Foundations for Australia's Future: Science and Technology in Primary Schools

1997
May 1997

The Hon Peter McGauran MP
Minister for Science and Technology
Parliament House
CANBERRA ACT  2600

Dear Minister

We have the honour of submitting to you a report: Foundations for Australia’s Future - Science and Technology in Primary Schools.

The study stems from our earlier work Matching Science and Technology to Future Needs: 2010, in which we emphasised the need to increase the level of both scientific and technological literacy in Australian society as we enter the 21st Century. The teaching of science and technology while in primary school is the most important means by which today’s children will begin to understand the importance and application of science and technology in their lives.

In accordance with the study terms of reference, this report: reviews the teaching and learning of science and technology at the primary level; assesses the degree to which primary schools are contributing to developing students’ confidence in dealing with science and technology; identifies opportunities for enhancing primary science and technology education; and recommends appropriate action to capitalise on the identified opportunities.

A feature of this study has been the Council’s wide consultation with primary school principals and classroom teachers. This has led, I believe, to a more complete understanding of the day-to-day problems experienced by those who are most directly responsible for the science and technology education of our children.

The report contains a number of recommendations which reflect the diverse interests and responsibilities for science and technology education across Australia. We would, of course, welcome the opportunity to expand on these recommendations.

Yours sincerely

[Signature]
Following the completion of ASTEC's previous study, *Matching Science and Technology to Future Needs: 2010*, in which the need to increase the level of our community's scientific and technological literacy was emphasised, the Council undertook to examine in greater detail an important means by which this will be achieved: primary level science and technology education.

ASTEC's study has relied largely on interview and survey techniques because the Council was keen to gain a 'snapshot' of the classroom in respect of how science and technology are being taught and learnt in Australian primary schools. To have relied only on third party interpretations and/or statistical analyses would, in ASTEC's view, have provided policy makers with a less complete picture of the problems being experienced daily by classroom teachers.

The initial findings and recommendations of the study were presented to the Prime Minister's Science and Engineering Council in September 1996 and released for public comment in December 1996.

ASTEC would like to acknowledge the individuals and organisations who assisted the study through the provision of submissions and written comments. ASTEC also would like to acknowledge the education systems participating in this study and the assistance of their officials. In particular, ASTEC wishes to thank those primary school principals and classroom teachers who freely gave their time to attend interviews and complete the Working Party's questionnaire.
In undertaking a study on science and technology education in primary schools, the Working Party should:

- **review** the teaching and learning of science and technology at the primary level;

- **assess** the degree to which primary schools are contributing to developing students’ confidence in dealing with science and technology (including curiosity, attitudes, skills in problem solving) to prepare them for their future responsibilities as citizens;

- **identify** opportunities for enhancing science and technology education at the primary level; and

- **recommend** appropriate action to capitalise on identified opportunities.
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Executive Summary

ASTEC's recent report, *Matching Science and Technology to Future Needs: 2010*, has argued that as the impact of science and technology on our daily lives continues to grow, so too must the level of our society's scientific and technological literacy. Indeed, being literate and numerate in the purest sense of the terms, will surely not be sufficient to live as informed citizens in any western society in the 21st Century.

The teaching and learning of both science and technology in our schools, and in particularly at the primary level, is one means by which these improvements in the understanding of science and technology can be achieved. ASTEC last reported on primary science and technology education in 1987. Since then, several initiatives have taken place with a view to improving the way these subjects are being taught. It is timely therefore to again examine this topic.

ASTEC's current investigation was based largely on invited submissions, a survey of primary school principals and parents, and interviews with teachers and students. In brief, the main findings are:

- much has been achieved in primary science and technology education over the past ten years but more remains to be done;
- there is a strong level of support among school principals, parents, teachers and children for primary science and technology education;
- there is a disparity between the 'in-principle' support for science and technology and that which occurs in practice;
- in those primary schools visited during this study, only 45 to 60 minutes (or about four percent of the teaching time) is allocated in the weekly timetable for both science and technology together;
- many primary teachers (both recent graduates and mid to late career) are less than totally confident about teaching science and technology;
- the availability of resource materials to support technology education is less extensive and familiar than for science education; and
- primary teachers tend to make only limited use of community resources to support their science and technology teaching.

ASTEC's recommendations, which flow logically from the above findings, are found in the body of the text and listed separately in Appendix A. In particular, ASTEC argues that action is required to address:

- low teacher confidence in primary science and technology education - two recommendations are made in this respect, firstly to examine the adequacy of current pre-service education for primary teachers, and secondly, to also provide suitable in-service education based on best practice adult learning;
- the curriculum time for science and technology - ASTEC recommends that a goal be set and adopted to improve the time allocation to these learning areas as teacher confidence and the availability of resource materials improve; and
- the availability of technology education resource materials - ASTEC recommends that a survey be undertaken of currently available resource materials with a view to identifying any gaps, and that a national inventory of such resource materials be developed.
Raising children who are well prepared to cope with life in a future world is not an easy task. There can be little doubt though that their education is a vital component of this upbringing. While the value of the 'three Rs' is undeniable, the totality of the knowledge and skills that today's children will require over the course of their lives is difficult for most of us to imagine. Their world will, however, be no less complex than ours, or the role of science and technology in their daily lives any the less significant.

ASTEC's more recent studies, such as *Matching Science and Technology to Future Needs: 2010*, have emphasised the need to increase scientific and technological literacy within the Australian community. Australia's economic growth, employment opportunities for tomorrow's workers and the ability of citizens to make informed decisions about everyday matters such as the foods they consume, the medical procedures they undergo, the machines, facilities and services they use and their impact on the environment will all increasingly require sound knowledge of both science and technology.

Clearly, literacy and numeracy are both key success factors in life and they have never been more important than they are today. However, given the ever increasing impact of science and technology in our lives, and in the future lives of our children, being literate and numerate will not be sufficient for life in the 21st Century. It is inescapable that to live as informed citizens in a western society in the 21st Century, individuals will need to be both literate and numerate in the purest sense of the terms, as well as, to be scientifically and technologically literate. It is necessary therefore for people to become literate in a
broader sense and perhaps we should no longer be speaking of literacy but instead of life functional literacy, that is, functional for the requirements of living in our complex society.

The Council finds the concept of life functional literacy useful not only because it better reflects the needs of the changing world in which we live and educate our children, but also because it makes clear ASTEC’s view that science and technology literacy, while in themselves vital, are but two of the necessary components. Achieving life functional literacy will present challenges to policy makers, education systems, school principals, teachers and parents alike, with the most important being attainment of balance among the components, in terms of both their curriculum status and resource allocation.

Our State, Territory and independent education systems have twin roles in terms of science and technology literacy. Firstly, these systems are the means by which future generations of scientists, technologists and engineers are trained. Secondly, and perhaps of even greater importance, they provide for most children their only formal science and technology instruction before they go on to any number of different careers or occupations.

