Australian School Science Education

National Action Plan 2008 – 2012

Volume 2

Background Research and Mapping

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Introduction

The purpose of this document is to provide background to the text and recommended actions of the Australian School Science Education National Action Plan, 2007-2012. The first part presents a synthesis of the national and international research used to identify gaps and overlaps amongst activities related to school science education in Australia. Where relevant and appropriate, the paper identifies and reinforces actions that have been recommended by stakeholders and recent reports. The second part of this document reports a mapping exercise carried out to scope the range of reports and initiatives that impacted on science education. It is not the intention in this document to examine the whole range of aspects in science education, especially as some of these aspects have been covered by other recent reports. Rather, its purpose is to explain the research basis from which we developed the Action Plan.

An early version of this document was prepared as an Issues Paper in which we provided our findings up to that time, and identified the issues that had arisen. Each issue was briefly described and ideas for possible action were suggested. The Issues Paper was presented for discussion at the first meeting of the Project's Advisory Committee on October 17, 2006, after which minor amendments were made. It was then sent for comment to a range of stakeholders and also for input from critical friends (identified in Volume 1, Appendix 1) and revised on the basis of their extensive feedback.

In developing the Action Plan, we received and accepted advice from major stakeholders in Australian science education. We have reported our findings and suggested actions from them. We assume that if stakeholders think those suggestions have merit they will act accordingly. We are also aware that some of the suggestions are already in place, or being put in place, by some stakeholders, and we endorse those actions. Because of this, we regard the Action Plan as an opportunity for "stock-taking" on the jurisdictional and national levels, and a basis for finding ways of moving forward together.

During the preparation of this document, the educational and political landscape of science, mathematics and technology education was relatively volatile. We have tried to remain abreast of current developments but are aware that our summary will quickly become dated. Nevertheless, we believe that the exercise has been worthwhile and has drawn attention to significant matters that, until adequately addressed, will restrain Australia's teachers from offering, and our students from receiving, the ideal science education we described in Volume 1.

Data Sources for Developing the Action Plan

Essentially this project drew on three main sources of information. The first consisted of various national and international documents and websites. The second source of information was representative persons from stakeholder groups, with data gathered using email, interviews, focus groups, written responses to draft material, and other forms of personal communication. The third source was feedback obtained from the Advisory Committee and Critical Friends. In the following section we provide an overview of the kinds of documentary information, groups and stakeholders from whom we obtained data.

Documentary Information

The documents and websites found useful in developing the Australian School Science Education National Action Plan can be clustered into three categories. These sources of data are documented in the References to this Discussion Paper and in the mapping exercise that forms the second part of this document.

1. Descriptive documents, such as reports of investigations and surveys, that aimed to describe the current situation in terms of school/VET/higher science education (often including technology and engineering) and frequently included recommendations to address the findings. The majority of these examined are Australian, but documents and projects sourced internationally are included when relevant. Major reports are the Backing Australia's Ability report *Australia's Teachers: Australia's Future* (Dow, 2003a, 2003b, 2003c), and the Education and Training Committee of the Victorian Parliament report *Inquiry into the Promotion of Mathematics and Science Education* (ETC, 2006). In addition, our earlier report, *The Status and Quality of Teaching and Learning Science in Australian Schools* (Goodrum, Hackling, & Rennie, 2001), published six years ago remains remarkably current.
2. National and international research-based perspectives, published as books or papers in journals, given as conference presentations or invited papers to education bodies. These sources identified issues, synthesised/analysed evidence, drew conclusions and offered recommendations for future actions and/or raised questions/problems that needed to be addressed. Naturally, the papers/reports reviewed for this section were written from the conceptual and cultural perspectives of their authors, in the context of science education in the authors' own educational systems. Nevertheless, there are remarkably consistent views about most of the problems and issues identified in current science education.
3. Reports and websites relating to specific initiatives or activities, at the national, state or local level, that attempt to address perceived issues/problems relating to school (and other levels of) science education. There are literally

thousands of specific initiatives that have been introduced over the last decade to promote science education. Most of these are small scale with local aims and limited or no evaluation. In this section we focused on large scale activities, or clusters of similar activities, primarily within Australia and which have most relevance to our situation.

Representatives from Stakeholder Groups

Key stakeholders in this project are the jurisdictions, that is, the State and Territory Education Departments, and the systems within those jurisdictions, including Catholic and Independent Schools sectors and Associations. Professional associations and national bodies, such as the Department of Education, Science and Training (DEST), Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Australian Science Teachers Association (ASTA), Australian Primary and Secondary Principals Associations, Australian Education Unions, Australasian Science Education Research Association, Australian Council of Deans of Science, Australian Council of Deans of Education, Australian Academy of Science, Australian Academy of Technological Science and Engineering, and the Federation of Australian Science and Technology Societies. A list of stakeholders invited to provide information is in Volume 1, Appendix 1.

Advisory Committee and Critical Friends

An Advisory Committee was formed with the assistance of DEST personnel and the first meeting was held on October 17, 2006. A second meeting, assisted by teleconference, occurred on March 20, 2007. The first meeting introduced the project and the Issues Paper was discussed. The Group’s views on the directions currently taken by the project and appropriate further directions were canvassed. Discussion at the second meeting was focused around a near penultimate draft of the project report.

Four persons agreed to act as Critical Friends to the project to provide feedback on the Issues Paper and the penultimate draft of the report.

Members of the Advisory Committee and Critical Friends are listed in Appendix 1 of Volume 1.

Summary of Findings

In the following part of this document, a summary of the findings from the first two data sources – documents and research-based perspectives – is presented. The summary is divided into three sections which report findings relating to students and the science curriculum, teacher education for science and professional learning, and systemic and community relationships. These sections provide the background for the syntheses presented in Volume 1 that identify foci for action.

Volume 1 addresses a total of eight foci for action. The three foci for action synthesised for students and the science curriculum are labelled curriculum, assessment and resources. For teacher education for science and professional learning, three foci for action relate to initial teacher education, professional learning and teacher supply and demand. Finally, the synthesis of broader, systemic and community relationships leads to actions suggested for systemic relationships and community sources of learning.

The final section of this document comprises the Mapping exercise, in which a précis and contact details are presented for a range of national and international documents, activities and initiatives that contributed to the summary in the following pages.

Students and the Science Curriculum

Declining Enrolments in Science

Over the last decade or so, in most countries, secondary and tertiary total enrolments in the science, engineering and technology subjects have increased but the proportion of the student cohort has declined, particularly in the physical sciences and mathematics. Internationally, life sciences and engineering enrolments are more stable, particularly at the tertiary level, and this is attributable, at least in part, to increased enrolments of females who remain poorly represented in the physical sciences and mathematics (OECD Global Science Forum, 2006).

However, international comparisons mask differences between countries due to different methods of recording data, and variation in school systems from country to country. In Australia, the percentages of students leaving school with any of chemistry, physics and biology all declined between 1993 and 2003 (DEST, 2006; Dow, 2003c). Further, there is variability amongst jurisdictions, so care must be taken in making generalizations about enrolment data without further information. Nevertheless, the generally consistent decline in proportional enrolments at school is matched by declining tertiary enrolments in science-related courses and an increasing shortage of workers with SET skills (DEST, 2006).

There is a need for better measurement procedures and consistency of indicators used to record enrolments. Longitudinal data to follow specific cohorts of students would be helpful, not only internationally, but within Australia.

Images of Science and Science Careers

Stereotyped images still typify students' ideas about science and scientists. General findings are that students have little understanding of the range of science-related careers, their importance or how they use Information Communication Technology (ICT) (OECD Global Science Forum, 2006). Data from the Relevance of Science Education (ROSE) project (see the Mapping for a summary) indicate that students, particularly those in developing countries, generally believe science and technology are important, however most do not wish to become scientists, especially students from developed countries and particularly females (Sjøberg & Schreiner, 2005). It seems that whilst students consider science and technology to be important in general terms, they do not see it as important to them personally (Jenkins, 2005). Such students are not likely to want to enrol in more science classes once science becomes an elective subject in the post-compulsory years of schooling.

There is evidence that negative experiences in school science lead to negative attitudes towards science and technology which are difficult to change, and (not surprisingly) that positive images of science and technology come from quality teaching (OECD Global Science Forum, 2006). Recognition of young people's loss of interest in studying science led the European Commission to announce, in November 2006, the creation of a group to look at what action could be taken in Europe to support science education in primary and secondary schools. In a press announcement, the European Science and Research Commissioner said “a truly knowledge-based society needs its citizens to be involved. We have to do more to prepare our young people for a future that will require good scientific knowledge and an understanding of technology” (European Commission, IP/06/1631, 27 November, 2006).

There is need for improved community understanding and awareness about science. Poor community understanding of what science is about, and what scientists do, results in ignorance about the extensive range of career options available for students who continue their participation in science. Better programmes are required for providing accurate information regarding science careers for students, career advisors, and parents, and for more informed access to those resources that already exist, such as the DEST Career Advice Australia initiative package and the myfuture.edu.au website (see Mapping). CSIRO is also currently developing a science careers website. A related matter is the relatively low average pay graduates with bachelor’s degrees can expect when they enter many, but not all, science-related careers.

Personal Value, Relevance and Engagement

There is a consistent view that many of the problems and issues in science education stem from the nature of the curriculum, which is viewed as content heavy and alienating to the majority of students. A content-laden curriculum hampers the efforts of even the best teachers to provide an engaging science education for all of their students. Aikenhead (2006) stated, on the basis of his review of a large body of international research findings, “A recurring evidence-based criticism of traditional school science has been its lack of relevance for the everyday world” (p. 31). Many students, but of course not all, find the school science curriculum on offer to be unimportant, disengaging, and irrelevant to their life interests and priorities. The culture of school science, with its traditional emphasis on what Aikenhead termed “canonical science concepts”, is at odds with these students’ self-identities, so for them science has little personal or cultural value.

Aikenhead’s conclusions are supported by Lyons’ (2006) comparison of independent studies of students’ perceptions of the nature of school science in England, Sweden and Australia. He found remarkable similarity in students’ views about their science classes. Three common and interrelated themes, transmissive pedagogy, decontextualised content, and the perceived difficulty of school science, seemed to be at the heart of students’ disinterest in science and declining enrolments.

A major survey in the UK suggested that even by the end of primary school, children’s attitudes to science are beginning to decline, perhaps associated with a high proportion of primary teachers reporting that they lacked confidence, expertise and training to be effective teachers of science (Murphy, Beggs, Russell, & Melton, 2005), and more than half of teachers lacked confidence in using ICT. Teachers felt the key to effective science teaching was to involve children in questioning about science in their everyday lives, thus making it more relevant to them.

In England, an online survey about the science curriculum, developed mainly by secondary students, hosted by The Science Museum and funded by Science Year, attracted nearly 1,500 respondents (Cerini, Murray, & Reiss, 2003). Students' responses emphasised the importance of good teachers who promoted student participation through practical work and discussion. Their overall recommendations were that the science curriculum should include more ethical and controversial issues, fewer topics with more detailed treatment, and connect chemistry and physics with real-life situations.

Whilst a move to include more ethical and controversial issues in school science will increase its relevance to students, it is important to note that the complexity of some scientific issues (such as stem cell research, increasing salinity in agricultural areas, and maintaining sufficient water supplies in Australia) means that they do not have clear cut solutions. Often, the relevant science knowledge is uncertain or incomplete, so that many science-related questions can be answered only in probabilistic terms. This is especially significant in issues where there is potential risk to the community. Even when the risks inherent in making a particular decision are assessable by scientists, cultural and social rather than scientific values are needed to decide whether or not the risk should be taken. Economic and political values often sway decision-making. Unless there is clear communication to the public about these complex and controversial issues, the result is confusion and lack of confidence in science and scientists. In turn, this has a detrimental effect on the image of science and technology, and can lead to a lack of trust. The curriculum in school science must provide opportunities to explore these complex issues to enable students to understand that the use of science and technology is often concerned with risk and argument (Jenkins, 2004; Osborne, 2006; Rennie, 2007). A related consideration is the perceived difficulty of school science, particularly the physical sciences. It might be argued that the inclusion of complex issues would make science seem more difficult. However the answer is not to exclude them and "simplify" science, but to use such issues to promote a more complete understanding of the nature of science and scientific knowledge.

Providing a science curriculum that has personal value for all students requires differentiation, so that all students can engage with content that is meaningful and satisfying with conceptual depth, rather than breadth. The curriculum must be built upon knowledge of how students learn (Bybee, 2006a), have demonstrable relevance to students' everyday world (Rennie, 2006), and be implemented using teaching and learning approaches that involve students in active inquiry and research. The US-based Biological Sciences Curriculum Study (BSCS) 5Es Model (Bybee, 2006a), which underlies *Primary Connections* (and before it, *Primary Investigations* and the pilot *Collaborative Australian Secondary Science Project*) and the scoping for *Science by Doing* exemplifies the inquiry approach.

Engaging students in science in ways that promote meaningful, rather than surface, learning cannot be achieved without curricula that are meaningful to those students. For example, programs such as CSIRO's CREST (CREativity in Science and Technology, see Mapping) provide flexible, student-centred projects that can enhance interest and relevance to students. Further, more inclusive teaching strategies, including teamwork as well as individual work, and integrated use of ICT, are needed to cater for the diversity now present in Australian classrooms.

