/methods subjects. The rest are curriculum methods subjects, general education subjects, practica and an internship. In these non-discipline subjects, the BHP students are purposely mixed in classes with other students.

The important aspects of this program have also been identified by the Ramsey Report as being good teacher education practice. These are industry retraining using RPL, and the school-based delivery using practising teachers, which helps the enculturation of students into schools.

Financial incentives

BHP paid all of the university fees for their employees. In addition, DET felt it was important to catch them in their final year of study, so about 30 scholarships were given to students in their final year. These scholarships provided a living allowance, and bonded the students to teaching in hard-to-staff areas such as western Sydney and inland areas of NSW. They were also given incentives such as support to move house, or teacher housing. Feedback from these graduates indicates that they have been very happy with their decisions.

Although this program does have contentious aspects, such as the training of industry people, and the relatively short (two-year) length of the program, we believe that it has been extremely successful. The graduates have now been teaching for about 12 months. They have been very well accepted by the schools and have a good reputation. We have tracked some of the graduates via the DET mentor process, and none of them (to our knowledge) have left teaching.

The future

The significance of the BHP initiative is that it showed that school-based teacher education, and RPL from a range of industries, can be successful. There are still going to be teacher shortages in some areas, especially computer technology, but we have managed to take design and technology off the number one priority shortfall in NSW. Currently we have 500 students enrolled in design and technology education at Newcastle (in various programs).

The students’ comments

Of the seven students interviewed, three were previously from BHP, and the others came from a range of trades including boilermaker, fitter and turner and electrician. They were all currently doing their internship, in the final semester of the program. The interview questions and their responses are as follows.

What appeals to you about being a D&T teacher?

Most of the students responded that they liked the hands-on aspect of teaching design and technology. One stated:

It’s a professional career and we can incorporate the skills we learnt at the trade level into teaching.
What did you like about the university program?

The students were in favour of the two-year program because it was more affordable and achievable than a four-year program. One stated:

*I think the biggest thing is that it's two years. I think if it was four years I wouldn't be able to do it because of the financial constraints.*

They also valued the RPL:

*For an adult of mature years, to take two years out of your life to retrain, when you've probably only got 10 or 12 years left of your working life is a big investment. I think that to be able to have the recognition of all your prior learning that you've built up till then is very important, and very valuable to your teaching in general.*

They felt success through achieving a university degree:

*It's like a self-achievement. When I left work and put my notice in they're going 'You're only a knucklehead sparky. You're not going to go to uni' and now I'm almost there it's a good pat on the back for yourself.*

The students were very supportive of the school-based subjects. One stated:

*To use the same tools that the students use, and the environment is basically the environment that we're going to go into. I found that to be an excellent way to do it rather than have us isolated until such time as they drop you into a school.*

They liked being taught by practising school teachers:

*They make it so much easier for us to learn from because they're teaching us how they teach the students, and I've learnt to adjust my expectations from what I thought was normal in industry, back to what's achievable in the school system.*

What sort of design projects have you done in your internship?

The students reported a range of projects which they had taught at schools, including candelabras, weather vanes and a table top soccer game. One reported making skateboards:

*The kids loved it because it was something they really wanted. It was a good project - it was fairly simple, and the end product looked good. When the content is relevant to the kids they're stoked on it.*

Some of the students also mentioned particular incidents that taught them about teaching and learning. For example:

*I've got a couple of tech drawing classes, and this one boy was really struggling. We did a fairly complex drawing, I broke it right down for him and he actually got it. He finished it and now the next drawing he's done is brilliant. You can just see the confidence. He said to me the other day 'I'm on fire'. And that was a really good feeling.*

Has the program prepared you to confidently begin teaching next year?

All the students reported a general readiness to begin teaching. However, they also recognised that they would continue to develop as teachers after they graduated:
We’re all fairly confident. We’ve still got a lot to learn. Teaching is still a nice, steep curve, but that’s just part and parcel of what we’ve decided to do. We want at this time in our lives to take that on.

Would you tell me about your scholarships?