More than ever before, the Council believes that science and technology education must meet the aspirations of parents and the needs of both students and the community at large. Science and technology education should not be seen merely as learning the laws of physics, theories of chemistry or principles of biology. Most educationalists agree that, at all levels of schooling, science and technology education assists students in developing life skills in the form of inquiring minds, analytical skills, the ability to solve problems and the capacity to innovate. In the context of this study, the Council has developed ‘descriptors’ for primary science education:

- the systematic acquisition of investigative skills and a body of knowledge and understanding of the physical, biological and technological worlds;

and for primary technology education:

- the purposeful application of knowledge and acquisition of skills to create products and processes that meet human needs.

Overseas, there is a clear trend to establish science and technology as part of the essential core learning for children at a young age. England, for example, now has three core areas in its primary curriculum: English, mathematics and science. In addition, England, Wales and Denmark have all recently doubled the time allotted to science in their primary curricula.

This focus on younger children being taught science and technology is not without some justification. In most western countries,
children spend about seven years in primary school. For many children, this period represents over half of their time in formal education. Children demonstrate a great eagerness to learn science and technology at the primary level if given the opportunity. Research has shown that young children can and do learn effectively in these two areas suggesting that their abilities to think abstractly and to design creatively may have long been underestimated. The period of primary education is known to be an impressionable time for children and many begin to form not only their attitudes to science and technology, but also ideas about their future vocations. A negative view of science and technology, resulting from poor educational experiences, may decrease children’s desire to learn more in these areas or to enter one day into scientific or technological careers.

Australia presently has an opportunity to ‘get things right’, especially in terms of primary technology education. With little real history of technology education in our primary schools, teachers have virtually a clean slate relative to secondary teachers, who bear the added burden of having to reconcile how traditional subjects such as manual arts relate to technology. The Council has become increasingly convinced that not having an effective education in science and technology during the seven year period of primary education is a serious lost opportunity to enhance the learning of children and through them, to create the kind of 21st Century society to which most Australians aspire.

ASTEC has previously reported on primary school science and technology education. In that report, ASTEC noted the unsatisfactorily low amount of curriculum time allocated to these subjects and recommended an increase to at least three hours per week. ASTEC is not the only body concerned with the state of science and technology education in Australia. Any informed discussion about the health of primary science teaching in the late 1990s must take place against a background of the Speedy Report which in 1989 found the teaching of primary science was in a "state of crisis", and "more honoured in the breach than it is by its presence" [sic]. Indeed, the review panel stated that the situation was so bad in the late 1980s that they had considered recommending abandoning primary science education, but decided against doing so because it would have unjustifiably denied Australian children any prospect of learning in this exciting area. It would also have meant that science would become an area of learning which excluded most students from its serious study, particularly girls. The panel further argued that without quality exposure to science at primary school, the confidence of children to participate in secondary science would be essentially determined by family and social influences, which for science at that time, were often negative or inequitable. ASTEC believes that these justifications for maintaining primary science (and technology) are no less valid today than they were in 1989. Relative to primary science, the health of primary technology teaching is largely an unknown. The emphasis of the Speedy Report was on science and mathematics. Technology education was mentioned only in passing. Since that time, there has been no major national study of primary technology education in Australia which, in part, led ASTEC to initiating this current work.

In undertaking this study, the Council did not attempt to measure quantitatively the learning outcomes of students in science and technology. Rather, the Council has relied on
The period of primary education is known to be an impressionable time for children and many begin to form not only their attitudes to science and technology, but also ideas about their future vocations. The current Third International Mathematics and Science Study (TIMSS) to provide this type of data, for science at least. Although the two studies are independent, the Council's approach to its study is consistent with the TIMSS conceptual framework which argues that the factors making up the educational environment can be understood from the perspective of three levels of curriculum - intended, implemented and attained (Figure I). The terms of reference for the Council's current study are clearly within the second (that is, implemented) level in the TIMSS framework. It is the Council's expectation that this study will complement the TIMSS and help provide primary education policy makers with a more complete picture of primary science and technology education in the late 1990s.

With these prior and current studies in mind, the Council has attempted to assess the impact of notable changes over the past seven years by investigating system support for science and technology teaching at the primary level, the contribution of science and technology to education goals, the way science and technology are taught, how teachers are coping with technology as a newly identified learning area, pre-service and in-service education of

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**Figure I The conceptual framework for TIMSS**

Source: Adapted from TIMSS (1996)
teachers, examples of best practice and impediments to science and technology teaching and learning.

Inputs to this study have taken many forms. Written submissions were received from 42 scientific, engineering, educational, business and professional organisations and individuals (Appendix B). Visits were undertaken to 53 primary schools in all States and Territories except New South Wales government schools (as the education department in that State declined ASTEC’s invitation to participate in this study). Discussions were held with 50 principals, about 150 primary school teachers and the science and technology curriculum officers from seven State and Territory departments of education. Focus groups were conducted with more than 300 final year primary and about 60 first year high school students. Over 100 parents and a randomly selected group of primary school principals (representing four percent of such principals across Australia) were surveyed. A background paper which provided an international perspective on primary science and technology education was also prepared for the Council by Professor Peter Fensham.

The Council has with good intention limited the scope of this study so that the task accorded with the available resources. Firstly, it chose to focus on primary school students for the reasons discussed previously. It is not the Council’s intention to imply through this action that it believes science and technology teaching at the secondary or tertiary level are any less important. Indeed, the Council considers that science and technology teaching at all school levels should be examined, and in particular, the way in which teaching interfaces across these different levels. Secondly, the Council recognises that a natural relationship exists between science, technology and mathematics. Clearly, teaching and learning in each of these areas has much to offer the others and many of the problems faced by primary teachers when teaching science and technology are no doubt also experienced for mathematics. Finally, the issues associated with science and technology education of children from a non-English speaking background and of Aboriginal and Torres Strait Islander descent were not a focus of this study. Although the Council agrees that the needs of these children should not be considered in isolation from those of the wider community, these matters are believed to be sufficiently important and unique to merit a separate study employing methodologies and working party expertise more suited to the task.
Chapter 2:

Where Things Stood in 1996

It is now a convenient time to investigate primary science and technology education, not only because ten years have passed since ASTEC last considered this important issue, but also because there have been a number of developments recently which have had a positive impact on both primary science and primary technology:

- States and Territories are now implementing the new curriculum area of technology;
- Many teachers are showing a high level of interest in science and technology, particularly in technology;
- Evidence is beginning to show the potential of technology education in facilitating the general learning of children;
- There is recognised potential for science and technology to be brought together with each learning area complementing and enriching the other;
- A number of organisations are concerned about the state of primary science and technology education, and some of these are for the first time offering their support and help with education resource materials; and
- Over the past few years there have been some successful programs aimed at the professional development of teachers, mainly in science education, but these efforts need sustaining.