Clearly, there is need to ensure that students' early experiences of school science are positive and engaging and that curricula are sufficiently flexible, interesting and relevant to meet the needs of all students, especially in the compulsory years. Goodrum et al. (2001) determined that when science was taught in primary schools, it was perceived by students to be enjoyable and worthwhile, but this was not the case in many secondary science classes. Early evaluation of the development of *Primary Connections* (Hackling & Prain, 2005) indicated very positive reception by primary teachers and students, and the scoping project for *Science by Doing* has attracted considerable interest and support as a potential curriculum resource for lower secondary science within Australia.

Science Curricula

Internationally, there is wide and steadfast agreement that scientific and technological literacy are fundamental requirements for all students, yet there is little evidence that this is a general outcome of current school science education. Instead, there is widespread belief that declining enrolments, students' lack of interest and the perceived lack of relevance of school science, particularly at the secondary level, are all linked to the nature of science curriculum. Various reasons have been suggested for this, and the answer is probably a combination of factors including those already discussed.

Who Does School Science Serve?

In many countries, including Australia, science curricula have tried to serve two groups: the minority of students who intend to move into science-related careers, and the majority who do not and simply require sufficient scientific literacy to be sensible citizens. This international problem was recognized and well explained by Fensham (1985, 1997) in Australia and by Millar (1996) in the United Kingdom. The outcome is that neither group is well served. Increasingly, as more students stay on at school, the traditional, academic science curriculum fails the latter group whose frequent response is to opt out of science.

One approach to serving both audiences requires differentiated science curricula at least in the final years of schooling, but as yet, this problem has not been solved. Attempts to introduce general, rather than discipline-specific, upper secondary science courses for tertiary entrance examinations in Australia have been only marginally successful because they are perceived to be of less status by teachers, career advisors, academic scientists and consequently, by the students themselves (Fensham, 2006). Some excellent, integrated science courses that do not contribute to tertiary entrance are in place, but enrolments are generally low, and there are many students beyond the compulsory years who take no science subjects.

Current Australian Science Curricula

In 1993, following a mapping of each State and Territory’s curricula, a National Curriculum Statement was released, and later published, for each of eight learning areas including Science (Curriculum Corporation, 1994a, 1994b). However, each State and Territory has continued to take its own approach to curricula and most have had several revisions and some are currently revising again. A very brief overview is presented at the end of the Mapping exercise. Recently, Dawson and Venville (2006) attempted to map the contemporary versions and found it a difficult and confusing task. They reported:

> the benefits of having tailor made curricula for each state and territory were not immediately apparent. [We] wondered about the enormous cost of developing [these] documents and support materials and the potential of a real national curriculum that would provide flexibility to enable professional science teachers to interpret appropriately for their own students in their own contexts. (p. 24)

Paul Carnemolla, current ASTA President, has argued strongly for a national curriculum, pointing out that there is more variability within states than there is between them (Carnemolla, 2006). The recent report recommending a common Australian Certificate of Education at the completion of Year 12 is an associated concept (ACER, 2006). Given the similarity of content in upper secondary science chemistry and physics (an analysis by Matters & Masters, 2007, suggested 85–95% commonality across jurisdictions), it was suggested that a single syllabus in each could easily be achieved. A single syllabus, however, would not of itself address issues such as the lack of interest and engagement referred to earlier without a different kind of implemented curriculum.

In August, 2006, MCEETYA endorsed Statements of Learning in five curriculum areas, including science. These documents (MCEETYA, 2006) contain statements describing “the knowledge, skills, understandings and capacities that all young Australians should have the opportunity to learn and develop in science” (p. 3) by the end of Years 3, 5, 7, and 9. The Science Statements of Learning are underpinned by a commitment to developing scientific literacy, enabling students “to become active, informed citizens who can confidently contribute to debates and make reasoned judgements about moral, ethical and social issues and the role of science and technology shaping their lives" (MCEETYA, p. 2).

The Science Statements of Learning are structured around three aspects: Science as a Human Endeavour, Science as a Way to Know, and Science as a Body of Knowledge. The Statements result from an attempt to have a nationally agreed, consistent core of learning opportunities within each jurisdiction's own curriculum. The Statements are written in active terms, that is "Students [verb] [description of skill/knowledge]…". Accompanying the Statements of Learning are Professional Elaborations, arranged in the same way, but using language that is more familiar to those concerned with curriculum. The Elaborations are worded in terms of "Students have the opportunity to …", and provide some more specific examples of skills and concepts. For example, at Year 3, one Statement is "Students explore how pushing and pulling objects affects their motion and shape" (p. 7), and the corresponding Elaboration is "Students have the opportunity to explore ways in which pushes and pulls (*forces*) act in everyday situations to make things stop, move or change shape" (p. 14). Under the current agreements between the Australian Government and State and Territory education authorities, these Statements of Learning must be implemented across the country from January 2008. The result will be a more consistent science syllabus across jurisdictions, but with sufficient flexibility to allow for accommodation to local needs.

Similarly, the Matters and Masters' (2007) analysis of the post-compulsory science subjects, physics and chemistry, indicated that it would be relatively easy to identify a common curriculum core of subject matter and skills but with space that allows teachers flexibility within their own contexts to shape the implemented curriculum to students' needs. In addition, Matters and Masters (2007) recommended a set of achievement standards that could provide a national statement of how well students are expected to learn that core.

Moving to a more national curriculum focus by aligning curriculum content and standardising achievement standards would assist a more collaborative approach to science education in Australian schools. However, a simple alignment is unlikely to make a significant impact on the current problems relating to disaffection with science. These problems relate in part to students' perceptions of the different science units at the senior secondary level. Unfortunately, the more applied integrated science units have lesser status than the traditional units like physics, chemistry and biology, especially in terms of university entrance, and thus are unattractive to high achieving students who do not necessarily wish to pursue careers in science. The evidence reviewed suggests that a different perspective is required, particularly at the senior science level, to provide curricula with the broader-based content that promotes scientific literacy and appeals to a wider range of students.

Recent Curriculum Change in England

In England, a significant change in the National Curriculum to the Programme of Study for Science in Key Stage 4 (14- to 16-year-olds, the final years of compulsory schooling) was introduced in September, 2006 (with revision to Key Stage 3, 11- to 13-year-olds to commence in 2008). In response to concerns about content overload and student disinterest in science, the double GSCE science unit (approximately 20% of the total curriculum) has been restructured from the four Attainment Targets (Scientific Enquiry, Life Processes and Living Things, Materials and Their Properties, Physical Processes, the latter three with quite long lists of science concepts), to a focus on knowledge, skills and understanding of how science works and a much shorter list of content clustered under the headings Organisms and Health; Chemical and Material Behaviour; Energy, Electricity and Radiations; and Environment, Earth and Universe (DfES, 2004). Such a change places considerably more emphasis on learning about science, rather than learning science knowledge, and has a greater potential to result in students developing more skills related to scientific literacy. Most students are expected to study double science by adding to the compulsory single GSCE Science unit by selecting a unit from additional general or applied science, or specific discipline science.

There has long been recognition that teaching approaches needed to change, especially to deal with ideas in science (Millar & Osborne, 1998). An important pilot project for *21st Century Science* began in September, 2003. Coordinated by the Nuffield Curriculum Centre, *21st Century Science* has the explicit aim of developing scientific literacy. It offers an alternative suite of three units, Core Science, which occupies 10% of total curriculum time and is taken by all students, and Additional Applied Science and Additional Science, one of which may also be taken for an additional 10% of curriculum time. Underlying the courses are ideas about science (focusing on people as consumers of scientific knowledge) and science explanations (focused on science concepts). Outcomes after two years have been generally positive from the teachers' perspective, especially in terms of the improved relevance of the curriculum material, the ICT resources provided, and reduced content (compared to the old GSCE Key Stage 4 units). Independent evaluators will provide more information in due course (Millar, 2006). The future of *21st Century Science* is an important issue, given that it is designed to offer a relevant, motivating science course that develops scientific literacy as well as proving a sound basis for future science study.

Current Curriculum in the United States

The *National Science Education Standards* (National Research Council, 1996) provide the framework for a comprehensive, inquiry-based science curriculum, based firmly on scientific literacy for K-12 education in the US. However, following these standards is voluntary, with individual states and about 15,000 school districts having control over their own curricula. Over the last 15 or so years, many State Systemic Initiatives have been funded federally, there have been state-funded initiatives, and there continues to be challenges to the science curricula from groups supporting the inclusion of creationism and intelligent design.

In 2006, The RAND Corporation released a report entitled *Improving Mathematics and Science Education* based on a 3-year study of five cohorts of students in association with three local systemic initiatives (Le, et al., 2006). This study found weak relationships between achievement in science and reform-oriented instruction (which might be interpreted as “inquiry” teaching), but that these effects increased over time. Importantly, the strength of relationship varied according to how achievement was measured, for example, responses to open-ended questions had higher relationships than performance on state-based tests. Further, teachers reported that high-stakes testing reduced their use of reform-based practice because they felt it was unlikely to promote high scores on state-accountability tests which required content coverage.

At this stage, apart from the continuing detriment to curriculum change of mandated testing, it is difficult to discern a specific trend. However, as Bybee (2006b) points out, the key to continuing improvement in science instruction lies in the basics: “the educational core – curriculum, instruction, assessment, and professional learning – is where our time, money and effort should be focused” (p. 30). Our review supports this position.

General Competencies and Science Education

Fensham (2006) identified and contrasted two challenges to the delivery of the traditional, discipline-based, content-focused science curricula in Australian schools. One challenge is exemplified by Aikenhead’s (2006) call for a humanistic science education, based on a curriculum which prepares citizens for understanding and using science in their everyday world. This challenge, coming from within the science education community, is research-based and aimed at engaging students in meaningful science learning.

The other challenge is from outside of science education, and has its roots in what Fensham (2006) calls “the world of work and the knowledge society”. The focus here is knowing how to learn, how to keep learning, and how to learn with others, rather than knowing lots of bits of knowledge. These ideas underpin curriculum changes, in a number of Australian states, that are placing focus on students having knowledge and skills, sometimes called essential learnings, that are important for personal, social and economic life. There has been a movement in some jurisdictions to organise the curriculum framework around generic areas of learning, such as thinking, communicating, personal futures, social responsibility and world futures, rather than the readily recognizable discipline areas (including science) of, say, the 1994 National Curriculum Statement.

These two challenges are by no means mutually exclusive; in fact a more humanistic science education would necessarily entail an increase in students' scientific competencies which would spill over into more general competencies. Rather, the challenge for science education is to assert its place within the context of the descriptions of the general competencies that should be learned. Unless the details within these curricula refer specifically to science content, the importance of science (an ideal subject in which to develop such competencies) may be overlooked and curriculum time devoted to it decrease. Fensham (personal communication, July 7, 2006) quoted anecdotes indicating that less science is being taught in some jurisdictions because teachers and administrators do not see the role of science in developing these general competencies. Clearly, if teachers are to teach science within such a different curriculum framework, they will need considerable assistance to structure their teaching in ways that enable students to develop sufficient science knowledge and understanding to develop the scientific competencies they will need to achieve scientific literacy. The magnitude of this challenge is hard to underestimate.

In considering the balance between domain-specific and competency-based curriculum, it is worth taking note of the OECD's position relating to key competencies. The central plank is the competencies identified in the Definition and Selection of Competencies (DeSeCo) project within the OECD (OECD, 2003). The three categories of competencies are using tools interactively, interacting in heterogeneous groups and acting autonomously. The first of these competency categories, using tools interactively, includes three competencies: using language, symbols and texts interactively; using knowledge and information interactively; and using technology interactively (OECD, 2005). The OECD Programme for International Student Assessment (PISA) measures in reading and mathematical literacy and numeracy are illustrations of the first of these competencies, and scientific literacy, as developed in the 2006 PISA framework (OECD, 2006) illustrates the second: using knowledge and information interactively. In other words, using knowledge and understanding about science are fundamental to being able to achieve this competency, and curriculum material specific to the discipline of science must be articulated clearly in school curriculum. Whilst the Statements of Learning provide direction here, there will be need to assist teachers to implement the kind of curriculum that will develop the scientific competencies that students need to make their way in the world as reflective citizens.

Assessment in Science Education

Quality in science education is frequently construed to mean achievement in terms of national and/or international comparisons. The Trends in Mathematics and Science Study (TIMSS, previously titled the Third International Mathematics and Science Study) and the OECD-PISA are the two international programmes referred to most frequently. They provide qualitatively different perspectives of science achievement. The TIMSS tests knowledge and understanding of science facts and concepts, and can be regarded as a summative measure. In contrast, PISA has a focus on scientific literacy with students required to interpret information that is not curriculum-bound. Both can contribute to understanding the performance of Australian students, but only if the results are interpreted with understanding of their structure and the very different cultures of the countries involved in making international comparisons are kept in mind. Their usefulness on the macro-scale backs up government funding that enables Australia's continuing participation in both. TIMSS and PISA are the only measures that enable Australia's performance in science education to be compared with that of other countries. In both tests, all students are assessed using the same criteria and against the same items of science knowledge or literacy. The results, therefore, represent a valid and objective comparative measure of Australian students' scientific knowledge and understandings relative to those exhibited by their international counterparts, irrespective of the cultural or structural differences that may exist among participating countries. At the micro-level, however, TIMSS and PISA have less to offer individual teachers and students in terms of measuring quality in the teaching and learning of science.