Two of the students reported that they held scholarships, and that they were bonded for a minimum of three years. They were happy about the arrangement:

I didn’t want to casual teach because I want the feel of ownership of a class, and I want a full time job and I saw security in that bond.

Are there any other comments you would like to make about the program?

The students reported that surviving the first semester had been a major difficulty, because their background had not prepared them for university studies and assignments:

It does seem very daunting when you first start. You feel like you’re way over your head in water and right out of your depth. I had nightmares about it. I thought I was an imposter. [After that] I just worked really hard. If you really want to be a teacher just take it on and do it. Get the job done. If you’re not sure that you want to be a teacher, well you’ll find out when it gets hard.

The other students agreed that they had had to work extremely hard over the two years, and several reported long hours of work completing assignments. One stated:

Learning where the hoops are situated, how high they are and then which ones they’re going to light up with fire. Eventually you jump through them all without getting too singed.

It was evident that the support of their peers had been an important factor in their progress:

At one time or another we’re all depressed, we’re all nervous, we don’t have a clue how to handle this particular assignment. Don’t be frightened of telling people you’re frightened. Use your friends as support and you’ll be surprised at how many people around you also feel the same way. Then it’s not so bad.

They suggested that new students entering the program could be helped through this difficult period by a mentoring program involving the more experienced students:

We don’t want to deny people the satisfaction of getting through the really hard period and coming out at the other end, but mentoring could make it a bit easier for them.
8. Conclusions

8.1 General comments

An examination of practices and innovations in the preparation of teachers for teaching science, mathematics and technology is particularly apposite at the present time, with the Federal government’s focus on innovation and science. From an understanding of what is currently offered in initial science, mathematics and technology teacher education in Australia, both the preparation of teachers and development of relevant government policy and practice can be assisted.

One of the main thrusts of the project was identification of innovative practice. Our study of initial teacher preparation programs for science, mathematics and technology has uncovered a diversity of innovation across universities, which was not initially anticipated on the basis of the high level of structural constraints in school-based education.

We note that Australian science, mathematics and technology teacher education is overwhelmingly a university-based education. This is largely but not exclusively the case internationally, and there are compelling reasons for it, namely:

- a world-class training in the disciplines that underpin teaching can only be gained in universities, where staff with highly developed skills in both teaching and research, as well as the appropriate and very expensive infrastructure, can be found;
- only where there is appropriate infrastructure for content delivery and a proper balance of qualified staff is it likely that programs of initial teacher education that are attractive, flexible, engaging, innovative and best practice can flourish;
- graduate and postgraduate education is the core business of universities and, if one accepts that teachers should be graduates, then they are best placed to deliver teacher education;
- the commitment of universities to research in concert with teaching provides for close national and international contact with continuing developments in relevant fields.

At the same time, we emphasise that the universities cannot provide for the complete education of teachers, since they do not have the capacity to provide appropriately for classroom teaching practice. Therefore the continuing development of high quality collaborative university-school links should be a priority.

Further, and where appropriate, involvement of industry and professional groups to expand the vision and quality of initial teacher trainees would seem appropriate. Science, mathematics and technology is served by a vibrant and active community of academic, government and industrial scientists and a wide range of professional
societies, the overwhelming majority of whom have a strong interest in the
maintenance and growth of effective primary and secondary education in the
sciences and mathematics. Their view is directed mainly towards the supply of
effective and innovative literati in their disciplines, but recognition of the role
played by teachers in attaining this goal is high. There is good support of education,
seen through a wide range of school-directed activity programs. Evidently, this
positive approach from the sciences should be nurtured and encouraged to grow
towards stronger support for teacher education.