ASTEC believes that a valuable window of opportunity is currently open before us to add significantly to this momentum and in doing so, to achieve a lasting change in the way science and technology are taught in primary schools. To this end, the Council has attempted through its surveying of principals and parents and interviewing of teachers and others associated with primary science and technology education to establish a preliminary
benchmark for best practice that will point the way to further reforms.

Over the course of this study, the Council has found a strong level of support for science and technology education among many principals, teachers, parents and children. The importance of each subject has now been clearly established through recognition in a National Statement and Profile as an identified learning area. When asked by the Council to rank eight identified learning areas in descending order of importance for their child's final year of primary education, parents, on average, placed science and technology third and fourth, respectively, behind English and mathematics. Children's answers to the Council's question as to why they learn science and technology at school, are both reassuring and indicative of the value which they place on science and technology:

- "the world is changing and you need ideas to help you in the future"
- "science is basically the thing that will get us into the future"
- "when you get older, you'll know what to do and when you have questions you'll have knowledge inside you to figure it out"

The benefits of science and technology in facilitating the broader goals of education were recognised by many of the principals, teachers and parents who participated in this study. A high level of agreement was found in the outcomes expected by each group for science and technology education (Table 1). Principals and parents most often identified developing an inquiring mind and problem solving skills as the main goals of science and technology education and, in addition, the encouragement to be innovative, understand technological concepts and to link and apply what is being learnt to everyday life as major goals of technology education. Principals and teachers alike spoke of the value they placed on science and technology as a useful means to generate enthusiasm in their classrooms, motivate their students and assist them in achieving literacy and numeracy learning outcomes, especially for children from non-English speaking backgrounds. Of some concern to the Council, however, was the lack of emphasis given by principals and parents to science and technology education as an important source of knowledge and skills as a basis for future citizenship, particularly in light of the Council's views on the need to increase our society's scientific and technological awareness and understanding as we move toward the 21st Century.

Despite these encouraging findings, the Council believes there is a disparity between the in-principle status which is accorded to science and technology education and that occurring in practice. This is obvious through a variety of indicators, but particularly the timetable allocation to science and technology and the availability of science and technology

*English, mathematics, science, technology, health and physical education, studies of society and the environment, the arts, and languages other than English.
### Table 1 Principals’ and parents’ goals for primary science and technology education

<table>
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<tr>
<th>GOALS OF PRIMARY SCIENCE OR TECHNOLOGY EDUCATION</th>
<th>% OF RESPONDENTS IDENTIFYING GOAL AS FIRST OR SECOND IN THEIR ORDER OF IMPORTANCE</th>
</tr>
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<tr>
<td></td>
<td>PRINCIPALS</td>
</tr>
<tr>
<td></td>
<td>SCIENCE</td>
</tr>
<tr>
<td>Understand scientific or technological concepts</td>
<td>15</td>
</tr>
<tr>
<td>Develop an inquiring mind</td>
<td>33</td>
</tr>
<tr>
<td>Develop problem solving skills</td>
<td>24</td>
</tr>
<tr>
<td>Learn about scientific or technological achievements</td>
<td>0.5</td>
</tr>
<tr>
<td>Encouraged to be innovative</td>
<td>5</td>
</tr>
<tr>
<td>Link/apply science or technology to everyday life</td>
<td>15</td>
</tr>
<tr>
<td>Gain knowledge and skills as a basis for future citizenship</td>
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Teaching resources. This disparity is, in the Council's view, likely to be both a reflection of the low status accorded to science and technology within the broader community and a result of structural impediments and system failures in primary science and technology teaching. Given the general nature of the former; it is the latter on which the Council will concentrate.

The study has revealed that, in those primary schools visited, only 45 to 60 minutes (or about four percent of the teaching time) is allocated in the weekly timetable for science and technology together. This low proportion of scheduled time spent on science and technology is consistent with the principals’ survey responses. Here children are reported as being engaged in science and technology learning for less than ten percent (a range of zero to ten percent) of the term. Students in junior and senior primary school spend a similar amount of time learning science and technology. Of those principals surveyed, 70 percent believed that both science and technology are under-represented in the primary curriculum.

In terms of teaching resources, only 41 percent of surveyed principals believed that their school's access was adequate for science and even fewer, 29 percent, believed access was adequate for technology. Fewer than 20 percent reported their schools as having a special room for science or technology. Libraries were well stocked with science materials in 58 percent and technology materials in 39 percent of the schools surveyed.

The Council was surprised to find that, given the involvement of a number of organisations.
in the development and provision of science and technology teaching resource materials, only eight percent and three percent respectively of the principals surveyed said that their schools used a particular set of science or technology resource materials. The Council is aware that use of the available resource materials varies not only by school but also by district and by State or Territory. When asked what type of teaching resources would most assist teachers, principals who reported inadequate resources suggested, for both science and technology, that there is a need for more hands-on activities, activities that show process outcomes, and for a well-structured curriculum.

It is becoming apparent that the interactive and hands-on approach to teaching science and technology is taking hold at the primary level. This approach is welcomed by the Council because it makes science and technology teaching more effective for all children, regardless of language skills, links science and technology to a child's existing understanding, caters for different learning styles and portrays science and technology as accessible and relevant to a child's everyday life.

Where possible science and technology are being taught in an integrated fashion with other learning areas via learning themes that last from a few weeks to a term. According to 63 percent of the principals surveyed, technology, while difficult to integrate, is integrated into the curriculum more frequently than is science. Nevertheless, technology education presents some unique problems relative to science. The majority of principals surveyed (68 percent) believed that technology is difficult to teach because it is difficult to describe and so can significantly lag behind science education. Furthermore, many principals feel that due to the lack of a true understanding about what technology really is, many teachers are frequently either teaching technology without calling it that (75 percent of respondents) and/or equating the teaching of technology with learning to use computers and other forms of information technology (73 percent of respondents).

During the course of this study, the Council had the opportunity to discuss science and technology education with many talented primary principals and teachers. It was not uncommon to meet teachers who, despite high levels of general and specific teaching skills, confided to the Council that they felt less than totally confident when it came to teaching science and technology and in particular, teaching technology. These admissions by individual teachers are fully supported by the survey responses from the principals who indicated that about half of the schools (53 percent) had a teacher specialising in science or technology and that only one to ten percent of their staff had a special interest in either science or technology. In addition, only one to ten percent of staff were reported as having undertaken any form of professional
development in science or technology over the last three years. This is of great concern to the Council especially as technology education is a new learning area for most teachers and one which is evolving rapidly.

Although much of this lack of confidence in teaching science and technology was found among older more experienced teachers, the Council was concerned to find also a lack of confidence among many younger teachers who had recently completed their pre-service education. It appears that insufficient attention has been given by the faculties of education to the science and technology content of many pre-service primary programs despite the Speedy Report's earlier recommendation to address this issue. A limited examination by the Council of the published pre-service course structures for the larger tertiary programs suggests that, on average, only two compulsory science and technology related units (about six percent of the total workload) are required of students in a bachelor level degree. A more detailed study of the subject matter of these units was beyond the scope of this study. However, the titles of the units suggested to the Council a limited substantive science and technology content.