Classroom assessment is often interpreted as testing, yet (as enshrined in our vision of the ideal science curriculum), good assessment serves the purpose of learning. To achieve this, classroom assessment at all levels of schooling must include more than the summative end-of-topic tests that seem to be routine in many implemented science curricula. Senior secondary science assessment related to tertiary entrance has long reinforced a content-based, cognitively limiting, summative approach to assessment in high schools, even down to Years 7 and 8 (Goodrum, et al., 2001). Whilst summative assessment has an important role in measuring students' achievement for the purposes of accountability and certification, formative, rather than summative, assessment is important in promoting learning (Black, 1998) because it assists teachers to understand what students know and don't know and provides direction for subsequent learning.

Successful teaching results when teachers design evaluation activities that provide acceptable evidence of students' learning and develop learning experiences that lead to success on those activities.[1] Developing and implementing learning experiences requires diagnostic assessment to determine what students already know, and formative assessment to provide feedback to assist them to monitor their progress. Approaches to mapping progress, such as Biggs and Collis' (1982) Structured Observation of Learning Outcomes (SOLO) approach, are also needed to promote good assessment practice. Considerably more attention needs to be given to formative assessment, particularly in secondary schools, where teachers have contact with large numbers of students and need to develop effective techniques for diagnosis of

[1] Working backwards from the intent of the curriculum, to the assessment activities to the learning experiences has been referred to as the "backward design" approach (Bybee, 2006a; Wiggins & McTighe, 2005).

students' difficulties and provision of timely feedback to scaffold learning. Professional learning is needed to encourage better understanding, and therefore better use of formative assessment. As Black (1998) pointed out, "teachers are the key to any change, and assessment practices cannot improve unless teachers can be supported by programmes to develop their assessment expertise" (p. 156).

The recent DEST-funded Science Education Assessment Resources (SEAR) project has provided helpful online resources for teachers to employ better diagnostic, formative and summative assessment. An important outcome of this project is a scientific literacy progress map, with three domains for scientific literacy and six levels of progress linked to the SOLO taxonomy which can be used by teachers to monitor students' learning and demonstrate progress. This map is integral to MCEETYA's national testing of Year 6 students' scientific literacy which is to occur every three years from 2003 (MCEETYA, n.d.). The 2003 results from Year 6 testing (which were somewhat disappointing) are available (MCEETYA, 2004), and the 2006 testing is complete with a report available during 2007. The Year 6 testing is based on sampling (as are PISA and TIMSS, the other components of the National Assessment Programme), and it should be noted that, in terms of quality of learning, international experience suggests that percentage sample testing is more efficient and cost-effective than the testing of entire cohorts as a way to monitor students' progress. There is a real danger that mandated cohort testing would distract teachers from teaching for scientific literacy and direct them towards a narrower, content-focused approach aimed at passing the national tests. This has certainly happened in the United States where standardised testing has become very politicised. It might be noted that in Finland, where there are no national tests at primary or lower secondary levels, the high level of PISA results in 2003 and 2006 has not led to changes in the assessment system, but has rather prompted research into the reasons for the success (Eurydice, 2006).

Resources for Science Education

The ideal science curriculum has excellent facilities, equipment and resources to support teaching and learning. Goodrum et al. (2001) reported great variability of resources across schools at both primary and secondary level, and our recent discussions with, and input from teachers indicate that this remains typical. Material resources which allow diversity and flexibility in teaching are essential. Effective science instruction involves hands-on activities and therefore appropriate science equipment. In primary schools, space for using and storing materials needed for science, and assistance in dealing with them, is required. Secondary schools need additional support (such as laboratory assistants) to organise and maintain their equipment.

Quality resources for curriculum innovation, professional learning, assessment and other needs, like computer learning objects, are expensive. Traditionally the cornerstone of science instruction has been the hard copy science textbook, but digital publishing will become more common. This form of curriculum resource offers more visual and dynamic impact with the increased potential for meaningful learning especially in science. In a country of Australia’s size, there are strong arguments for cooperation across jurisdictions to jointly develop curriculum resources to ensure the best outcome for the investment made.

An example of resource development at the national level is the creation of world-class science learning objects by *The Le@rning Federation* (see Mapping section). Effective implementation of these learning objects, however, has been slow, and consideration must be given not only to developing resources but to implementing them. In particular, given Australia’s geographic and ecological diversity, it is crucial that learning objects are prepared that are environmentally appropriate for a range of localities. Other national efforts include the *Primary Connections* science curriculum materials which are already having an impact. The proposed lower secondary project, *Science by Doing*, which includes a professional learning approach for teachers backed with curriculum and professional learning resources, has the potential to result in improved science understanding and greater interest in science. This project has received support from all jurisdictions and major stakeholders. Extending curriculum resource development beyond primary and lower secondary school to the upper secondary level should be considered. There is a significant number of teachers in secondary schools who are teaching out-of-field who could be assisted by curriculum resources targeted at this level.

Australia’s geography provides significant challenges to the implementation of effective and equitable science education. The National Centre of Science, ICT and Mathematics Education for Rural and Regional Australia (SiMERR) conducted a national survey of science, ICT and mathematics education in Australia (Lyons, et al., 2006), receiving responses from 2,940 teachers and 928 parents/caregivers. The report highlighted diversity in the provision of teachers, teacher development and material resources between metropolitan, provincial and remote areas. A key issue was the need to provide engaging, well-resourced science, ICT and mathematics curricula that accommodated diversity among students, particularly gifted and talented, NESB (which includes many Indigenous students) and those with special needs. The diverse cultural backgrounds of students in remote areas requires much greater flexibility for schools to determine their own resource needs, for material, support personnel and professional learning, in order to maximise student learning opportunities.

Students and the Science Curriculum: Issues to be Addressed

Curriculum Issues

Conversation is required at the national level to resolve issues associated with the notion of common core science curricula. The adoption of the Statements of Learning should provide the basis of a common core curriculum that retains sufficient flexibility to accommodate diversity among individual schools up to Year 10. Further discussion is required to consider common core curricula at the upper secondary level.

Better understanding is needed of those teaching and learning approaches in the science curriculum that engage and enthuse students and promote the outcome of scientific literacy.

Sufficient time must be allocated to science within the school curriculum at all levels of schooling to enable students to develop skills, understanding and scientific competencies appropriate for their level.

Ways must be found to improve the inclusion of minority groups, particularly Indigenous students, in school science education.

Additional, easy-to-access strategies are required to provide accurate, contemporary information regarding science careers for students, career advisors, and parents.

Assessment Issues

More attention needs to be given to ensure that assessment practice is aligned with instructional practice. This means that greater priority must be given in assessment practices to considering how we can measure what students are expected to learn.

Improved assessment practice depends upon the effective use of diagnostic, formative and summative assessment to assist in planning instructional activities, monitoring students' learning and measuring the outcomes. Support for these kinds of assessment must be embedded in the development of curriculum resources

Performance in science should be monitored at the national level by using quality assessment instruments and in ways that do not distract from science learning at the school level.

Resource Issues

The development of quality curriculum resources at the national level is efficient and should be supported. This will require consultation and collaboration between the jurisdictions, and the cost savings can assist with the development, monitoring and broader implementation of the resources.

There is a need for quality curriculum and professional learning resources for the upper secondary science areas, in particular for physics, chemistry, biology and general science.

Primary school science is poorly supported within some schools in most jurisdictions. Assistance for teachers, a designated space, and funds for consumables are required to support science in primary schools.

As educational digital publishing comes of age, Australia should take a national approach to investigate how best to facilitate and coordinate the development and dissemination of curriculum resources using these technologies.

Teacher Education for Science and Professional Learning

The Dow review (Dow, 2003a) argued that excellence in science outcomes was dependent on quality teaching. Overall, the factors affecting the quality of science teacher graduates are those generally related to the state of teacher education in Australian universities. These include the following challenges:

- providing adequate funding of teacher education programs,
- attracting quality teacher education staff from a teaching profession that is generally better paid than academics,
- balancing the demands on education academics of being a good teacher and a good researcher,
- enhancing the partnership relationships between schools and universities, and
- attracting high achieving students into teacher education.

A national vision is required for attracting and retaining teachers, strengthening teacher education and providing adequate professional learning. Improvements in teacher education and conditions in the teaching profession will flow to improvements in science teacher education and the quality of science teaching.

Although considerable criticism is found in the literature about the nature of the science curriculum and the need for change, it is its implementation which is the crucial element in students' learning. The teacher is the critical factor in student learning, interest and motivation to learn (Wiliam, 2006). The groundwork for effective teaching occurs during initial teacher education. Consequently, programmes, and the teacher educators who present them, must offer contemporary science education that provides adequate training in both content and pedagogy. Once they enter their own classrooms, teachers must keep abreast of changes in educational contexts and science and technological developments that affect the currency of the science curriculum.

Teacher Education and Teachers' Knowledge

Four years of training is typical for Australian teachers of science, usually through a 4-year BEd, a 3-year BSc plus 1-year Dip Ed, or sometimes a double degree in science and education. In all cases, some field experience is included to develop their teaching skills in the classroom.

Shulman (1986) identified several kinds of teacher knowledge, including content knowledge, pedagogical knowledge, and pedagogical content knowledge, and these are useful concepts in considering teachers' learning. Initial teacher education is aimed at developing all three kinds of knowledge, but it is not until teachers arrive in their own classrooms that the extent of their knowledge becomes evident in their practice. Once there, pedagogical knowledge and pedagogical content knowledge continue to develop through practise and professional learning, but keeping content knowledge up-to-date and relevant is usually left to the teacher.

Initial teacher education for primary teachers focuses on learning to teach not only science but at least five other content areas, and the key focus in pre-service education is usually literacy and numeracy. Frequently, this leaves science content knowledge underdeveloped, with a resulting lack of confidence to teach science. Although surveys of middle primary teachers in Western Australia during 1983 and 2003 indicated improved perceived confidence and expertise in teaching science, still around 20% of teachers felt “not very confident” and that “extra preparation [was] needed” for teaching science (Rennie, 2004). Lack of confidence becomes a major constraint on the extent to which science is taught at this level (Appleton, 2003) with estimates averaging between 40 and 60 minutes each week (Angus, et al., 2004; Goodrum, et al., 2001), an amount recognised as entirely inadequate. The situation is made worse by poor resourcing of primary schools for materials, space and assistance to look after students with special needs (Angus, et al., 2004).

With experience, good primary teachers may develop excellent pedagogical knowledge, but still have limited content knowledge in science. However, it is difficult to improve pedagogical content knowledge for teaching science without appropriate material resources and further professional learning. These problems are not confined to Australia. The Wellcome Trust’s report on Primary Science Education (Murphy, et al., 2005) recommended that initial teacher training should provide a solid background in science skills and understanding to strengthen intending teachers’ content and pedagogical content knowledge. In addition, the Trust concluded that the key to improving primary teacher confidence was good quality continuing professional learning, and recommended such be provided.

Secondary teachers also need to be confident in their teaching. Initial teacher education, particularly for those teachers gaining their teaching qualification through a 1-year graduate diploma following a bachelor’s degree in science (about three quarters of current science teachers, according to a recent survey by Australian Council of Deans of Science [ACDS], Harris, Jensz, & Baldwin, 2005), usually aims to develop pedagogical knowledge and pedagogical content knowledge, and assumes sufficient content knowledge. However, many teachers with narrow and specialized science degrees have had limited opportunities to acquire the content knowledge needed to teach general science at a lower secondary level and their initial content knowledge dates rapidly. Further, many graduating secondary teachers have not had time to develop deep understanding of pedagogical knowledge, which limits their pedagogical content knowledge and also their ability to broaden their teaching beyond the traditional science content in ways that enable students to connect science at school with science in the outside world.

So far, the effects of developing Professional Standards for science teachers are unclear, particularly in terms of promoting effective preservice education for teachers.

Lawrence and Palmer (2003) reviewed the initial preparation of teachers of science, mathematics and technology across Australia, using a combination of telephone surveys and case studies. They provided a comprehensive description of programmes in 2001, found some significant examples of innovation, and made a number of suggestions to guide further innovation. They found that the most common constraint in initial teacher education was lack of funding which resulted in reduced contact hours with students, mass lectures replacing tutorials, and a reduction of the in-school component of the teaching practicum. Goodrum et al. (2001) noted a similar situation, and, as the recent House of Representatives (2007) inquiry into teacher education indicates, there is no recent evidence suggesting this constraint has been lessened.

Professional Learning

The Need for Professional Learning

As Hewson (2007) pointed out in a review chapter entitled Teacher Professional Development in Science, “as the educational context changes, teachers’ existing practices and beliefs may not be well matched with the revised demands of new reform effects” (p. 1180). Given Australia’s aging teacher workforce and the rapid changes of science and technology in society, it is likely that a significant proportion of science teachers may require assistance to maintain their understanding of contemporary science and the skills to adapt their teaching to meet new challenges. According to the SiMERR National Survey (Lyons, et al., 2006), this is especially so for teachers in provincial and remote areas. Currently, about 8% of Australian secondary science teachers have completed no tertiary science subjects (Harris, et al., 2005), and thus began teaching science with inadequate content knowledge. They, too, would benefit from in-service professional learning that enables teachers of science to remain up-to-date, in terms of their content knowledge, to enhance their pedagogical content knowledge, and to promote linkages for students between science in the classroom and the science that happens outside of it.

Many teachers, particularly those teaching lower secondary science, may also benefit from professional learning to assist them to develop the pedagogical strategies that promote teaching for inquiry and the development of scientific literacy, as described in Volume 1, Appendix 2. In addition, it is difficult for teachers in classrooms to keep abreast of the kinds of scientific and technological instrumentation used in science-related industries and to find ways to incorporate them into class work.