8.2 Current teacher education programs

Of the thirty-nine universities offering undergraduate degree programs in Australia,
only four do not offer some program of initial teacher training. Moreover, many of
the universities offer degrees in education at several campuses. In addition, one
tertiary college also provides teacher training degree programs. Outlines of the
range of degree offerings are presented in Chapter Two and Appendix A. Overall,
undergraduate degree programs in education offered in Australia now number well
over one hundred, and in addition there are a range of postgraduate teacher
education programs available. The diversity of programs and courses extant is
commendable, providing students with a wide range of study options. This diversity
means that the number of programs offered by a provider may be fairly extensive
and consequently student cohorts in discipline specialisations can be small. It
should be emphasised that small cohorts in science, mathematics and technology
are the result of a complex range of factors. The main drawback to small cohorts
lies with concomitant staffing and funding constraints in budgets that are EFTSU-
driven, rather than being an educational issue.

Overall, and with some very few exceptions, the equivalent of four years of full-
time tertiary education is required for accreditation as a teacher. Teaching
qualifications are obtained typically through five distinct modes, via:

- four-year (full-time or equivalent part-time) single degrees;
- four-year (full-time or equivalent part-time) double degrees, with typically ~50
  per cent education and ~50 per cent other discipline content;
- one-year (full-time or equivalent part-time) graduate diploma of education
  following a minimum of a three-year degree in another approved field;
- one, one-and-a-half or two years (full-time or equivalent part-time) degree in
  teaching following a minimum of a three-year degree in another approved field
- one-and-a-half or two year (full-time or equivalent part-time) coursework
  masters degree in teaching following a minimum of a three-year degree in
  another approved field.

There is some evidence to suggest that the double degree model is becoming
favoured by those offering education degrees. For example, the majority of new
undergraduate degrees offered for the first time to candidates in 2002 are double
degrees, replacing single degrees. However, this trend varies with state.

It is in the preparation of pre-school, primary school and adult or vocational
teachers that single degree programs are more often met. Secondary school teacher
training in a majority of states seems to be moving more towards double degree mode for student entry following acquisition of a higher school certificate (HSC) or equivalent qualification.

In cases where recognition of prior non-traditional learning is given, such as for special entry programs for retraining persons already in the workforce as teachers, the period of formal tertiary education is reduced below four years full-time.

Existing graduates seeking a teaching qualification take a second degree, graduate diploma or coursework masters pathway, with a minimum of one year and a maximum of two years of additional full-time study required. Postgraduate entrants to teacher education may still attain a teaching qualification in several states as a one-year full-time Diploma of Education, but there has been a clear shift towards progression to teaching through a second degree or even masters program of no more than two years full-time duration in some states and institutions.

The areas of specialisation for which teachers are prepared vary from university to university, with not all training teachers across the full spectrum of specialisations relevant to primary and secondary teaching.

Where universities have several campuses, it is more common to find pre-school or primary school teacher preparation programs operating on most or all campuses. Consequently, the training of teachers for the initial years of schooling is geographically widely available, and is supplemented further by some distance-mode programs from a limited number of universities.

Secondary school teacher preparation programs are more often restricted in campus location, presumably because of the need to include discipline specialist training which may not be available at each campus. That some institutes operate split-campus mode programs, requiring discipline training at one site and education training at another, reflects this. For science, mathematics and technology in particular, it appears that the requirement for appropriate discipline-relevant facilities and expert staff plays a key role. An obvious consequence is that teacher education in these fields, while broadly based in the nation, is not offered at as wide a spread of locations geographically as is the case for primary school programs. For technology teaching, education provision is not broadly available.

We note the opportunity exists to employ computer-based distance learning technology, which is already being addressed by some providers. However, we also note that the experimental nature of science and technology subjects demands provision of appropriate and deep laboratory- or workshop-based experiences. This requires an on-site component even in distance education subjects.

8.3 Innovation in teacher education programs

In Appendices D–G we presented descriptions of mathematics, science and technology teacher education programs across Australia. In Chapter 6, we summarised the main features of these programs and highlighted particular programs that contained innovations. Our definition of innovation was loose rather than strict, and referred to any practice which appeared to be interesting or different or new, by comparison with the bulk of the other programs, and which seemed to have the potential to enhance learning. As much as possible, our
decisions were guided by the findings of the education research literature, although it was recognised that new innovations would not necessarily have been evaluated in publications. The information presented in this study suggests that there are many examples of genuine innovation in teacher education programs across Australia, and many of the ideas summarised should be of interest to developers of future programs.