Given the claimed deficiency in science and technology teaching resources, the Council was disappointed to find that relatively limited use is made by primary teachers of local community resources. Between 50 and 70 per cent of the principals surveyed reported their schools hardly ever or never involved their students in activities run by CSIRO, state science or technology teachers associations, public science and technology centres, science and technology advisers or other non-school organisations. Similarly, few teachers took advantage of the professional development opportunities offered by these community groups.

While the focus of this study is not on secondary education, the Council's attention was drawn on several occasions during our interviews to a possible primary-secondary transition problem in which students lose their initial enthusiasm for science and technology during their early secondary education. The Council did not investigate this issue further; however, it is aware of other studies which present evidence that unfavourable attitudes to science and technology are emerging among junior high school students. Of those students surveyed, in these studies, many considered science to be boring, difficult and irrelevant to their lives after they leave school. In addition, science was seen as a subject to be taken only by the smart kids: the "nerds" and "dorks". Given the potential for an interface problem of this kind to block benefits from primary education reforms, we believe the matter deserves the serious attention of school systems.
Chapter 3:

The Status of Science and Technology in the Primary Curriculum

The reasons are likely to be complex for the disparity between the status of science and technology education in the primary curriculum as indicated by, on the one hand, the National Statements and Profiles, and on the other, that commonly found in practice. Previous studies, along with our survey and interview results have suggested a range of possible causal factors: resources, equipment, funds, curriculum materials and teacher education. Several past programs implemented to support the teaching of primary science and technology have viewed these factors as 'agents of change' and addressed them accordingly. However, the impact of these programs to improve the low status of science and technology in the primary curriculum was limited and short lived. In the Council's view, most, if not all of the above factors, are likely to be secondary in nature relative to the primary drivers of change. These primary drivers of change will include such things as the expectations of parents for their children's primary education, development and implementation of improved curricula, raising the status of science and technology through leadership in schools, and facilitating a 'cultural change' among all principals and teachers in terms of the value they place on science and technology education. The Council believes these last two points are pivotal in addressing the low status of science and technology education. They are discussed more fully in the next chapter.

Community Attitudes to Science and Technology

Given the status accorded to science and technology in our society, and that it is reasonable to expect priorities in schools to reflect those of society, it should not come as a surprise to find the status of primary science
the status of both science and technology in the primary curriculum are arguably higher today than they might otherwise have been without the development of the National Statements and Profiles and technology lagging behind other identified learning areas. Public opinion is, in one respect, part of the problem, but it can also be part of the solution in that, once moving, it becomes a powerful means by which to effect lasting change. As the numbers of committed parents, motivated principals, teachers and officers of education systems increase, so will the momentum for change. Children, particularly those fortunate enough to now be receiving a good quality science and technology education, are likely in turn to demand similar high standards for their own children. In the shorter term, the Council believes that a range of activities such as the Commonwealth’s Science and Technology Awareness Program, and responsible media coverage of science and technology issues, will help raise the status of primary science and technology education via an impact on public opinion.

National Statements and Profiles
Although not as high as the Council would like to see, the status of both science and technology in the primary curriculum are arguably higher today than they might otherwise have been without the development of the National Statements and Profiles. The Council recognises that the Statements and Profiles have been subject to debate and that education systems have made their own decisions regarding their use. Nevertheless, they have indicated to schools, and the community-at-large, that both science and technology have a legitimate and integral role in the primary curriculum.

A recent study by the Australian Council for Education Research of the extent and nature of the take-up of the Statements and Profiles by the various education systems has found that most schools had begun the process of implementation in 1994 or 1995, and that using the profiles for assessment or reporting on student learning outcomes was more advanced for English and mathematics than for either science or technology, where the emphasis was still on the programming phase (see Table 2). As a result, it is ASTEC’s expectation that the status of both science and technology, and technology in particular, in primary curricula will continue to improve as education systems make progress with their implementation of the Statements and Profiles, or develop their own State or Territory curricula in these areas.

The Status of Primary Technology Education
The results of this study have indicated to the Council that the status of technology education in the primary curriculum is low compared to that of science. There are no doubt numerous factors which have contributed to this relative difference. However, the Council believes that two main causes can be readily identified. Firstly, as has been noted previously, there has been, prior to the development of the National Statements and Profiles, no real history of technology education in our primary schools. Science, on the other hand, has been taught at
Table 2 Primary schools' emphases for implementation of curriculum profiles by area of study

Source: Australian Council for Education Research (1996)

<table>
<thead>
<tr>
<th>Emphasis</th>
<th>English</th>
<th>Maths</th>
<th>Science</th>
<th>Technology</th>
<th>Health/Physical Education</th>
<th>Studies of Society and the Environment</th>
<th>The Arts</th>
<th>Languages other than English</th>
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<tr>
<td>Familiarising</td>
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<tr>
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<tr>
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<td>30</td>
<td>29</td>
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<td>49</td>
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</tbody>
</table>

the primary level, in one form or another, for some time prior to the Statements and Profiles being developed. As such, the 'starting points' for each of these two learning areas are quite different. It is to be expected therefore that the status of technology education in the primary curriculum would naturally lag behind that of science. This said, it should not be surprising therefore that the level of teacher preparedness and the availability of teaching resources for technology education are lower than those for science. This observation leads directly to the second of the two main causal factors: the widespread lack of a deep understanding among many of those principals, teachers and others consulted by the Council of what primary technology education encompasses and how it relates to and differs from science education. The Council acknowledges that this problem is recognised by many people associated with primary technology education and that much useful work has already been done in this area. The National Technology Statement and Technology Profile for example, seek to address this issue. As far as primary technology education is concerned, it has now been agreed that the concept of design should be incorporated into teaching and a strong emphasis placed on the generation of a range of solutions, reflection and responsible decision making. In this latter context, both social and environmental issues relevant to the application of knowledge should be considered when teaching primary technology. Ultimately however, technology education is about learning to find solutions to particular needs, that is, it is purposeful.

Despite this past and on-going work, it is the Council's view that more remains to be done if the majority of primary principals and teachers are to understand fully the nature and purpose of primary technology education. In this context, the identification and publication of best practice teaching techniques and learning exercises in primary science and technology may be worthwhile. The Council remains concerned that without an increase in
understanding about what constitutes proper science education and technology education among principals and teachers, the integrity of each identified learning area may be placed at risk. It follows, in the Council's view, however, that if better understanding can be achieved, and teachers are adequately prepared and equipped, the higher status being sought for technology education in primary curricula will follow as a matter of course.

Recommendation 1: Improving the Status of Science and Technology in the Primary Curriculum

The Council considers that while science and technology have improved in status within the primary curriculum since 1989, their status is still too low. Their status is influenced by many factors including the level of understanding by principals, teachers, and the general community of (a) the nature of science and technology, (b) the differences between the two, and (c) their different desired learning outcomes. The status of science and technology in the primary curriculum will remain low until there is a better understanding of these factors and unless there is continuing pressure for improved science and technology teaching from motivated principals, teachers, parents and children.