Effective Professional Learning

Over the last three decades, research into curriculum implementation and teacher change has established that for teachers to modify their current practice they must first believe that there are benefits for themselves and their students. Further, to effect long-term changes to teachers’ professional practice, they must engage in a multifaceted and long term approach to professional learning (Bybee, 1997; Guskey & Huberman, 1995). Effective professional learning has several requirements.

- Teachers must understand what needs to change. This requires modelling of the activities and strategies to be implemented into the classroom, showing how resources may be used to support the new approach, and demonstrating how the new approach promotes students' learning (Kahle, 1999; Loucks-Horsley, 1998).
- Professional learning takes time, not just making time available for teachers to attend the programme, but time during the programme for teachers to reflect on their current practices and the likely effectiveness of the new ideas, time for them to implement the activities/ideas/resources into their classrooms, and then time to reflect upon the effects on their teaching and students' learning (Loucks-Horsley, Hewson, Love, & Styles, 1998).
- Teacher collaboration is important. Teaching is a social activity, and curriculum change requires mutually supportive interaction amongst teachers. Effective leadership, either by key teachers or administrators (such as the principal) within the school, will help teachers to implement and maintain changes to their practice (Goodrum, et al., 2001; Horowitz, 1996; Jones & Compton, 1998; Kahle, 1999; Rennie, 2001).

Whilst these principles are generally agreed, it is also important that the teaching and learning strategies that are the focus of professional learning are demonstrated by research to actually impact on student learning. It is also important to realise that the ability of teachers to effect change following professional learning is associated with having sufficient support within their school environment.

Practical Aspects of Professional Learning

There are several practical aspects that limit current professional development practices. The first relates to when professional development should be conducted; during class time, or outside of class time. Difficulties associated with in-class time include the cost. Teacher relief is expensive, and there is also the problem of finding quality teacher relief, particularly in remote areas and in the physical sciences. Further, many teachers are becoming unwilling to leave their classes to participate in professional learning activities. The alternative is to conduct sessions during the holiday or "stand down" periods. Obviously, this approach poses some problems for teachers. Another issue is the professional learning site. There is evidence that a local, whole-school approach to professional learning has benefits, but there is also need for a regional or jurisdictional venue where teachers from many schools can discuss and share relevant experiences and issues.

Once in service, and apart from their own professionalism, there are limited incentives for teachers to maintain their content knowledge and improve pedagogical knowledge and pedagogical content knowledge through professional learning. Incentives for teachers to continue their professional learning may be required, and it is not unrealistic to consider the need for extrinsic rewards. For this reason, there should be recognition that continuing professional learning should be reflected in salary and promotional steps and perhaps be related to continuing teacher registration.

Most jurisdictions are in the process of developing, or have developed, teacher accreditation boards or institutes and have mandated requirements of professional learning for initial and continuing accreditation. It is important to ensure that such professional learning is genuinely focussed on teachers' needs, and does not encourage piece-meal, unfocused programmes that build hours of professional learning but are peripheral to the real needs of teachers. A positive step is the move towards national recognition of teacher registration processes in the different jurisdictions, which will promote consistency and facilitate movement of teachers.

Despite several decades of research into teachers' knowledge and effective teaching, we still do not know enough about the excellent teaching practice that enables effective teachers to draw on their pedagogical content knowledge to develop and implement a coherent and integrated sequence of strategies and experiences that maximise student learning over a sustained period. We have descriptions (and there are video exemplars) of examples of effective strategies, but not of sustained good teaching. A comprehensive digital resource, developed in conjunction with research to ensure effective outcomes, is needed for both preservice and inservice teacher education.

Australia is fortunate to have many excellent teachers of science, at both primary and secondary levels, whose students thrive in an active and challenging learning environment. Professional development including these teachers provides opportunities for them not only to share with and mentor less experienced teachers but to have time themselves to collaborate with their colleagues to reflect and renew.

Teacher Supply and Demand

Teacher shortages in science and mathematics are becoming increasingly serious. The data available indicate that the median age of mathematics and science teachers is increasing, minority groups are under-represented in the teaching profession (Dow, 2003b), and the profession is feminised, particularly in the primary schools. However, there are more male than female teachers of secondary science, and more than a third of male teachers are aged 50 years or more (Harris, et al., 2005). Retirement and movement of teachers to other careers threaten Australia's teacher supply. The Australian Council of Deans of Science (Harris, et al., 2005) reported that almost 40% of early career teachers of secondary science were uncertain they would still be teaching in five years time. The Australian Secondary Principals Association's (ASPA) survey during June, 2006 (response rate 25%) indicated that 678 science teachers would retire across Australia in the next five years (ASPA, 2006). More data, collected on a regular basis, are required to present a clearer picture of the entrance, retention and retirement in the teaching profession to assist in workforce planning.

Two consequences of teacher shortages are that some science classes are taught by teachers without appropriate pedagogical content knowledge and with limited content knowledge, and that finding relief teachers in order for current teachers to leave their classrooms to receive professional learning is a problem, especially in rural and remote areas. ASPA (2006) reports that in June, 2006, over 40% of Principals reported at least one science class was being taught by a teacher without expertise in science. Over 50% reported that it was impossible to find relief staff in science, and this figure was 42% for urban, 64% for rural, and 84% for remote schools. Similarly, the SiMERR National Survey highlighted the much greater teacher supply difficulties in provincial and remote areas compared to metropolitan areas, including high annual staff turnover, and much greater difficulty in filling vacancies.

Active recruitment of teachers is a priority already identified (Dow, 2003b) but is unresolved, and there is no sign that the status of teaching as a career has improved. Dow (2003b) made a number of recommendations directed to a range of major stakeholders relating to teacher retention, but there is little evidence of effective action being taken. The ACDS report examined the factors affecting retention of science teachers (Harris, et al., 2005). Many of the issues are common to teachers in other subject areas, including heavy workload (especially non-teaching work) and long hours, dealing with disaffected students and thus “wasting time” that could otherwise be used for teaching, and policy decisions (such as new curricula) beyond their control. Science teachers also complained of frustration due to lack of time to prepare for practical science classes and insufficient physical resources.

Teacher Education for Science and Professional Learning: Issues to be Addressed

Teacher Education

Funding for initial teacher education is generally inadequate and should be increased.

Appropriate standards for the science content and pedagogical requirements should be set and adhered to for initial teacher education for both primary and secondary teachers.

Quality resources for professional learning in assessment are required for both pre-service and in-service teachers to improve their ability to assess student learning and monitor their progress.

The development of a national video databank to demonstrate best practice in pedagogical content knowledge is required to enhance professional learning, in both pre-service and in-service environments.

Professional Learning

Professional learning opportunities for teachers of science tend to be piecemeal and split between schools and systems. A two-tiered structure would provide and maintain a balance between systems leadership in professional learning and school-based delivery where teachers have a role in determining their own needs and how those needs can be met.

Opportunities for professional learning are not equitable; better provision is required for teachers in remote and provincial locations.

There are difficulties in providing professional learning for teachers during the school term. The possible provision of financial incentives for teachers to engage in professional learning activities during “stand down” periods could be explored with jurisdictions and stakeholders.

The efficiency and effectiveness of the current range of professional learning strategies is not well understood or evident in practice. A review could identify those that actually improve student learning and thus can provide the maximum value for effort.

Teacher Supply and Demand

There is no readily accessible or extensive database that documents the number of pre-service science teachers that enter and exit university courses, the number and qualifications of science teachers registered and the retention of those teachers in the profession.

Attracting new science teachers, and retaining those we have, are significant challenges, for without an adequate supply of teachers, it will be increasingly difficult to maintain quality in the profession. Further, financial incentives to train and retain teachers must be re-considered, and greater efforts to remove barriers for people to train (or re-train) to become teachers are required.

There is a shortage of teachers and teacher aides from Indigenous and other minority groups.

The expansion of teachers’ work with non-teaching duties takes significant time from lesson preparation, teaching, and reflection, and is a significant barrier to teacher retention.

The procedures for the registration of teachers have yet to demonstrate a positive contribution to maintaining the supply and quality of science teachers, particularly part-time and relief teachers.

Systemic and Community Relationships

Australian education is funded by State, Territorial and Commonwealth governments and non-government schools have significant funding from sectorial sources. Consequently, the responsibilities for the provision of education, schools and teachers vary across those systems. Within each jurisdiction, however, there is one authority which mandates the curriculum to be implemented within that jurisdiction. For many years, activities within each jurisdiction have developed curricula and curriculum resources with different emphases and also different sequences of content. The result is considerable disjunction between the educational experiences in different jurisdictions when students or teachers move from one to another.

Goodrum et al. (2001) recommended a greater national focus to promote collaborative approaches to research and data collection, innovation and development of curriculum resources for teachers' professional learning and science education. Since that time, significant progress has been made in supporting innovation, such as through the Australian School Innovation in Science Technology and Mathematics (ASISTM) project, and curriculum resources, such as *Primary Connections* and The Le@rning Federation. Increasingly, there has been discussion of national curricula, with some mutually agreed steps (such as the MCEETYA Statements of Learning) being taken. There remain, however, significant areas of duplication in the production of resources and issues for students transferring between jurisdictions.

We are hopeful that inter-relationships amongst jurisdictions and between jurisdictional and national bodies will become even more cooperative with a resulting decrease in duplication. In addition, there is increasing recognition of the role that community resources can play in science education, and avenues for cooperation between, and with, them are developing.

Community Sources of Science Learning

School students spend less than 20% of their waking hours in school, and less than 20% of this time will be explicitly about science. However, learning continues outside of school and there are numerous institutions and services within the community that deal with science (Braund & Reiss, 2004; Rennie, 2007). Students learn about science by interacting with families and friends, by visiting institutions, such as museums, zoos, aquaria, environmental centres and similar places that have an educational aspect to their mission, from the many community and government organisations that educate the public about science-related issues, including health (e.g., skin cancer, smoking, obesity), safety (e.g., fire, electricity, chemicals) and conservation (e.g., recycling, water resources, pollution, quarantine). Most importantly, the media, particularly television and the internet, but also radio, newspapers, magazines (especially related to hobbies) and advertising are pervasive sources of science-related information for young people.

Rennie (2006) has argued that bringing school science and the out-of-school science community much closer together is a powerful way to enhance science learning, because this shows students that science has demonstrable relevance and value to them, and provides opportunities for them to see and use science in their outside life.

Several recent initiatives, funded by DEST, have aimed to build science-community partnerships. The Science Awareness-Raising Project (Rennie & ASTA, 2003) and its successor, the School Community and Industry partnerships in science (SCIps) programme (ASTA, 2005), both managed by ASTA, enabled schools to collaborate with people and organizations in their community to work on a project revolving around a science-related issue. Schools received a small amount of funding used mainly for consumables, equipment or students' travel, and the results showed considerable value for students. In particular, the small amount of funding usually resulted in outcomes worth much more, with many projects continuing beyond the time frame. The ASISTM project, with $34m over 7 years is a much larger scheme. Entering its third year, it has already funded over 300 projects, but it is too early to judge whether or not its impacts in schools are lasting. Limited anecdotal evidence suggests some issues relating to coordination between school and non-school partners, such as timetable constraints in secondary schools. A central component of ASISTM projects is the use of critical friends, almost exclusively from university education faculties, who provide expert educational advice and guidance, and assist with liaison between project members.

A notable Australian Government funded programme, over a number of years, is the Cooperative Research Centre (CRC) Programme which funds dozens of research centres with national linkages. The CRCs are partnerships between universities, government institutions and industries focused on Australian mining, agriculture, manufacturing, the environment and medicine. The CRCs lead research in these areas, and can provide avenues for teachers, students and their communities to gain awareness and understanding of cutting edge research and technological advances. Productive programmes could result from educational institutions seeking to work with CRCs to exploit those opportunities and some CRCs already provide information and related educational experiences for teachers and schools.

In the broader community, the Australian Government has supported many science-related projects through its Science and Technology Awareness Programme (STAP), the National Innovation Awareness Strategy that replaced it in 2001, and now the Science Connections Programme run by DEST. Many of the projects targeted particular audiences, such as adolescent youth, adult learners and women, and included programmes ranging from science-based competitions to open days at scientific organizations to media presentations to science prizes. However, as Gascoigne and Metcalfe (2001) pointed out, both nationally and internationally, the effectiveness of such programmes is rarely known because evaluation is not built into the implementation. Reviews of STAP itself failed to establish a causal link between its component projects and any changes in Australians' awareness of science and technology or the role of science in society or the economy (Gascoigne & Metcalfe, 2001). Similarly, in the UK, reports commissioned by the Wellcome Trust that mapped science activities and gathered the views of scientists about their role in science communications found that evaluation of the large range of activities is non-existent or weak (Office of Science and Technology and the Wellcome Trust, 2001). Thus while interest in promoting community engagement in science continues, research findings about their effectiveness are rare and mostly equivocal.

For some years, ASTA published annually a list of activities for school students, first in a booklet, then on their website. For example, in 2003 there were listed 146 separate activities, competitions, programmes, and events aimed at students and science teachers, sponsored or organized by a range of professional science-related associations, universities, industries, and other non-government organizations. These ranged from science poetry competitions, science fairs, summer schools, and work-experience placements, to teacher and student awards. Such lists are a valuable guide for teachers.