The case studies were then chosen from amongst those innovations. The selection of case studies was a difficult process, which took into consideration the views of other stakeholders such as science deans and professional bodies, as well as the need to provide a representative balance between different types of programs and different Australian states, with respect to the terms of reference of the project. In general, the case studies that were chosen did provide evidence of high quality. They had well-described philosophical perspectives which had been enthusiastically and thoughtfully implemented. In those case studies which involved student interviews, there were many instances in which students expressed not only their enthusiasm for the program, but also described quality experiences which they had had in schools as a direct result of that program.

Some general patterns of innovation are evident. Firstly, innovative practices are well spread across all states and most teacher education institutions. They are not confined to any particular states or universities. Of the 36 institutions involved in this study, 32 were mentioned in Chapter 6 as having noteworthy and/or innovative practice in relation to at least one of their programs. All states were strongly represented in this group. Further, innovative practices are well spread across primary, middle school, secondary mathematics/science and secondary technology programs.

Many of the innovations reflected high quality practices that were identified in the literature review, indicative of their contemporary nature. Amongst the innovations identified for primary programs were examples of:

- integration;
- problem-based learning;
- constructivist approaches;
- closer links between schools and universities by the use of dispersed practicum days or the use of in-school experiences within methods subjects; and
- emphasis on hands-on and real life applications of mathematics, science and technology.

Amongst innovations identified in the secondary programs were examples of:

- research and problem-based approaches;
- lecturers modelling innovative teaching strategies and then providing in-school experiences which allowed students to practise these strategies with small groups of children;
- dispersed practicum days which helped to integrate theory and practice; and
- flexibility to allow students to choose areas of interest and even to choose the timing of their practicum blocks.
The secondary technology programs displayed an outstanding range of links between Education, other faculties, TAFE colleges, schools and industries, and were also obviously leading the way in the provision of entry pathways which recognised students’ prior knowledge and experiences.

With respect to middle school programs, it could be argued that the paucity of programs of this type means that they could all be considered innovative, especially where they involved the modelling of middle schooling principles such as integration, flexible learning pathways, teamwork, authentic tasks, and negotiated learning pathways.

Finally, there are two main types of innovations involved, namely:

- innovations at the program level; and
- innovations at the unit (course) level.

Innovations at whole program level were relatively few, but those that were identified deserve to be highlighted:

- The Bachelor of Behavioural Studies/Education (Middle Years of Schooling) at the University of Queensland, and the Bachelor of Learning Management at Central Queensland University were noteworthy for their development of integrated modules to replace traditional discipline areas.
- The Master of Teaching programs at Queensland University of Technology and the University of Sydney were based on research and problem-based learning respectively.
- The Knowledge Building Community program at the University of Wollongong adopted a problem-based and school-based approach.

The bulk of the innovations however, applied to particular units within programs (e.g. an innovative mathematics unit or an innovative way of organising practice teaching) rather than to the whole program. Many of these appeared to be cases in which one or two highly motivated individuals had developed an innovative approach and were maintaining it largely by their own energy and enthusiasm.

8.4 Reflections on the analysis of current teacher education programs

At this point, it should be emphasised that a program does not have to be innovative in order to be high quality, and not all innovations will ultimately be successful in improving the quality of teaching and learning. In the following sections, we will take a more general view of the structure of teacher education programs for mathematics, science and technology. Our intention is to highlight some issues that we believe are particularly significant, and make some suggestions as to the directions that future innovation and research may take.

8.4.1 Nature and level of content studies

Most of the undergraduate programs for primary teacher education are of the four-year Bachelor of Education type, although there are some double degree programs.
These programs contain a range of specific courses in the areas of mathematics, science and technology, usually designed and taught specifically for primary teacher initial education. In general, they cannot be avoided, meaning that primary teachers enter the classroom with formal training in aspects of mathematics, science and technology, which form part of the primary curriculum in all schools in all states. In about two-thirds of these programs, the science faculty is directly involved by offering content subjects or mathematics/science electives, but in the other one-third of programs all the units are Education offerings. In almost half the programs, the students have the opportunity to study up to a major or minor of general offerings of the science faculty, but very few students typically choose this option.