The Council recommends that education systems continue working actively towards an improved understanding by all principals and teachers of what science and technology education, and in particular, technology education, encompass.

It further recommends that mechanisms be sought to encourage and support motivated principals, teachers, parents and children as change agents for improving the status of science and technology within our systems of primary education.
Chapter 4:

Teacher Confidence and Professional Development

Of those factors identified by the Council in this study as being serious impediments to primary science and technology education, the limited confidence of many teachers in their own ability to teach these subjects is the most significant. Although there are several different ways of tackling this problem, the Council does not believe the solution is to replace classroom teachers with specialist science and technology teachers. Use of specialist teachers may be detrimental in view of the strong relationships that develop between young children and their teachers, and the desirability of integrating science and technology into other areas of the primary curriculum. Instead of specialist teachers in primary schools, the Council suggests that classroom teachers remain responsible for both science and technology education, just as they are for English and mathematics, but that they become 'empowered' to better teach science and technology.

Classroom teacher empowerment is not an easy issue to address as it means that some attention must be given to both the pre-service and in-service education of primary teachers. The Council's concern about the pre-service education of primary teachers was discussed previously in Chapter 2. It is sufficient to say here that the greater emphasis now being placed on science and technology education in primary schools, relative to the emphasis at the time that most current teachers received their pre-service education, is ample justification for additional professional development in science and technology education at the primary level. Although the Council agrees that some in-service education will always be required if teachers are to keep themselves abreast of advances in science, technology and teaching practices, in-service
classroom teachers remain responsible for both science and technology education, just as they are for English and mathematics, but that they become ‘empowered’ to better teach science and technology education should not normally exist to compensate for shortfalls in pre-service education. Ideally, permanent improvement in the confidence and capacity of primary teachers to teach science and technology should follow from improved pre-service education.

Unfortunately, given the large number of teachers reporting low confidence in their capacity to teach primary science and technology, solutions which focus primarily on improvements to pre-service education will not be timely. Instead, the Council believes most strongly that additional science and technology professional development is needed for most primary teachers.

Whatever mechanisms are chosen to deliver in-service education, they must, in the Council’s view, be relevant to the local conditions. As these differ substantially across Australia, it is unlikely that one in-service mechanism will suit all situations equally well. Experience has shown that the capacity of schools to support professional development for their teachers in terms of funds available for training, acquisition of resources and relief teaching support vary widely. A program which is relevant to one group of teachers may not be relevant to another given the diversity of the teacher population. Teachers are not all located in metropolitan schools and those employed in the rural and remote regions may find it difficult, if not impossible, to participate in a program based on multiple training sessions away from their home school. New graduates are employed each year; experienced teachers return to work and a high staff turn-over is common in many of the rural and remote schools, making continuity in any in-service education program difficult to achieve. As with any group of people, teachers’ interests will vary. Some will like science and technology and be keen to undertake in-service education, others will be ambivalent or even opposed. The professional development requirements of teachers will depend not only on their location, experience and interests, but also on the specific needs of their students, such as those from a non-English speaking background or Aboriginal or Torres Strait Islanders.

Although, as noted previously, it is unlikely that any one model of in-service education will be universally applicable Australia wide, our experience, together with the results of other similar studies, have identified several key features (discussed below) which are likely to be associated with successful outcomes. When considered together, these features may provide a useful ‘design framework’ for education systems considering the implementation of a primary science and technology in-service program.

Of prime importance, the program cannot be seen as just another short-term exercise in the professional development of a few teachers. Instead, a substantial and sustained professional development program is required. Without
Recommendation 2: Pre-service Teacher Education

The Council believes that any long-term enhancement of primary science and technology education will depend on teachers having a good knowledge of both substantive science and technology and the teaching practices appropriate to these learning areas.

In view of the importance which the Council attaches to pre-service education, it recommends that the Council of Education Deans together with the Australian Science Teachers Association and the Technology Education Federation of Australia review the balance of learning in substantive science and technology and in teaching practices required of training teachers.

Furthermore, the Council suggests that the total time devoted to science and technology in the pre-service teacher education curriculum be determined in accordance with the identified learning areas in the primary curriculum.

such a commitment, there is a limit to what even the best designed programs can achieve. The philosophy underlying the program must be that all teachers should be confident and competent in all the identified learning areas including science and technology. The goals of the program therefore need to be broad, including greater teacher confidence, improved understanding of substantive science and technology, establishment of long lasting and self-sustaining support mechanisms for teachers and, ultimately, a change of culture among both principals and teachers in terms of science and technology education. Good support and networking mechanisms are vital for teachers, especially those working in smaller schools and rural and remote regions. Incorporating on-line services into an in-service program for these teachers will be one useful way to tackle this difficult problem.

The decision to establish a primary science and technology in-service program should be taken by a relevant State, Territory, independent or other education authority and presented to teachers in such a way that as many as possible elect to participate voluntarily. Establishing a high degree of program ‘ownership’ and employing mechanisms such as providing small grants to participants to help maintain their initial enthusiasm are also seen by the Council as potentially useful.

Programs intended to aid primary teachers in science and technology education should be structured to allow those teachers who are less confident to develop new skills while, at the same time, allowing teachers who are already fairly proficient, to add to their existing skills. It is to be expected that some targeting may be necessary to encourage participation by those teachers with little or no prior science and technology in-service education. Similarly, the monitoring of gender balance among participants is desirable and, if necessary, encouragement should be given to ensure the mix of participants approximately matches that of the teacher population.

Best practice adult learning techniques such as a collegiate approach to instruction should be adopted wherever possible. Teachers must be
Recommendation 3: Teacher Confidence and Professional Development

The Council recommends that all State, Territory, independent or other education authorities act quickly to address the low level of confidence of many primary school teachers in science and technology education through provision of in-service education.

In view of the need for a rapid and nation-wide response, the Council suggests that there is a good case for the Commonwealth to take the lead in this matter and provide matching funding for this training.

While local conditions will dictate the specific nature of how this professional development is provided, the Council recommends that education authorities and providers be mindful of best practice in adult education and the features of success identified in this report.

Noting that certain teacher-leader or coordinator models incorporate many of these success features, the Council further recommends that such models be generally supported by State, Territory, independent and or education authorities and the Commonwealth.

Encouraged to reflect on their own attitudes to science and technology, adjust them if necessary, build on their existing experience and be provided with sufficient time to 'internalise' change rather than be subject to a one-off intensive training exercise.

Flexibility may well be the primary feature of success in any in-service education program. A staged approach could be used to meet the needs of teachers with differing interests and requirements. In the first instance, the aims of an in-service program might be limited to awareness raising, and subsequently, amended to provide teachers with more content knowledge and practical experience. With sufficient flexibility, some use might be made of existing resources and consequently, the program costs and its establishment time minimised.