The annual National Science Week is a major event that receives significant government funding from the Science Connections Programme in cooperation with other agencies, including the Australian Broadcasting Commission, ASF limited, ASTA and the CSIRO. It coordinates a large number of separate official events and activities. Rennie and ASTA (2003) analysed the 2001 National Science Week event calendar and found that 40% were public lectures, forums, or debates, 20% school activities and competitions, 15% special exhibitions in museums or displays in public places, 5% open days/nights at science venues or to show science in industry, 5% tours or excursions, and a range of other awards, presentations, conferences, on-line activities, science theatre, and so on. Analysis of the 706 activities on the 2006 National Science Week event calendar revealed a similar spread of activities. In 2002, a comprehensive search for effective evaluation of the outcomes of these activities provided little beyond data for attendance/participation and subjective or self-reported assessment of the public’s response (Rennie & ASTA, 2003). The Australian Science Festival in the ACT is run in conjunction with National Science Week each year, with the 2006 Festival advertising 92 events in its brochure.

Outreach programmes promoting science are important to people in remote and rural areas. Garnett (2003), on behalf of the National Reference Group (superseded by the National Science Partnership (NSP), comprising Australian Science Centres, Museums and Science Education Centres), surveyed 63 museum-sponsored and private outreach providers of education and awareness programmes in science, mathematics, engineering and technology. Returns from 57 providers reported contacting more than 400,000 students during 2002. Garnett conducted a case study in one town in each Australian state and one territory, and collected 207 surveys from schools that had participated in a recent programme. The self-reported findings suggested that these programmes increased students' interest and skills levels, at least in the short term, and that teachers and students benefited by the demonstration of new approaches, content, techniques, and resources. Provision in remote areas fell well short of perceived need, with programmes reaching only 1 in 4 children annually. Teacher resources and supporting websites were offered by two-thirds of providers, one-third offered student resources and teacher workshops, and more than half also offered programmes/exhibitions for the general public during their tours. These outreach programmes are now the major providers of professional learning for teachers of science outside of major cities, and Garnett found that teachers in only one in every four schools believed they had access to professional learning sufficient for their needs.

Surveys of the variety of science awareness-raising activities in Australia, such as those described above, reveal large numbers of activities for a variety of audiences, offered by providers ranging from an individual to large, national institutions. Not surprisingly, easily accessible groups, such as urban school children, are well-served but geographically remote and other groups, such as parents and the media, are less well-served. At present, there is little coordination amongst the large majority of providers to service the broad community more effectively.

At the national level, Australia is well-served by the roles of two significant providers of science education and awareness experiences: CSIRO Education and Questacon – The National Science and Technology Centre. CSIRO Education and Questacon work cooperatively and operate complementary programmes. CSIRO Education, as part of Australia's largest scientific research organisation, operates programmes which link research directly to school curriculum and highlight career options. It has established productive and long-standing partnerships with all state and territory education departments (in Western Australia through the Scitech Discovery Centre). Its physical presence in each state and territory provides an effective base for operating a range of in-centre and travelling hands-on programmes that reach across the country. This national presence has the potential to deliver or support future national science education initiatives. Questacon's focus is on creating and delivering interactive and engaging experiences to increase science awareness and understanding for children and their families, for students and teachers, and the wider community. Questacon's exhibitions and programmes complement the CSIRO programmes. Questacon attracts a wide range of visitors from throughout Australia to its exhibition galleries in Canberra. In addition, Questacon's travelling exhibitions and programmes reach metropolitan, regional, rural and remote communities across Australia. Its outreach programmes, through visits to primary and secondary schools and community venues, promote understanding of the relevance of science in everyday life and consideration of science study and career options.

Coordination is necessary at both the national and local level. National providers, such as Questacon and CSIRO Education have established a strong cooperative alliance, and the NSP, which includes state-based as well as national science centres and other major providers of out-of-school science education, plans collaboratively to promote complementarity of activities. In addition, the NSP contributes to Australian Government and other national initiatives, particularly National Science Week, and data collection relating to science awareness activities. At the local level, some providers have limited resources and coverage, and it is currently very difficult to coordinate availability to maximise benefits to all schools and communities.

Systemic and Community Relationships: Issues to Be Addressed

Systemic Relationships

A more national approach to science education requires continuing discussion and collaboration within and between the systems at the national, jurisdictional and local levels. Effective resolution of different perspectives requires a balance between cost efficiency and local ownership that best meets the needs of schools, students and teachers in their particular situations.

Community Sources of Science Learning

The work of scientists and the image of science portrayed in various media still reflect dated stereotypes which deter public engagement with science and interest in pursuing a science career.

The community hosts many institutions and agencies that actively promote science experiences and provide opportunities for students, teachers and other adults to engage in science-related activities such as field trips or school excursions. Larger organizations are networking among themselves to establish more coherent and collaborative ways of delivering these experiences. Remaining issues include how best to coordinate the smaller providers to improve delivery to underserved groups, and to increase networking amongst providers and potential recipients for cross-promotion of activities and opportunities to engage in science-related activities.

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Mapping of Source Documents and Initiatives

Descriptive Documents – Australian Sources

Location	Organisation	Document	Description	Reference	Comments
National	Australian Council of Deans of Science (ACDS)	Report: *Who's teaching Science: Meeting the demand for qualified science teachers in Australian secondary schools* (January 2005)	A report of surveys of 1207 secondary science teachers and 266 heads of science departments in secondary schools. Used a stratified random sample of secondary schools taking into account state, region, sector and socio-economy in determining the sample.	http://www.acds.edu.au/ Harris, K-L, Jensz, F., & Baldwin, G. (2005). *Who's teaching Science: Meeting the demand for qualified science teachers in Australian secondary schools*. (Report prepared for the Australian Council of Deans of Science). Melbourne: ACDS.	This report concludes that there are serious issues to be addressed in maintaining a viable teaching workforce in science. 40% of schools experienced difficulty in attracting and retaining science teachers, especially physics and chemistry. Teachers' backgrounds are strongest in biology, 1 in 4 senior physics teachers have not studied physics at university, 8% of all science teachers had no tertiary science subjects. Nearly 40% of early career teachers were uncertain they would still be teaching in 5 years time.
National	Australian Academy of Technological Sciences and Engineering (ATSE)	Report: *The teaching of science and technology in Australian primary schools: A cause for concern* (2002)	A report of concerns with the teaching of primary school science and technology. ATSE argues that science and technology must be nurtured in school if Australia's population is to cope in the increasingly technologically dependent 21st century.	http://www.atse.org.au. Australian Academy of Technological Sciences and Engineering (ATSE). (2002). *The teaching of science and technology in Australian primary schools: A cause for concern.* Melbourne: Author.	The report has 10 recommendations relating to in-service professional development for teachers, improved facilities and equipment of teaching, teacher training, ways of enhancing the teaching profession, and teacher supply and demand.

Location	Organisation	Document	Description	Reference	Comments
National	DEST	Report: *Australia's Teachers, Australia's Future: Advancing innovation, science, technology and mathematics* (2003)	Major, three volume report documenting all of the key issues relating to teachers and teacher education with a focus on science, technology and mathematics education. Prepared as part of the Australian Government Backing Australia's Ability Strategy.	Dow, K. L. (Chair, Committee for the Review of Teaching and Teacher Education). (2003). *Australia's Teachers, Australia's Future: advancing innovation, science, technology and mathematics.* Canberra: Commonwealth of Australia.	This comprehensive report has been the stimulus for several other reports and initiatives aimed at strengthening Australia's teaching force, particularly in science and mathematics. A direct outcome was the establishment of the National Institute for Quality Teaching and School Leadership (now Teaching Australia). Data on science teachers has been updated by the recent ACDS report (2005).
National	DEST	Audit of science, engineering & technology skills (July 2006)	Investigated supply of SET skills in terms of trends, demand from industry and research and supply from education and training sectors.	http://www.dest.gov.au/sectors/science_innovation/policy_issues_reviews/key_issues/setsa/report.htm DEST. (2006). *Summary report of the science, engineering & technology skills audit.* Canberra: Commonwealth of Australia	Found proportion of domestic students decreasing, international students increasing in SET courses. Perceived lack of qualified teachers in area, negative community perceptions of careers in SET, lack of student interest. Recommends better understanding of area, reward paths, retention strategies, to meet Australia's future needs

Location	Organisation	Document	Description	Reference	Comments
National	DEST	Report: *Clever teachers, clever sciences: Preparing teachers for the challenge of teaching science, mathematics and technology in 21st century Australia* (2003)	Study commissioned by DETYA as an Evaluations and Investigations Program project.	http://www.dest.gov.au/NR/rdonlyres/C571311D-04D5-4DB3-BA26-65051BD21FBE/812/03_06.pdf Lawrence, G. A., & Palmer, D. H. (2003). *Clever teachers, clever sciences: Preparing teachers for the challenge of teaching science, mathematics and technology in 21st century Australia* (EIP Report 03/06). Canberra: DEST.	Project focused on initial teacher education, particularly searching for innovative practices. Used a mixed-method approach with surveys and case studies. Findings are mainly descriptive, with suggestions rather than recommendations. Main challenge faced by institutions was a lack of funding that resulted in reduced contact hours with students, more mass lectures rather than tutorials, and less time spent in field experience. Found instances of innovative practice, but also that many teachers in schools were using chalk-and-talk pedagogical approaches which was at odds with the approaches taught and advocated in initial teacher education.
National	DEST	Report: *The sufficiency of resources for Australian Primary Schools* (SRAPS)	Report of a study of 30 schools in terms of resources. Report of the second of a three-stage process, funded by DEST.	Angus, M. et al (2004). *The sufficiency of resources for Australian Primary schools.* Canberra: DEST. (http://www.primaryresourcing.com.au/downloads/SRAPS2.pdf)	The third stage of SRAPS, based on a sample of 160 schools, will be reported later in 2007. Based on these reports, the Australian Primary Principals Association has issued a paper, *Primary Education A National Priority*, strongly endorsing more resources for science education.
National	DEST	Report: *Year 12 curriculum content and achievement standards* (2007)	Australia-wide review of five subjects, including physics and chemistry, in the final year of secondary school.	Matters, G., & Masters, G. (2007). *Year 12 curriculum content and achievement standards.* Canberra: DEST. (http://www.dest.gov.au/sectors/school_education/publications_resources/profiles/y12_curriculum_standards.htm)	Comprehensive review of content and skills in the five subjects and recommendations about producing a core curriculum, and standardising terminology for discussing matters such as curriculum, achievement and its recording on certificates.

Location	Organisation	Document	Description	Reference	Comments
National	MCEETYA	*Statements of Learning* (Released August 2006)	These documents are agreed across jurisdictions as statements about what students should have opportunities to learn, not a curriculum. There are two parts, the Statements (written in plain English), and the Professional Elaborations (using the professional language of the Science curriculum).	http://www.mceetya.edu.au/mceetya/default.asp?id=11893	Aim to describe the essential skills, knowledge, understandings and capacities that Australian students have the opportunity to learn at the end of Years 3, 5, 7, and 9. Purpose is to achieve greater consistency in curriculum across jurisdictions. MCEETYA endorsed compliance to these statements by jurisdictions no later than January 1, 2008.
National	MCEETYA	Report: *Options for the assessment and reporting of primary students in the key learning area of science to be used for the reporting of nationally comparable outcomes of schooling within the context of the National goals for Schooling in the Twenty-First Century* (2000)	A report commissioned by the National Education Performance Monitoring Taskforce, prepared by Sam Ball, Ian Rae, and Jim Tognolini. Has formed the basis for the Year 6 Science Literacy assessment in 2006.	http://www.mceetya.edu.au/verve/_resources/SUMMARY_PAGE_Ball_report.pdf	Considered primary science a crucial curriculum area and recommended the adoption of the PISA definition of scientific literacy. Concluded that understanding was a more important goal than knowledge of science facts, and that skill in the use and understanding of scientific processes was also essential. Recommended the implicit commonality across primary science curriculum in the jurisdictions be made explicit, and considered that any differences could be accommodated in a nationally comparable monitoring. Made recommendations about how that assessment should be carried out.
National	MCEETYA	*National Assessment Program Science Literacy, Year 6, 2006*	Description of the assessment domain and progress map used to develop assessment.	http://www.mceetya.edu.au/verve/_resources/ASSESSMENT_DOMAIN_2006_2.pdf 2003 results available at http://www.mceetya.edu.au/mceetya/default.asp?id=12107	Explains the assessment domain for scientific literacy, provides progress map and the major scientific concepts to be tested.

Location	Organisation	Document	Description	Reference	Comments
National	MCEETYA	Report: *Australian Directions in Indigenous Education 2005-2008* (July 2006)	Report prepared by the AESOC Senior Officials Working Party on Indigenous Education, approved at the 20th meeting of MCEETYA, 3-6 July, 2006.	http://www.mceetya.edu.au/verve/_resources/AUSTRALIAN_DIRECTIONS_IN_INDIGENOUS_EDUCATION__2005–2008_.pdf	Not science specific but relevant in general terms. Names five domains for critical engagement: early childhood education, school and community partnerships, school leadership, quality teaching, and pathways to training, employment and higher education.
National	PMSEIC Independent working group	Working paper: *Science engagement and science education: equipping young Australians to lead us to the future* (November 2003)	Paper prepared by an independent working group for the 11th meeting of PMSEIC.	http://www.dest.gov.au/sectors/science_innovation/publications_resources/profiles/science_engagement_and_education.htm	Emphasised the contribution of out-of-school resources to science education. Recommended a national framework but with local action, focusing science via literacy in primary schools, by doing in secondary schools and though business to enhance careers. Viewed teachers as the key to success in science.
National	Standing Committee on Education and Vocational Training	Report: *Top of the Class* (February 2007)	House of Representatives report on the inquiry into teacher education.	http://www.aph.gov.au/house/committee/evt/teachereduc/report.htm	Currently under discussion, this report has 12 recommendations aimed at increasing the effectiveness of teacher education. Whilst not specific to teacher education for science, if implemented, the suggested recommendations would have benefits for all teachers.
Victoria	Education & Training Committee of the Victorian Parliament	Report: *Inquiry into the promotion of mathematics and science education.* (March 2006)	Comprehensive report from a parliamentary committee after an extensive review including hearings, submissions and visits in Victoria and a visit to WA.	http://www.parliament.vic.gov.au/etc/fs_inq_prom_math.html Education and Training Committee (ETC) Parliament of Victoria. (2006). *Inquiry into the promotion of mathematics and science education. Final Report.* Melbourne: Victorian Government Printer.	Examined and made recommendations relating to factors supporting teaching and learning of science and mathematics, national and international trends, sharing of resources in Victoria, ways of including industry and business applications in science and mathematics, gender issues in these subject areas and ways of promoting greater interest in careers. The Victorian Government's response to the inquiry report was tabled on 2 September, 2006. Of the 23 recommendations, 18 were accepted, two were rejected and three were noted.