Many of the interviewees mentioned the primary education students’ negative attitudes towards mathematics and science, and it was noted that previous research has also indicated that the majority of primary education students dislike science, and lack confidence in their ability to teach it. It was heartening therefore to find that attitude change is a stated aim in many primary programs, with interviewees describing a range of teaching approaches which they used to create positive attitudes in both science and mathematics.

Secondary programs are now more commonly double degree in character. While it is notable that the period of time for single and double degree programs are equivalent, the integrated programs call more heavily on discipline content from the traditional science faculties. Arguably, the double degree provides a better level of science discipline training while at the same time giving an adequate level of education discipline and practicum training.

In secondary education programs, the mathematics and science discipline content is delivered by the science school/faculty, and the content courses (units) are standard B.Sc. offerings (or its equivalent). Interviewees stated that the discipline preparation of the students was therefore quite strong, with students in undergraduate double degree programs, for example, graduating with a full professional level B.Sc. However, it can be argued that the responsibility of discipline lecturers does not stop there. The case study at Edith Cowan University (Case Study 2) highlighted the important impact that discipline lecturers can have as role models of good teaching practices. An aim for teacher education programs should therefore be that they not only contain strong content studies but also that those content studies are taught using interesting and motivating strategies which can easily be transferred into secondary school classrooms.

The secondary education students are typically required to complete a major and a minor from subjects such as physics, mathematics, biology, chemistry or Earth science. This undoubtedly would give students a strong discipline knowledge in one or two senior specialisations in science. However, science at junior high school level has components of four to five disciplines (physics, chemistry, biology, geology and astronomy). This leaves a deficit of at least two sciences in which there has been little or no preparation. The next step forward is to develop patterns of discipline studies that will maintain a high professional standard, but incorporate significant preparation in the full range of junior sciences.

Secondary technology programs are relatively uncommon, with only nine undergraduate programs identified (five in NSW). Most of these are the Bachelor of Education type, and the content studies are offered by non-Education providers such as Engineering faculties and TAFE. The content studies often comprise a
design core (or design and technology major) and either one or two specialist areas to be chosen from (for example) agriculture, food technology, engineering studies, textiles and design or information technology.

These technology programs are often highly innovative, especially in the development of links with other faculties and other institutions such as TAFE, and in adapting to the widely varying previous qualifications and experiences of the students. However, technology covers a huge and diverse range of discipline areas (including agriculture, the built environment, textiles and clothing, engineering, food, information and communication, software, leisure and transport) and not all institutions were able to offer discipline studies for teacher education in all of these areas. This should not be seen as a criticism of the institutions, but rather, it is a product of the current nature of technology education itself. The problem of breadth in technology studies can be traced to the fact that many technology programs have a design core. Design is a process rather than a discipline, and it is a process that can be applied to a huge range of discipline areas, as has been evidenced. A further problem is that university faculties are structured around discipline content rather than processes, so there is no clear pathway for graduate students to enter technology education through the university system. This issue lies at the heart of technology education, and should provide a focus for future curriculum development at high school level.

8.4.2 Articulation between content and pedagogy

In the primary programs, the mix of content and pedagogy in the curriculum method studies provided a good articulation between the two areas, because in many cases the lecturers were able to model appropriate teaching strategies as they presented the content. Most of the programs had two to four compulsory mathematics courses (one semester units) over the four years, and two or three compulsory science/technology courses. One concern was that the amount of stand-alone design and technology in primary programs was relatively low. However, there were some innovative and high quality primary technology units identified, which should provide good models on which to base future program development. The case study at the University of South Australia (Case Study 1) demonstrated the considerable range and depth of high quality technology activities which can be incorporated into a program.