Situations where it is necessary for teachers to be absent from their schools and classrooms for extended periods of time must be avoided if at all possible. Instead, the most practical alternative is, in the Council's view, for the professional development to be available at or near a teacher's home school, and after hours if necessary.

Despite the difficulties in recommending any one model of in-service education, the Council notes that the teacher-leader or coordinator model as used previously in South Australia and currently in Western Australia (see over page) incorporates most of the above listed features likely to bring success. For many primary schools in Australia, although by no
means all, the Council believes that there is a good case for establishing a coordinating teacher position for science and also for technology, or similar positions based on the general teacher-leader/coordinator model.

The Council is not alone in making such a recommendation. In 1989, the Speedy Report\(^1\) suggested the creation of the position of resource teacher for science in all primary schools of a reasonable size (say, about 100 students). Similarly, in 1996 the Australian Council for Education Research (ACER)\(^2\) identified the presence of a teacher-leader within schools as an essential factor for ensuring a positive response by teachers to the implementation of the National Statements and Profiles. ACER observed that:

"this person tends to have a personal commitment to the goals and benefits he or she sees as being obtained by the implementation of the profiles; is familiar with the structures and jargon of the statements and profiles, perhaps through a previously held position; and translates this familiarity into documentation and teacher talk for colleagues which is firmly contextualised in the school’s learning and teaching environment, which in turn increases the acceptance level and time for other staff.”

While in agreement with the above observation, ASTEC would add that, to be truly effective, a teacher-leader or coordinator must also have a good understanding of the principles of the subject matter being taught.

Some possible duties for science and technology coordinators include:

- promoting science and technology in the school curriculum
- providing professional development in the school, both through formal programs and informal assistance to other teachers
- providing advice about available professional development opportunities in science and technology education, and encouraging participation
- establishing networks and cooperative teaching activities, including with teachers at other schools
- keeping abreast of available teaching resources
- supervising the acquisition and maintenance of equipment
- identifying opportunities for community members and community organisations to participate in school activities
- organising and implementing special events such as parent workshops and science/technology days for children
SOUTH AUSTRALIA’S SCI-TEC IN-SERVICE TRAINING PROGRAM\(^{13,14}\)

In the first phase of the Sci-Tec project a number of focus teachers participated in three weeks of in-service training. Subsequently, these focus teachers provided similar in-service training to the Year 5-7 teachers in their own schools. In the second and third phases of the project, in-service training was continued with the Year 5-7 teachers working with two teachers from each of three to five neighbouring schools, who were, in turn, providing in-service training for the Year 5-7 teachers in their schools.

From the outset, the project was based on the premise that each of the teachers selected to participate as a focus teacher should already possess a wealth of knowledge, skills and attitudes which were compatible with the aims of the project. The first task was to enable these focus teachers to share this expertise with all other participants. The second task was to blend their expertise with that of the other Year 5-7 teachers in the focus schools, and ultimately other participating schools. Several approaches were deemed likely to achieve this:

- modelling and maintaining a collegial approach throughout the activity-based program during the first phase of the project;
- facilitating interactions between focus teachers during activity sessions and in informal ‘social’ discussions;
- openly valuing the ideas of all participants, particularly their views of what science and technology are in the context of the primary school;
- seeking a school commitment via the principal of each focus school to match the personal commitment of the participants, and the financial and ideological commitment to this model by the Education Department;
- spending most of the time devoted to the project in the focus schools;
- encouraging participants to reflect critically on their beliefs about science and technology, and on the processes by which they had come to these beliefs;
- using a ‘hands-on’, child-centred approach in which children investigate problems that they find relevant;
- having two focus teachers from each school so that there would be immediate in-school support when they began providing in-service training for their colleagues;
- ensuring a gender balance similar to that of the mix of teachers across the state, by requiring at least one of the focus teachers nominated from each school to be a woman; and
- involving all participants in the planning of activities and the establishment of support networks.

While the model has some of the features of the ‘train the trainer’ model, it differs in a number of respects. The ‘trainers’ did not see their role as providing the answers that the focus teachers lacked. Uppermost in the minds of these trainers was the need to develop the focus teachers’ ability to analyse the various in-service activities and see their potential for the classroom and future in-service training. Each activity was perceived as a model for reflecting on classroom practice rather than a trick to be replicated with a class.
The primary teacher leader program is a strategy to train science teacher leaders in all Western Australian school districts. The teacher leaders are supported to facilitate subsequent professional development programs for primary school science coordinators in their respective school districts.

Training the Leaders
In 1995, a primary teacher from each district participated in a 15-day training program held in two- or three-day sessions throughout the year. The program provided training to become effective leaders with workshops on 'best practice', evaluating existing resources, outcomes based education, assessment, effective teaching and learning, developing and evaluating a district plan to support schools, integrating science with other learning areas and facilitating effective professional development. Teacher leaders were trained to become accredited leaders for the Australian Academy of Science's Primary Investigations program. In 1996, a second teacher leader in each school district was trained and the 1995 leaders were provided with further training. Also participating in the 1996 program were teachers with expertise and experience in early childhood education, Aboriginal education, English as a second language, isolated and distance education.

Support in Districts
Teacher leaders have been supported through an allocation of funding to each district to develop, implement and evaluate plans to provide professional development for the primary science coordinators. This has resulted in a variety of activities in the districts, including:

- school science coordinator network meetings
- district newsletters
- whole school Primary Investigations professional development
- district science conferences.

Support for schools has varied depending on the need of the school, the teachers' knowledge and confidence and the stage of science curriculum development. These stages have been broadly grouped as follows:

- school reflection, awareness raising and identification of needs
- whole school program with teachers confident to teach science using Primary Investigations
- embedding and building on the whole school program.

The third of these stages has three main components:

- continued whole school development
- individual teacher professional development
- professional development (PD) for school science coordinators to support their school.

Examples of activities in this stage have been:

Whole School Development
- integrating science
- use of school-developed materials
- monitoring student progress

Individual Teacher PD
- content knowledge
- constructivism
- linking science to technology
- portfolio assessment

Science Coordinator Support
- science coordinator networks and PD programs.
The Council has found difficulty determining the average amount of time spent each week by primary school students learning science and technology. While the Council's school visits suggested a figure of about 45 to 60 minutes each week, no doubt some additional time will be spent learning about science and technology during instruction in related identified learning areas. Conversely, some of the time allocated to science and technology education will be spent on other topics given the integrated approach to teaching at the primary level. Whether or not the net difference means that time in addition to the estimated 45 to 60 minutes per week is available for science and technology education, could not be accurately determined. The Council remains concerned that because of the difficulties being experienced by many teachers in understanding what technology education is and what it seeks to achieve, our estimate of the current curriculum time for science and technology, and technology in particular, may be an overestimate. The view of many teachers that learning to use personal computers, the Internet and other forms of information technology constitutes technology education further adds to the Council's concerns.