Location	Organisation	Document	Description	Reference	Comments
Victoria	Catholic Education Office Melbourne/ Monash University	Book: *Looking into practice: Cased studies of science teaching and learning* (2006)	Resource book comprising short case studies, written by teachers, focused on events in classrooms.	Loughran, J., & Berry A. (Eds.). (2006). *Looking into practice: Cased studies of science teaching and learning.* Melbourne: Catholic Education Office Melbourne and Monash University.	Useful book to assist teachers' professional learning by discussing the cases, but also as exemplars for reflecting on their own practice (which was how the book evolved).
Victoria	Catholic Education Commission Victoria (CECV)	Report: *A study of the factors affecting performance of Catholic Education Commission of Victoria (CECV) Schools in VCE Science*	Report commissioned to investigate factors affecting high achievement in VCE level science, specifically in Catholic schools.	Wilkinson, J., Ingvarson, L., Kleinberg, E., & Beavis, A. (2005). *A study of the factors affecting performance of Catholic Education Commission of Victoria (CECV) Schools in VCE Science* (Unpublished Report). Melbourne: ACER.	Concluded that impacting factors are effective science coordination; extension opportunities to able students; content, sequence and time allocation to science in Years 7-10; and access to quality professional development.

Descriptive Documents – International Sources

Location	Organisation	Document/Website/Issue	Description	Reference/Source	Comments
England	Council for Science and Technology	*Science teachers: A report on supporting and developing the profession of science teaching in primary and secondary schools* (February 2000)	Report addresses the question of what would make a material difference in helping science teachers improve their practice. Surveyed 900 head teachers and 1500 science teachers.	http://www2.cst.gov.uk/cst/reports/#4	Found that teachers reported that they were not engaged in systematic CPD, had difficulty accessing it, and that there was a need to secure a "step change" in this. The report recommended a new framework which has led to the establishment of the Science Learning Centres.
England	DfES	*Mathematics and Science in Secondary Schools The Deployment of Teachers and Support Staff to Deliver the Curriculum* (January 2006)	DfES commissioned report by the National Foundation for Educational research.	http://www.dfes.gov.uk/research/data/uploadfiles/RR708.pdf Moor, H., Jones, M., Johnson, F., Martin, K., Cowell, E., & Bojke, C. (2006). *Mathematics and Science in secondary schools: The deployment of teachers and support staff to deliver the curriculum.*	Finding are quite similar to those in the ACDS report for Australia, with regard to teacher qualifications (eg, 44% were specialists in biology, 25% in chemistry and 19% in physics, 8% had no specialisation, around 10% of the time A-level science was taught by a teacher with no tertiary experience in the subject). About two-fifths of teachers were satisfied with their professional lives. Only 57% of teachers under 55 years thought they would still be teaching in five years time.
England	DfES and QCA	National Curriculum, Science	Websites relating to the National Curriculum at Key Stage 3 and 4.	http://www.nc.uk.net/nc_resources/html/about_NC.shtml http://www.qca.org.uk/12265.html	The National Curriculum Key Stage 4 has a new science Program of Study from September, 2006, and changes are being designed for Key Stage 3 for 2008. A pilot 21st Century Science Course focussed on scientific literacy has been in operation 2003-2006.

Location	Organisation	Document/Website/Issue	Description	Reference/Source	Comments
England	DfES/ Wellcome Trust	Science Learning Centres Courses began at the Regional Centres from October 2004. The National Centre opened in Autumn 2005.	Network of 9 regional and 1 national centre. Goal of helping British teachers lead the world in science education. In response to concerns about engagement of young people in science.	www.sciencelearningcentres.org.uk	The network of Science Learning Centres is made up of nine Regional Centres across England and one National Centre, based at the University of York. The Regional Centres have satellite venues across their region to ensure that every teacher has easy access to the resources and support offered by the Science Learning Centres. The National Centre offers residential courses to teachers from across the UK in a purpose built Centre which includes hotel facilities. Teachers and technicians can attend courses at any of the Science Learning Centres; using the expertise and wide-range of resources at their Regional Centre while also travelling to Centres further a field to explore the different specialisms developed across the network.
Europe	OECD: Global Science Forum	Report: *Evolution of student interest in science and technology studies: Policy report* (4 May 2006)	Report of an international conference debating findings from a working group of the Global Science Forum.	http://www.oecd.org/dataoecd/16/30/36645825.pdf	Analysed data from 19 OECD countries including Australia. S&T enrolments decreasing in relative terms, especially in physical science and mathematics. Women still underrepresented, student choices determined by the image of S&T professions, the content of curricula and the quality of teaching.
Europe	Eurydice, Directorate-General for Education and Culture	Report: Eurydice. (2006). *Science Teaching in schools in Europe: Policies and research.* Brussels: Eurydice.	Review with data on issues relating to science education for 30 European countries.	www.eurydice.org	Report covering science teacher education programmes, science teacher trainees, school science curricula, standardised pupil assessments and a very useful review of science education research and the training of science teachers. This report may have stimulated the European Commissions decision in November, 2006 to create a group to look at what action could be taken in Europe to support science education in primary and secondary schools.

Location	Organisation	Document/Website/Issue	Description	Reference/Source	Comments
India	Editorial Collective, Contemporary Education Dialogue, Bangalore	Special issue of journal: *Contemporary Education Dialogue*, Volume 4:1, Monsoon 2006	Special issue of this journal devoted to discussion of the National Curriculum Framework (NCK) released by the National Council for Educational Research and Training (NCERT) in 2005 and currently being implemented.	Advani, S. (Ed.). (2006). *Contemporary Education Dialogue*, *4*(1), Special Issue.	Apart from an initial chapter about the problems implementing "Curriculum 2005" in post-apartheid South Africa, this issue presents a series of views about the implementation of the NCK from 2005. The discussion emphasises the difficulties in changing direction, particularly the centrality of the child and the child's local knowledge into the curriculum and the fear of traditional defenders of the important of the traditional didactic, knowledge-based science curriculum.
UK	Wellcome Trust	Report: *Primary horizons – starting out in science* (2005)	Report based on a research study commissioned by the Wellcome Trust in 2004 and carried out by Queen's University Belfast and St Mary's University College Belfast. Explored teachers' views and experiences of primary science education across the UK and made recommendations for improvement.	http://www.wellcome.ac.uk/doc_WTX026627.html Murphy, C., Beggs, J., Russell, H., & Melton, L. (2005). *Primary horizons – starting out in science.* London: Wellcome Trust.	Large scale, comprehensive study concluding primary teachers still lack confidence in teaching science and in using ICT. Conclude greater emphasis should be given to making primary science more relevant to children's lives, using creative approaches to developing children's thinking, questioning and investigating skills, and better incorporation of ICT.

Location	Organisation	Document/Website/Issue	Description	Reference/Source	Comments
UK	Wellcome Trust	Conference Report: *Science for all: Is public engagement engaging the public?* (3–4 April 2006)	Report of a conference supported by the Wellcome Trust held in Manchester.	http://www.wellcome.ac.uk/assets/wtx032159.pdf	The report contains 13 chapters by key writers in public engagement and in science curriculum (including Robin Millar, co-director of 21st Century Science). Aim was to improve public engagement with science and a significant focus on the importance of making science at schools have more positive outcomes. Jon Turney's summary noted there are many agendas embodied in science engagement work, a vast number of initiatives, and science engagement is now an established part of science policy, demanding much from many people!
USA	RAND Corporation	Report: Le, V-N, et al. (2006). *Improving mathematics and science education: A longitudinal investigation between reform-oriented instruction and student achievement.* Santa Monica, CA: RAND Corporation.	Study over three years with five cohorts of students association with three local systemic initiatives.	http://www.rand.org/pubs/monographs/2006/RAND_MG480.pdf	Found weak relationships between achievement in mathematics and science and reform-oriented instruction (which might be interpreted as "inquiry" teaching). Found effects increased over time, and that strength of relationship varied according to how achievement was measured, e.g. open-ended questions had higher relationships than state-based tests. Teachers reported that high-stakes testing reduced their use of reform-based practice because they felt they were unlikely to promote high scores on state-accountability tests, which required content coverage.

Location	Organisation	Document/Website/Issue	Description	Reference/Source	Comments
USA	National Research Council	Report: *Taking Science to School: Learning and Teaching Science in Grades K-8* (due for 2007 release)	Committee's task "was to answer three broad questions: (1) How is science learned, and are there critical stages in children's development of scientific concepts? (2) How should science be taught in K-8 classrooms? (3) What research is needed to increase understanding about how students learn science?"	*Taking Science to School: Learning and Teaching Science in Grades K-8* (ISBN: 0309102057)	Report supports the development of scientific literacy, arguing that students should: *"1. know, use, and interpret scientific explanations of the natural world; 2. generate and evaluate scientific evidence and explanations; 3. understand the nature and development of scientific knowledge; and 4. participate productively in scientific practices and discourse."*

Description of Activities and Initiatives – Australian Sources

Location	Organisation	Initiative	Description	Reference	Comments
ACT	ACT Department of Education & Training	Data logging professional learning (2005)	3-day program for about 120 high school and college teachers to promote use of data loggers in schools.		Aim to encourage greater transition in science from Years 10-11. Professional learning for teachers around pedagogy and curriculum implications.
ACT	ACT Department of Education & Training	High School Development Program	Aimed to build teacher capacity as developers of curriculum with high quality professional learning in curriculum, assessment, pedagogy and inclusive practice.	http://www.det.act.gov.au/publicat/pdf/schooldevreport2002.pdf http://www.det.act.gov.au/schools/HighSchoolDevelopmentProgram.htm	Reaches approximately 70% of all high school science teachers
ACT	ACT Department of Education & Training and CSIRO Education	Researching with Scientists (RWS) Project (2001-ongoing)	Aim of RWS is to provide closer links between the scientific and educational communities in the ACT. Enables students and teachers to be involved in research, to become more aware of science in society and learn from latest scientific research and its applications.		Students in Years 10-12 and ACT teachers of science are subsidised to interact with visiting scientists and their hosts.
ACT	Centre for the Public Awareness of Science (CPAS), ANU	Workshops for teachers in hands-on Creative Science Teaching,and workshops on science communication	One or two day workshops aimed at increasing primary and secondary teachers' pedagogical content knowledge; workshops on effective science communication for scientists and others.	www.cpas.anu.edu.au/	Over the past eight years, CPAS staff have offered workshops grounded in research about learning, including aspects of alternative conceptions, analogies, inclusion of narrative and learning styles. Each activity models strategies for teachers, so that the workshops do not become just simple sets to take away for use in the classroom.

Location	Organisation	Initiative	Description	Reference	Comments
ACT	DEST	Science-based Careers Forum (16 August 2006)	Aimed to bring together people with a common interest in promoting science-based career opportunities.	Attended	The forum revealed that there were many individual initiatives to encourage students to choose science-based careers. Review and synthesis is needed, together with long term evaluation to determine what ones might be amalgamated for efficiency of scale and what might be supported at a national level. Professional learning experiences are needed for career advisors, and a more active and supportive media. Suggestion that career information be introduced at primary school level.
National	AAS	*Primary Investigations* (began 1992)	Science, technology and environment program for Australian primary schools, including teacher resource books and student books. Students work cooperatively in groups with hands-on activities using simple equipment.	http://www.science.org.au/pi/aboutpi.htm	Based on a BSCS course developed in the US. Uses the 5E model. Wide take up across Australia, especially in WA.
National	AAS/DEST	National Primary School Science and Literacy Project – *Primary Connections: linking science with literacy* (began 2004)	Program which links teaching and learning of science in primary schools with the teaching of literacy. Includes professional development and resources to increase teacher confidence and competence.	http://www.science.org.au/primaryconnections	Further funding announced in 2006 to continue program development and implementation. In 2007 DEST announced 500 awards of $2,000 for pre-service primary teachers who complete science education units that incorporated elements of *Primary Connections*.
National	ACER	Trends in International Mathematics and Science Study (TIMSS)	Provides international data on the mathematics and science achievement.	http://nces.ed.gov/timss/	Data are being collected in Australia in 2006. Focus is on knowledge and understanding of science facts and concepts, with international comparisons. Australia has usually performed in the top band internationally, but there are differential performances among states.