Most of the four-year undergraduate programs for secondary mathematics/science are of the combined degree type, in which the content studies dominate the earlier years and the education studies dominate the later years. Most of the secondary programs appear to have a good balance between the amount of discipline content studies and the amount of educational studies. In fact, in many programs the actual ratio is 50:50. Although this intuitively seems to be a fair ratio, which should be agreeable to both faculties, it is not clear whether it is the best ratio for a future teacher. Is 50 per cent too much for educational studies or not enough? Perhaps future research will be able to identify the value and importance of the different components in teacher education programs, so that answers to this question will be made on educational rather than political grounds.
8.4.3 The integration of teaching theory and practice

There is some variation in the quantity of teaching practice in various programs. Undergraduate primary education programs tend to have the highest amounts of practicum (many having 18-22 weeks) whereas the secondary undergraduate programs typically include 16-20 weeks of practicum. Much of this practicum tends to occur in the latter half of the program, which often includes an internship in the fourth year. The two-year graduate programs typically include 16-20 weeks of practicum, but the one-year graduate programs normally have only 8-10 weeks.

It must be emphasised that the quality of the teaching practice is also a significant issue. In a number of programs there are innovations such as the use of dispersed days that lead up to block practica, and the linking of specific education subjects to block practica, which are intended to create closer links between theory and practice. However, interviewees reported that it was still possible for:
- primary education students to be placed with teachers who taught little or no science;
- secondary mathematics students to be placed with teachers who taught from the textbook;
- secondary science students to be placed with teachers who used a ‘chalk and talk’ approach; and
- design and technology students to be placed in schools where they were expected to teach traditional woodwork subjects.

As a result, some interviewees suggested picking and choosing classroom teachers as mentors, while others had created separate in-school experiences linked to curriculum method subjects, in which students could teach small groups of children using innovative strategies that they might not otherwise get a chance to practise. How best to ensure a high quality practicum for all students is one issue that still offers considerable scope for innovation. We anticipate that universities should be able to accept the challenge of developing mechanisms for providing for more effective and or extensive practicum.

8.4.4 Differences in teacher preparation between different types of programs

Most of the institutions have a graduate program, of either one or two years, for primary and secondary teacher education. In Queensland and Tasmania, all the secondary mathematics/science graduate programs are of the two-year type; there are no two-year secondary programs in the Northern Territory or Western Australia; and other states have some two-year programs and some one-year programs. In these programs, students are assumed to have completed their content studies. However, several interviewees mentioned that the graduates are often strong in one science area, but deficient in others. For example, students with previous degrees in physics or engineering may lack studies in biology. These graduates will certainly be required to teach biology at junior high school level, so the next step forward should be to develop ways of including discipline studies in graduate programs. This might be especially achievable in two-year programs, as they are perhaps less intense than the one-year programs.
Double degree or combined degree programs have been introduced for secondary teacher education during the last few years, and nearly all of the institutions in the ACT, New South Wales, Northern Territory, Queensland and Western Australia have created them or are in the process of doing so (interestingly, combined degrees are much less common in South Australia, Tasmania, and Victoria). The double degree concept is intended to be attractive to students because it offers them the opportunity to complete two degrees in four years. However, the secondary double degree programs typically had few mathematics and science students enrolled (half a dozen students in each year was fairly common). In most cases, the one-year graduate programs at the same institutions had higher numbers of students. It therefore appears that the double degree has not been successful in attracting large student numbers into mathematics and science teaching.

Middle schooling is an innovative approach to education in this country, as it is still relatively uncommon, as are middle school teacher education programs. However, the middle school years are extremely important ones for children, during which they develop for example, their attitudes towards mathematics, science and technology, which will determine whether they continue to study these subjects in later years. The potential of middle school programs to provide teachers in areas of shortage, such as mathematics and science, is an additional reason for encouraging their development.

The provision of teachers with skills in teaching indigenous students has been addressed through provision of programs in a limited number of universities, although degree-level programs are offered in all mainland states. The two institutions whose indigenous programs were described in the present study (Batchelor Institute and the University of South Australia) showed that these programs can take an interesting and unique approach to the disciplines of science, mathematics and technology.