Despite the difficulties in determining the true allocation of time for science and technology education in the primary curriculum, the Council is confident in claiming that the current allocation is too little. Science and technology are, after all, two of the eight identified learning areas. In view of the importance attached to these identified learning areas by Council and by a majority of the parents surveyed, there is a strong argument indeed for science and technology education to be accorded a more equitable and substantial part of children's learning time.
On first consideration, the matter of how best to achieve an increase in the curriculum time for primary science and technology education seems obvious - a minimum time allocation could be mandated. However, the Council believes that a forced increase in the curriculum time allocated to science and technology is a simplistic response and unlikely to be effective. Throughout this report, the Council has emphasised that a long-term and sustainable solution to the problems faced by primary science and technology education will require that a cultural change takes place among principals and teachers with respect to the value which they place on science and technology education. The Council believes that forcing an increase in the curriculum time for these identified learning areas by mandating a minimum time allocation will not bring about such a change of culture but instead, is likely to engender discontent among principals and teachers. Similarly, the Council does not believe that mandating a minimum time allocation is wise for any identified learning area owing to the inevitable tendency of those identified learning areas without a mandate to suffer relative to those with a mandated minimum. One must also question the merit of the mandating option for science and technology education when, as was often claimed by many primary teachers themselves, even the 45-60 minutes currently allocated may not be being used effectively given the low teacher confidence and lack of teaching resources.

In the Council's view, the most appropriate solution to the issue of inadequate curriculum time allocation for science and technology in primary schools is to set a goal of working towards a doubling of the current time allocation as both teacher confidence and the availability of teaching resources increase. Indeed, the Council believes that time allotted to science and technology will tend to increase automatically as teacher confidence and ease of access to teaching resources increase. The improvement of curriculum time for primary science and technology education is therefore linked with the provision of additional in-service education as discussed in Chapter 4 and teaching resources as discussed in Chapter 6.

Given that teacher confidence and teaching resources are issues to be addressed, the problem remains of how best to increase the amount of time children spend each week learning science and technology in what is already an overcrowded primary curriculum. Although integration of science and technology with other identified learning areas is already a widespread teaching practice in many primary schools, the Council believes that the further integration of these identified learning areas is a useful and practical response to an otherwise intractable problem. Further integration offers the opportunity to not only achieve extra time for science and technology education in the primary curriculum without challenging the other identified learning areas but, according to many of the teachers we interviewed during this study, it also assists them with additional ways of achieving a wide range of learning outcomes, particularly literacy and numeracy.
A higher level of integration of science and technology with the other identified learning areas is not without some risks. The Council acknowledges that further integration could present an opportunity for those teachers who are not confident in their ability to teach science and technology to minimise their teaching time, if not avoid the topics altogether: If not carried out in a skilful way, integration may result in a reduction in the level of substantive science and technology being taught in primary schools. Poor integration may also challenge the integrity of science and technology as two separate and distinct identified learning areas, each with its own learning outcomes. Despite these perceived risks, during the course of this study the Council has found no major evidence of such confusion among either teachers or students.

Indeed, many of the children to whom the Council spoke seemed quite clear as to the differences between the learning outcomes expected for science and technology:

"science is discovering things, technology is making things after you have tried them out with science"

"science is finding out how to do things, technology is using the science you've found out, using the technology for all the science stuff"

Whether or not any potential disadvantages of further integration become significant will, in the Council's view, depend entirely on how well skilled our primary teachers are in the integration of teaching and learning of all the identified learning areas. It is for this reason the Council believes that in-service education for primary teachers must address this issue as a matter of priority.

**Recommendation 4: Increasing Science and Technology Curriculum Time**

The Council recommends that curriculum time for primary science and technology should not be mandated.

Instead, the Council recommends that a goal should be set and adopted by all State, Territory, independent or other education systems to allocate a more substantial and equitable part of the available primary curriculum time to science and technology education as the confidence and capacity of their teachers to teach quality science and technology increase.
Second only to the issue of low confidence of many primary teachers in their ability to teach science and technology, the Council is most concerned by the number of primary school teachers who indicated they lacked suitable technology education resource materials. Still other teachers suggested to the Council that the problem was not so much a lack of technology education resource materials, but the lack of a national inventory and a means to publicise information about those resources which are currently available.

During the course of this investigation, the Council was not able to determine which of these two factors is the primary cause for teachers not having access to adequate technology education resource materials. The Council is aware that a range of materials exists but that these may not be suitable for all teachers. Under these circumstances, the Council believes that it is not appropriate at this time to produce additional technology education resource materials before surveying the currently available materials, determining whether any gaps exist in the type of materials that are available, and identifying best practice examples of technology education resource materials, both from Australia and overseas. In the Council's view, a useful adjunct to this task would be to establish a national inventory of available technology education resource materials, possibly as an on-line service for all teachers.

Should it eventuate that the existing technology education resource materials are deemed to be inadequate, the Council strongly recommends that suitable materials are promptly developed, perhaps utilising or adapting the model employed for the development of the Academy of Science's
it is not appropriate at this time to produce additional technology education resource materials before surveying the currently available materials, determining whether any gaps exist in the type of materials available, and identifying best practice examples of technology education resource materials. Primary Investigations program for primary school science. If a program to produce additional primary technology resource materials is undertaken, the Council urges that those same factors which are thought to have contributed to the success of Primary Investigations, such as adequate testing, involvement of primary teachers in the design and preparation of the materials, adequate content and adaptability to local conditions, be essential elements of the new program. Although the Council believes that meeting the purchase cost for a program of this kind is properly a matter for schools to address when determining their spending priorities, the Council suggests that the cost of the resource materials to schools be kept to a minimum, especially given the equity implications involved. In addition to the above success factors, the Council believes that the designers of any new technology education resource materials, should, where possible, keep in mind those aspects of cultural differences among children that may influence learning.

Despite the claim by many primary teachers that technology education resource materials are inadequate, few seem to be compensating for this shortage by taking full advantage of the wide range of community resources that are available, including parents and retired or non-working technologists. Industry, particularly the mining industry, has taken initiatives in support of primary technology education. The CSIRO and the public science and technology centres provide teaching resources for primary technology. The Council is concerned that primary teachers may often overlook useful technology education resources such as visits to a local water-treatment and supply plant.

Recommendation 5: Inventory and Development of Technology Teaching Resources

The Council recommends that the Commonwealth provide funding to an appropriate group to (a) survey the currently available technology education resource materials, (b) determine whether or not gaps exist in the existing materials and (c) identify best-practice examples of such teaching resources, both in Australia and overseas.

In addition, the Council recommends that the Commonwealth provide funding to the same or a similar group to establish an on-line national inventory of technology education resource materials. In the Council’s opinion, an appropriate group to undertake this task would include representatives of the Technology Education Federation of Australia, the Academy of Technological Sciences and Engineering and the Institution of Engineers, Australia.
machine workshop, clothing factory or local printer. These less-obvious community resources may be of particular importance to primary teachers working in rural and remote regions given their ready availability in all but the most isolated communities. While the Council does not support school visits for the sake of school visits, available community resources are invaluable in support of primary technology education if used wisely.