Location	Organisation	Initiative	Description	Reference	Comments
National	Australian Science Teachers Association (ASTA)	SPECTRA (Science Program Exciting Children Through Research Activities)	SPECTRA provides awards to students at two levels (Years 1-4 and Years 4-9) who do science activities either in school or out.	http://www.asta.edu.au/resources/spectra	Activities are described on cards and cover all science disciplines. Teachers ensure completion and students obtain a badge and certificate.
National	CSIRO	CSIRO Education	Website describing and linking to the CSIRO science education projects.	www.csiro.au/education	Includes descriptions of CSIRO Science Education Centres (laboratories in each state and territory), Double Helix Science Club for students, including two magazines), Science by Email (weekly e-newsletter), *Totally Wild Science* (30-minute TV program), CREST (award scheme for primary and secondary students), Student Research Scheme (for senior secondary students), plus other activities.
National	CSIRO with support from Alcoa, DEST and state and territory education departments	CREST – CREativity in Science and Technology	Non-competitive, project-based awards program for primary and secondary students involving open-ended investigations.	http://www.csiro.au/crest/index.html	Designed to encourage skills development, creativity, application and perseverance. CREST also creates links between schools and the science community. About 6,000 students annually earn CREST awards which have several levels. Coordinated by CSIRO Education.
National	CSIRO with support from state and territory education departments, Catholic Education, universities and industry	CSIRO Science Education Centres	Hands-on science laboratories located in all states and territories. Offer programs across the science curriculum from early childhood to Year 12.	www.csiro.au/csirosec	Over 45,000 students visit these centres each year with an additional 250,000 students serviced by the travelling Lab on Legs program.

Location	Organisation	Initiative	Description	Reference	Comments
National	CSIRO with support from state and territory education departments, Catholic Education, universities and industry	Lab on Legs	Travelling hands-on science classes which service schools in metropolitan, rural and remote areas. Based at CSIRO Science Education Centres.	www.csiro.au/csirosec	Accessed by over 250,000 students each year with 76,000 of these in non-metropolitan areas.
National	CSIRO with support from universities	Student Research Scheme/Teacher research Scheme	Senior secondary students and science teachers are placed with scientists to undertake their own research projects.	www.csiro.au/srs	Over 400 students complete projects each year.
National	CSIRO	Double Helix Science Club	Science club for ages 7 years and above. Publishes two magazines, The Helix and Scientriffic, each with an accompanying Teacher's Guide. Includes national projects engaging students, teachers and families in genuine scientific research.	www.csiro.au/helix	Established in 1986, has 20,000 individual members and 4,700 school bulk subscriptions.

Location	Organisation	Initiative	Description	Reference	Comments
National	DEST	Cooperative Research Centre (CRC) Programme	The CRC programme funded 56 Centres in 2006. CRCs are partnerships between universities, government institutions and industry. They provide extensive cross-national centres for research in mining, agriculture, manufacturing, environment and ICT.		Each CRC has an educational component for undergraduate and graduate training programmes. Many also provide educational opportunities for teachers, students and the community. Examples include the Centre for Sustainable Resource Processing, which has a teacher professional development programme, industry site tours, community lectures and regional area visits in Western Australia and Queensland (www.csrp.com.au), and the Molecular Plant Breeding CRC, which runs Get into Genes workshops linked to the state biology curricula for secondary school students and teachers in Adelaide and Melbourne (www.molecularplantbreeding.com.au and www.getintogenes.com.au). .

Location	Organisation	Initiative	Description	Reference	Comments
National	DEST	Australian Government Quality Teacher Program (AGQTP)	Funded for $300 million, this initiative aims to support programs at state, territory and national levels for quality teaching and school leadership. The website provides information about various activities being undertaken.	http://www.qualityteaching.dest.gov.au/default.htm Reports and evaluation of the 2000-2004 stage of the program are available at http://www.qualityteaching.dest.gov.au/agqtp_2000_2004/	The AGQTP is not specific to science education, but supports many science-related projects. Its general objectives for the years 2005-2009 are "to equip teachers with the skills and knowledge needed for teaching in the 21st Century; provide national leadership in high priority areas of teacher professional learning need; and to improve the professional standing of school teachers and leaders". The programme operates at three levels, supporting projects in each state and territory, projects at the national level (including *Primary Connections*), and Teaching Australia. Each state and territory has a strategic plan and activities funded by this project (see http://www.qualityteaching.dest.gov.au/state_territory_projects.htm). With regard to science, the evaluation of the project notes "In science, the major achievements have been around the development of pedagogies which strengthen the authenticity of science teaching, supported by external mentoring and partnership arrangement" (p. ii).

Location	Organisation	Initiative	Description	Reference	Comments
National	DEST	Boosting Innovation, Science, Technology and Mathematics Teaching Programme (BISTMTP) (began 2004 and due to run to 2011). The main element of BISTMTP is the Australian School Innovation in Science, Technology and Mathematics (ASISTM) Project.	Program aims to raise science, mathematics and technological literacy and the innovative capacity of Australian students. Has three elements: national school initiatives in science and innovation, teacher associates and data collection. The first two elements comprise ASISTM. ASISTM aims to encourage innovation in schools through partnerships and programs with organizations/institutions external to schools. www.asistm.edu.au	BISTMTP external program guidelines 2004-05 to 2010-11: http://www.dest.gov.au/NR/rdonlyres/435AD2FB-503C-4C84-9994-58825495C21E/5228/BISTMTProgrammeguidelines1.pdf	By the end of 2006, $23 million was being applied through ASISTM to 300 projects including 1650 schools and 1000 non-school partners (among them, most of Australia's universities). Each project is assigned an independent critical friend to provide expert advice and guidance.
National	DEST	Quality Outcomes Programme	Australian Government schools program that provides funding for strategic projects that support the Australian Government's key objective of improved student learning outcomes in schools and its national leadership role in school education.	http://www.dest.gov.au/sectors/school_education/programmes_funding/programme_categories/professional_skills_leadership/quality_outcomes_programme.htm	The Quality Outcomes Programme supports improved learning outcomes of Australian school students through strategic and collaborative initiatives. It incorporates a number of sub-programs. It is a source of funding for high priority initiatives, which may include science education projects – for example, the Science Education Assessment Resource website.
National	DEST (Questacon)	Questacon – The National Science and Technology Centre	Range of programs related to science learning, teaching and science careers, most offered nationally.	http://www.questacon.edu.au/index_flash.asp	Many outreach programs that travel nationally. The Shell Questacon Science Circus is a significant one, which through liaison with CPAS at ANU trains annually a cohort of science communicators, many graduates have significant positions in this field nationally and internationally.

Location	**Organisation**	**Initiative**	**Description**	**Reference**	**Comments**
National	DEST (Questacon)	Questacon – Smart Moves	Travelling program to bring Science, Engineering and Technology innovation and entrepreneurship to rural and regional secondary school students across Australia.	http://smartmoves.questacon.edu.au	Expansion under the ASISTM project, and now offered by other science centres in conjunction with Questacon.
National	DEST	Career Advice Australia (New in 2006)	Comprehensive national career and transition support network for young Australians (13 to 19 years) to provide advice and to information for other groups, including career advisors.	http://www.dest.gov.au/sectors/career_development/programmes_funding/programme_categories/key_career_priorities/career_advice_australia.htm	Not specific to SET. DEST initiative $130m in next three years. Emphasis on partnerships and network of career advisors.
National	DEST/DITR	SCOPE – Science Connections Programme	Support for science, engineering and technology awareness programs, including National Science Week, and various science prizes, including Eureka Awards and the Prime Minster's Science Prizes.	https://sciencegrants.dest.gov.au/NIAS/Pages/Elements.aspx	Major supporter of National Science Week and related activities promoting science.
National	DEST-funded ACER and Curriculum Corporation	Science Education Assessment Resources (SEAR)	The Science Education Assessment Resources (SEAR) provide a wide range of assessment resources (or 'tasks') suitable for use across the compulsory years of schooling. The tasks have been indexed to six levels as described in the national scientific literacy progress map.	http://cms.curriculum.edu.au/sear/	The SEAR assessment tasks are a data bank of items that can be used for diagnostic, formative and summative purposes. They are supported by marking keys linked to the national scientific literacy progress map: (http://cms.curriculum.edu.au/sear/newcms/view_page.asp?page_id=3539#map) and scale that connects with the OECD PISA assessments for 15-year olds and the national primary science assessments for Year 6 students .

Location	Organisation	Initiative	Description	Reference	Comments
National	MYCEETYA Australian, state and territory governments	myfuture.edu.au website (released 2002)	Online career information service	http://www.myfuture.edu.au	Not specific to SET. Aimed at job seekers providing advice and search facilities for education, jobs, scholarships and career paths. 20 million hits per month.
National	National Science Week (partnership programme between DEST, and the ABC, ASF Limited, ASTA and CSIRO)	National Science Week (Annual event)	Annual event, usually in August. ASTA, with assistance from DEST produces the Schools Kit, the ASTA Teacher Resource Book and makes grants available to schools through the member associations.	http://www.scienceweek.info.au/	In 2006, 706 separate events were listed on the national website. There were many more local events which were not listed. Major visibility of science during this week.
National	OECD/ACER	Program for International Student Assessment (PISA)	International 3-year surveys of 15-year-old student achievement in English, mathematics and science.	www.pisa.oecd.org	Provides information about Australian students' achievement with international comparisons. This year science is the main subject surveyed, with a focus on scientific literacy. Results expected in December 2007.
National	DEST	Teaching Australia – Australian Institute for Teaching and School Leadership (formerly the National Institute for Quality Teaching and School Leadership (NIQTSL))	Teaching Australia – Australian Institute for Teaching and School Leadership was established to raise the status, quality and professionalism of teachers and school leaders throughout Australia.	http://www.dest.gov.au/sectors/school_education/programmes_funding/programme_categories/professional_skills_leadership/teaching_australia.htm	Teaching Australia's core activities are to support and advance the quality of teaching and school leadership and to strengthen the profession. The Australian Government is providing $30 million over the five years to 2009 to fund the Institute. It is not science specific and is currently focussing on professional accreditation for teachers.

Location	Organisation	Initiative	Description	Reference	Comments
National	DEST	What works: The Work Program National Curriculum Services (NCS) and the Australian Curriculum Studies Association (ACSA)	Professional Development Package comprising a Guidebook, a set of digital materials and a Workbook.	http://www.whatworks.edu.au/	The What Works Program evolved from the research and other information derived from the Australian Government Indigenous Education Strategic Initiatives Programme's Strategic Results Projects, and since been developed with the support and collaboration of Indigenous Education administrators from across Australia and many other people involved with initiatives in the education of Indigenous young people. Not science specific, but aimed at assisting in the education of Indigenous students.
National	Science Schools Foundation	Siemens Science Experience	Three-day science experience for students about to enter Year 10 including lectures and experiments.	http://www.scienceexperience.com.au/	Run in January by participating universities and in association with the Rotary Club, Young Scientists of Australia and ASTA. Has reached more than 40,000 Year 9 students.
National	State Science Teachers Associations	Science Talent Search (STS)	Science Talent Search is run annually and coordinated within each jurisdiction by the local Science Teacher Association	Contact local Science Teacher Association	Significant prizes at a range of levels are available. Many schools run STS as a whole school activity.

Location	Organisation	Initiative	Description	Reference	Comments
National/ Australia and NZ	Curriculum Corporation	The Le@rning Federation (TLF)	The Le@rning Federation (TLF) is a collaborative initiative involving the Australian Government, States/Territories and New Zealand. TLF prepares online curriculum content in all curriculum areas to encourage student learning and support teachers in Australian and New Zealand schools. The Australian Government is providing $60 million over the eight financial years 2001-02 to 2008-09. States/Territories match this amount and New Zealand is also participating in the initiative.	www.thelearningfederation.edu.au	Curriculum resources are made freely available to all school jurisdictions. Jurisdictions provide their schools with access to these resources. Access is arranged by each jurisdiction's contact liaison officers in each state and territory. Materials are also being made available to universities under a licence agreement to allow for pre-service teacher training. There is a showcase section on TLF website to provide examples of the materials developed.
National/ state	ASTA led, funded by DEST	ASTA Science Awareness Raising Model (2002-2003)	Developed and trialled a model to raise awareness in the school and general community of science education, why science is important and why time should be spent on it in schools. Eight projects were funded nationally.	http://www.dest.gov.au/sectors/school_education/publications_resources/profiles/science_awareness_raising_model_evaluation.htm	This project was carried out in 2002-2003, evaluated and a final report prepared for DEST. This led to the implementation of the SCIps Project in 2003-2004.

Location	**Organisation**	**Initiative**	**Description**	**Reference**	**Comments**
National/ state	ASTA led, funded by DEST	ASTA School Community Industry partnerships in science (SCIps) Project (2004-2005)	The SCIps Project provided for schools, students, teachers, community and local government, industry and/or business people to work in partnership to design and implement a small innovative science-based project that promoted scientific literacy in their community. A total of 24 successful projects were funded nationally during 2004-2005.	http://www.asta.edu.au/scips/home.htm Final report: Australian Science Teachers Association (2005). *SCIps School Industry Partnerships in Science: Final Report.* Canberra: Department of Education, Science and Training. (available at http://www.asta.edu.au/scips/gui/files/final_report.pdf)	The SCIps Project used the science awareness-raising model developed in the ASTA project. A central plank was a comprehensive website which participants could use for communication with ASTA and each other, and which contained resources to assist in project planning and evaluation.
National/ state	ASTA	ASTA National Professional Standards for Highly Accomplished Teachers of Science	Professional standards for teachers of science.	http://www.asta.edu.au/home/whatsnew/profstandards	The standards are built around three categories: professional knowledge, professional practice and professional attributes.
NSW	NSW Institute of Teachers	Accreditation of teachers against Professional Teaching Standards	All NSW teachers who started teaching in NSW after 1 October 2004 are required to be accredited against the Professional Teaching standards. The Standards include demonstrated knowledge of subject content.	http:202.148.138.218/Acc_The-Teacher-Accreditation-Manual.html	Accreditation is mandatory and teachers who are unable to meet the standards cannot continue to teach.