Several institutions have innovative non-Education programs that give students experience in schools. The two that were described for this study were the Peer Tutor program at RMITU (Case Study 9) and the STAR program at Murdoch University. These programs have strong links with both schools and education faculties, and are generally well enrolled. Perhaps programs such as these have the potential to attract students into mathematics and science teaching, but how to make best use of them is, at this stage, an open question.

### 8.4.5 Skilling teacher education students in practices to develop literacy and numeracy in school students in relation to these content areas

Literacy and numeracy studies were assumed to be basic components of primary teacher education programs so they were not specifically investigated in the primary programs. At secondary level, interviewees typically stated that these components were present in their programs, but it was not possible to describe them in detail because of the need to keep the interviews within acceptable time limits. However, interviewees did sometimes describe specific literacy activities, and a compilation of these from various secondary programs did reveal the wide range of activities, which could be usefully incorporated into literacy courses.
In addition, two of the case studies focussed on the issue of numeracy, as specific numeracy courses appeared to be less common in teacher education programs. One of these was an example of a cross-curriculum numeracy course (Case Study 10) which provided insight into such a course might be structured. The other focussed on the use of newspaper articles as a way of encouraging future teachers to provide authentic numeracy experiences for children (Case Study 11).

The issue of literacy and numeracy in mathematics, science and technology is a very complex one because the curriculum requirements vary from state to state and, as several interviewees commented, there are specialist conceptions of technological literacy, scientific literacy, mathematical literacy and mathematical numeracy which need to be clarified. It is noted that there is a parallel DETYA project, which is focused on national literacy and numeracy strategies and projects.

8.4.6 The exposure of teacher education students to school projects and programs designed to improve students’ outcomes in their method area

Interviewees reported a wide range of links to innovative school projects and programs, such as the ‘Science Talent Search’, the ‘Mathematics Challenge’ and gifted and talented programs. The case study on the Landcare project at the University of Tasmania, provided evidence of the high quality experiences which teacher education students may gain from involvement in these projects (Case Study 12). However, school programs in design and technology were notable by their absence. There is clearly a need for the development of innovative school projects and programs in this content area.

8.4.7 The links between the teacher education program and business/industry

Most of the programs have established links with the wider community, particularly informal education centres such as museums and science centres. Several of the mathematics courses have created innovative links with local businesses (e.g. for students to investigate the use of mathematics in real life situations). Design and technology programs often have industry experience components, which are linked to the VET or TAFE components of their programs. However, in general, there are relatively few links between teacher education programs and mathematics, science and technology businesses/industries in the community.

8.5 The wider context

In the previous sections we have identified a range of areas to which future research and innovation could usefully be applied. However, this should not be taken as implying any serious deficiencies or lack of innovation in teacher education programs. Rather, our view is quite the opposite – the overwhelming impression after carrying out numerous interviews and case studies is that there are many dedicated and imaginative people working with mathematics, science and technology teacher education programs across Australia.
It should be emphasised however, that there are powerful forces working against innovation at the present time. In particular, interviewees stated that lack of funding had created pressure to reduce contact hours with students, move towards mass lectures rather than tutorials, and reduce teaching practice. It is clear that innovative best practice cannot flourish under this constraint, and any serious commitment to educating our future teachers should be linked to increased levels of funding.

It should also be emphasised that lack of students in secondary mathematics, science and technology programs was also seen by interviewees as a serious issue. The question of how to attract talented, flexible students into these programs is one of the greatest challenges facing the education community at the present time, and the continuing development of high quality teacher education programs should be seen as just one of the steps which is needed to address this problem.

We encourage the use of the information collected in this study as a resource for further development. Idea trading between providers should be a vital part of the fabric of teacher education. It is our sincere hope that the large range of interesting ideas, innovations and issues which have been identified in the present study, may prove helpful to institutions as they design programs for teachers of science, mathematics and technology in the 21st Century.
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