While it is tempting in a situation such as this to recommend that more use should be made by all primary teachers of community resources, perhaps it is more helpful to identify the reasons why only limited use is currently being made of these resources. Our research has revealed that a comparable problem exists for community resources as for technology education resource materials in that teachers are not always fully aware of what community resources exist within their local areas. There is a real need here for more information. However, it is not a national inventory that is required in this situation, but instead, a local compendium. The preparation of such a document would fit easily within the range of responsibilities envisaged by the Council for a teacher-leader or science and technology coordinator.

The logistics of school visits, together with difficulties that are sometimes experienced with incorporating the visit into the school timetable, were viewed by many of the teachers interviewed by the Council as being major disincentives to the greater use of community resources. Frequently the comment was made during our interviews that community resources are so much easier to use if the resource is willing and able to travel to the school. This would obviously be more the case for schools located in rural and remote regions and is a factor to be borne in mind by the community resource providers. The development of on-line services is a practical, if only partial solution to this problem but is one with which Australia has significant prior experience, albeit with different technology, in the form of the School of the Air.

Finally, the term 'community resource' is a little misleading in that it may imply a free resource which, in many cases, is not true. With school and parental budgets stretched to their limits, even a small charge can act as a disincentive to the greater use of community resources. No doubt some parents also remain unconvinced of the value of school visits in the technology education of their children. Economies of scale generated by cooperation among neighbouring schools may provide a partial solution to the problem of visit costs, especially in situations where the community resource is able to travel to the school.

Recommendation 6: Better Use of Community Resources

The Council recommends that, despite the significant obstacles, teachers take full and appropriate advantage of available community resources in support of primary science and technology education.

The Council further recommends that teachers, especially those working in rural and remote regions, be mindful of some of the less-obvious technology teaching resources that are available within the infrastructure of most communities.
Notes


15. F. Deshon (personal communication)
Appendix A:

Summary of Recommendations

The Council recommends:

1. To improve the status of science and technology in the primary curriculum:
   - that education systems continue working actively towards an improved understanding by all principals and teachers of what science and technology education, and in particular, technology education, encompass; and
   - that mechanisms be sought to encourage and support motivated principals, teachers, parents and children as change agents for improving the status of science and technology within our systems of primary education.

2. To improve pre-service teacher education for science and technology:
   - that the Council of Education Deans together with the Australian Science Teachers Association and the Technology Education Federation of Australia review the balance of learning in substantive science and technology and in teaching practices required of training teachers; and
   - that the total time devoted to science and technology in the pre-service teacher education curriculum be determined in accordance with the identified learning areas in the primary curriculum.

3. To improve teacher confidence and professional development:
   - that all State, Territory, independent or other education authorities act quickly to address the low level of confidence of many primary school teachers in science and technology education through provision of in-service education;
   - that the Commonwealth take a lead in this matter by providing matching funding for appropriate in-service education;
   - that education authorities and providers be mindful of the features of best practice in adult education and the features of success identified in this report; and
that models such as the teacher-leader or coordinating teacher be generally supported by State, Territory, independent or other education authorities and the Commonwealth.

4. To increase science and technology curriculum time:

that curriculum time for primary science and technology should not be mandated; but instead

that a goal should be set and adopted by all State, Territory, independent or other education systems to allocate a more substantial and equitable part of the available primary curriculum time to science and technology education (eg., double the current level) as the confidence and capacity of their teachers to teach quality science and technology increase.

5. To document and develop technology teaching resources:

that the Commonwealth provide funding to an appropriate group (eg., representatives of the Technology Education Federation of Australia, the Academy of Technological Sciences and Engineering, and the Institution of Engineers, Australia) to (a) survey the currently available technology education resource materials, (b) determine whether or not gaps exist in the existing materials and (c) identify best-practice examples of such teaching resources, both in Australia and overseas; and

that the Commonwealth provide funding to the same or a similar group to establish an on-line national inventory of technology education resource materials.

6. To encourage better use of community resources:

that, despite the significant obstacles, teachers take full and appropriate advantage of community resources provided in support of primary science and technology education; and

that teachers, especially those working in rural and remote regions, be mindful of some of the less obvious technology teaching resources that are available within the infrastructure of most communities.
## Appendix B:

**Individuals or Organisations Making a Submission**

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Position/Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mr Peter Clarkson</td>
<td>Faculty of Education, Monash University</td>
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<td>2</td>
<td>Mr Peter Ferguson</td>
<td>Lecturer ECE/Primary School Science Education, University of Tasmania</td>
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<td>3</td>
<td>Dr Russell W. Jones</td>
<td>Science Educator; University of Melbourne</td>
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<td>Dr Russell W. Jones</td>
<td>Australian Academy of Science</td>
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<td>5</td>
<td>Professor T W Cole</td>
<td>Education Committee for Engineering and Technological Sciences, Australian Academy of Technological Sciences and Engineering</td>
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<td>6</td>
<td>Ms Marj Colvill</td>
<td>Australian Science Teachers Association</td>
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<td>7</td>
<td>Assoc Prof Denis Goodrum</td>
<td>School of Maths, Science and Technology Education, Edith Cowan University</td>
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<td>Assoc Prof Tim Hardy</td>
<td>Faculty of Education, University of Canberra</td>
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<td>9</td>
<td>Professor Don Watts</td>
<td>Research and Postgraduate Studies, University of Notre Dame</td>
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<td>10</td>
<td>Ms Lynne Reeder</td>
<td>Senior Policy Analyst, Institution of Engineers</td>
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<td>11</td>
<td>Mr Bob Staples</td>
<td>Inspector-Technology, New South Wales Board of Studies</td>
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<td>Mr Don Laird</td>
<td>Chairperson, Standards Council of the Teaching Profession</td>
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<td>Dr Ken Appleton</td>
<td>Faculty of Education, Central Queensland University</td>
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<td>Mr Stuart Palmer</td>
<td>School of Engineering and Technology, Deakin University</td>
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<td>16</td>
<td>Dr Bruce Waldrip</td>
<td>Faculty of Education, Curtin University of Technology</td>
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<td>17</td>
<td>Dr John Wallace</td>
<td>Key Centre for School Science and Mathematics, Curtin University of Technology</td>
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<td>18</td>
<td>Assoc Prof Leonie Rennie</td>
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<td>19</td>
<td>Ruth Hickey</td>
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<td>20</td>
<td>Dr Ian Ginns</td>
<td>Centre for Mathematics and Science Education, Queensland University of Technology-Kelvin Grove</td>
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21 Dr James Watters
22 Professor Kym Adey
23 Dr Keith Skamp
24 Dr R.A. Osborne
25 Ms Miriam Moloney
26 Professor H. Harrison
27 Ms Moira Welch
28 Mrs Judy M Webber
29 Dr David Denham
30 Mr Paul Hauenschild
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42 Ms Sharyn Dickerson

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