Location	Organisation	Initiative	Description	Reference	Comments
NSW	NSW Institute of Teachers	Implementing professional development that meets Professional Teaching standards. Endorsing programs of universities and other initial teacher education providers.	All accredited teachers are required to maintain their accreditation by undertaking professional development that meets the Professional Teaching Standards. This included in-depth knowledge of subject content and the NSW Science syllabi underpin content requirements. All providers of initial teacher education are required to have their programs endorsed by the NSW Institute of Teachers.	http://202.148.138.218/Continuing-ProfessionalDevelopment.html http://202.148.138.218/Initial-Teacher-Education2.html	Specialist science education professional development providers offer registered provision for accredited teachers.

Location	Organisation	Initiative	Description	Reference	Comments
NSW	Department of Education and Training	Essential Secondary Science Assessment program (ESSA)	The Essential Secondary Science Assessment program aims at: • Providing diagnostic information to teachers, parents, students, schools and the larger community about students' achievement in Stage 4 (Years 7-10) science • Raising the profile of science education in schools • Providing resources and training for teachers • Access to a data analysis tool, 'School Measurement, Assessment, Reporting Toolkit' (SMART), to enable these data to be interrogated at a number of levels.	http://www.schools.nsw.edu.au/learning/7-12assessments/essa/index.php	ESSA is accompanied by a students' survey at Year 8 level which will provide rich data in relation to the perceived link between declining enrolments, students' lack of interest and the perceived lack of relevance of school science.

Location	Organisation	Initiative	Description	Reference	Comments
NT	Tropical Savannas Cooperative Research Centre, in partnership with the Department of Employment, Education and Training	Website: *EnviroNorth: Living Sustainably in Australia's Savannas*	The Tropical Savanna Knowledge in Schools Project has developed the EnviroNorth website, which is an extensive online resource,for NT teachers and students over the past three years.	www.environorth.org.au	Learn Savannas is the interactive part of the website with interactive modules focusing on savanna sustainability. Savanna Walkabout (http://www.environorth.org.au/learn/savanna_walkabout/index.html) is the first module available on this site with future modules underway. It is a learner-centred interactive module for biodiversity conservation in the Tropical Savannas biome. Teach Savannas is the teaching section, includes curriculum links and teaching support materials for each module, with a focus on middle school. Savanna Windows is the resource section for student (and teacher) inquiry.
QLD	Department of Education Training and the Arts	Science Education Strategy 2006-2009	Professional development for science teachers.	http://education.qld.gov.au/curriculum/area/science/strategy.html	Main focus is provision of targeted high quality professional development for primary and secondary teachers of science, through Working with university partners (Six Science Centres of Innovation and Professional Practice to facilitate professional development for teachers, principals and school curriculum leaders in collaboration with university partners); Working with industry (Four Senior Science Officers have been appointed to liaise with industry and research organisations to provide real life science experiences for students and teachers); promoting *Primary Connections*; Recognition and sharing innovation and good practice.

Location	Organisation	Initiative	Description	Reference	Comments
QLD	Department of Education Training and the Arts	Spotlight on science (2003-2006)	Program aimed at increasing students studying science and valuing good teachers.	http://education.qld.gov.au/publication/science/sciencestate.html	Spotlight on Science 2003 - 2006 was a six-step action plan developed following extensive state-wide consultation in 2002. It aimed to increase the scientific literacy, increase the number of students aspiring to careers in science, and improve the overall quality of science education in Queensland. The Spotlight on Science action plan was succeeded by the Science Education Strategy 2006-2009.
South Australia	Department of Education and Children's Services	Strategic Directions for Science and Mathematics in South Australian Schools	A series of 14 projects 2003-2006 funded for $2,100,000. Some projects have continued into 2007.	http://www.scimas.sa.edu.au/	Projects included Action Research in schools with $5,000 funding, a "twinning" of teachers with scientists for a period of up to two years, Premier's Industry Awards for teachers to work in industry or business for up to 10 days.
Tasmania	Department of Education	Science Inquiry Professional Learning Program (2005-2006)	Three half-day workshops to increase teacher confidence in conducting science inquiry with their classes.	http://www.ecentre.education.tas.gov.au/C6/ScientificInquiry/default.aspx (Appears to need password to open)	Approximately 70 teachers attended each year.
Tasmania	Department of Education/ Woodbridge School	Marine Discovery Centre	Discovery centre runs programs for students of all ages about the marine environment, including day trips in a vessel.	http://www.woodbridge.tased.edu.au/mdc/	Attracts about 9,000 visitors each year.

Location	Organisation	Initiative	Description	Reference	Comments
Victoria	Department of Education and Training	School Innovation in Science (SIS) – an initiative of the Science in Schools Strategy for 2003-2004. School Innovation in Teaching – Science Mathematics and Technology (SIT) developed out of SIS in 2003.	SIT developed from the Science in Schools Project, and aims to improve the teaching and learning of science in Victoria at P-10 levels. SIT is built around the six principles of the Principles of Learning and Teaching (PoLT) program which has been implemented across Victoria.	http://www.scienceinschools.org/home.htm http://www.scienceinschools.org/research/final_rep.pdf http://www.sofweb.vic.edu.au/blueprint/fs1/polt.	Outcome of the Science in Schools (SIS) Research Project, funded by the Science in Schools Strategy of the Victorian DET, and operated in 224 primary and secondary schools during 2000-2002. Final report of the SIS Project (dated April 2003) indicates improvements in the teaching of science in most project schools. The new strategy employs the SIS components of external support, training and materials, and school-based resources (such as commitment and time for planning) to result in improved student learning and attitudes. Over 400 schools have been involved in SIS and SIT programs.
Victoria	Department of Education and Training	Principles of Teaching and Learning P-12 (PoLT) Program	Part of the Blueprint for Government School's Flagship Strategy 1 designed to support teachers working with Victorian Essential Learning Standards.	www.eduweb.vic.gov.au/edulibrary/public/teachlearn/student/bgpaper!.pdf	Background paper contains expansion of the six PoLT principles and explains how they can assist teachers to explore their own pedagogy in ways that require cycles incorporating collaborative reflection and action.
Victoria	Catholic Education Commission Victoria (CECV)	Used funding from the Australian Government Quality Teacher Program to implement a series of science projects.	Identifying a need to lift standards of science education, the CECV directed a considerable portion of its funding towards improving skills and knowledge in science education. A range of initiatives have been undertaken by the CECV in Science through AGQTP.	http://www.qualityteaching.dest.gov.au/About.htm	Initiatives include: Science Partnership Program: Teacher Industry Placements; Monash University Science Teaching and Learning project; Middle Years Science Innovation Grants; Local Area Science Partnership Grants; Science Resource Officers; Science Project Officer; Advancing Scientific Literacy Programs; Professional Standards in Science; Environmental Science projects.

Location	Organisation	Initiative	Description	Reference	Comments
Victoria	Department of Education and Training	Better schools, better performance	Plans for investment of $7.5m from 2007-2011 for purchase of science equipment; $3.6m to primary schools for science and mathematics at Years 5 and 6; create 50 scholarships for mathematics and science graduates to undertake teacher training; build three new science and mathematics specialist centres; refurbish, replace or build 200 science classrooms; build the Sir John Monash Science School.	http://www.alpvictoria.com/alp/pdf/policies/Better_Schools_Better_Performance.pdf	Current government policy aimed at ensuring economic growth and increasing the level of community's scientific literacy.
WA	Department of Education and Training	Primary Science Project (commenced 2005)	Project aimed at government primary school teachers. Provides professional learning in science for identified support teachers representing every district across the state . Each support teacher is provided with some time to help their colleagues in class with science.	http://www.det.wa.edu.au/education/science/primary/index.htm (in the process of being updated)	This project works on a school based support model like Getting it Right Literacy. It builds the confidence and competence of primary teachers in science and develops primary science leaders across the system. The evaluation is ongoing. In 2006 support teachers commenced an outreach component where they supported local cluster schools with science professional learning. 40 science support teachers supported 200 schools and around 400 teachers. In 2007, there will be 50 science support teachers in every district supporting 200 schools and around 600 teachers.
WA	Department of Education and Training, and Office of Education, Science and Industry	Science HECS Reimbursement Scheme and the Final Year Teaching Scholarships	Final year scholarship program targets people with appropriate qualifications who might not have thought of taking up a teaching career in government schools.		

Location	Organisation	Initiative	Description	Reference	Comments
WA	Department of Education and Training	Teacher Development Centres (TDC) (to commence in 2007)	Course specific TDC coordinators will be provided time and contingency funding over the initial two to three year phase of the new senior school Courses of Study, including science.		Purpose is to support the curricular change in senior school. TDC Coordinators are classroom practitioners with proven record of student academic performance. Emphasis on classroom practice, effective learning strategies and development of a collaborative approach to managing change.
WA	Department of Education and Training	Professional Learning Institute (commenced 2005)	Level 3 Classroom teacher career structure supports retention of exemplary teachers in the classroom.	http://policies.det.wa.edu.au/our_policies/ti_view?uid=f8f3768e253c5545e71645b755153535&iview=summary_view	Available for all teachers, a number of primary and secondary teachers of science have been successful. Rewards past and future performance by salary and FTE allocation.
WA	Department of Education and Training	Monitoring Standards in education –Year 9 (MSE9) Assessment in science (commenced 2005)	All Year 9 students assessed in mathematics, English and science.	http://www.det.wa.edu.au/education/standards/Assessment%20Literacy.html For science http://www.det.wa.edu.au/education/mse9/science.html	Aims to support teachers by providing data with comment to assist targeting areas that need addressing in students' understanding and assist teachers to address these areas.
WA	Department of Education and Training	Making Consistent Judgements (MCJ)	MCJ professional learning in science for Year 9 teachers was presented in 2005, and will be presented for Years 5 and 7 teachers in 2007. Part of Curriculum Assessment and Reporting Policy and Guidelines.	http://www.det.wa.edu.au/education/curriculum/CIP2	Aimed at building capacity of teachers to make judgments about the progress and achievement of students in all learning areas. Teachers use work samples to engage in professional dialogue about students progress using the criteria from eth Outcomes and Standards Framework (OSF).

Location	Organisation	Initiative	Description	Reference	Comments
WA	Scitech Discovery Centre	Kids Science State Initiative (commenced 2003)	The Kids Science State Initiative is a series of mainly outreach programmes, and includes the Science Roadshow, teacher professional development and other programs.	http://www.scitech.org.au/	Like science centres in other states, Scitech is a significant state contributor to science education at child, school and adult levels. Partly funded by the State Government, and extensively supported by industry, Scitech has a range of programs, builds and tours science exhibitions nationally and internationally and hosts ScienceNetwork Western Australia (http://www.sciencewa.net.au/), an outlet to promote public engagement with science.
WA	Department of Education and Training, and the University of Western Australia	SPICE (commenced 2006)	Program provides an enrichment program for government secondary teachers of science.	www.spice.wa.edu.au	Includes teachers in residence program, for teachers to spend a term working with a scientist, and work with multimedia producers to prepare professional development activities for teachers. Also has a program of enrichment activities based around UWA science activities, and teaching and learning resources.

Description of Activities and Initiatives – International Sources

Location	Organisation	Initiative	Description	Reference	Comments
Europe	European Commission's Directorate General for Research, as part of the European Science Education Initiative	Website under the Nucleus project	This is a comprehensive website providing access to a large range of resources. Nucleus is a cluster of EU projects funded by the European Commission's Directorate General for Research, as part of the European Science Education Initiative. The cluster comprises: PENCIL, ESTI, CISCI, Scienceduc and Volvox.	http://www.xplora.org/ww/en/pub/xplora/nucleus_home.htm	CISCI (Cinema and Science) is coordinated by the Vienna University of Technology and offers a free and extensive database focusing particularly on movies clips and Internet sources. The Volvox network aims to provide teachers with motivating resources and activities relating to bioscience. PENCIL (Permanent European Resource Centre for Informal Learning) involves 14 science centres/museums which are "creating mini-networks involving schools, pupils, teachers associations, research laboratories, educational authorities, education and science communication specialists" to provide a range of innovative quality tools for science teaching. European Science Teaching Initiative (ESTI) involves science on stage and a journal for teachers, Science in Schools Scienceeduc is a set of documentary resources available by weblink.
Europe	Supported by European Commission	Website for communication	A network of "seed cities" across Europe, aimed at creating links between primary school classes to share science activities.	http://www.pollen-europa.net/?page=1	Provides, via website, tools for teachers, coordinators, etc. to assist in establishing links between primary schools in the 12 seed cities. Includes a newsletter (first in December, 2006).

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Norway	Relevance of Science (ROSE)	Website	International project involving 40 countries using a questionnaire to measure secondary students' attitudes about science.	http://www.ils.uio.no/english/rose/	Results from the ROSE project are now appearing in various journals and providing a picture of some variability among countries but some quite negative perceptions, and differences between boys and girls. Australia is a participant but as yet no data are reported.
USA/UK	Center for Informal Learning and Schools (CILS)	NSF-funded partnership between The Exploratorium, King's College, London and University of California Santa Cruz based at the Exploratorium in San Francisco	CILS has four programs related to developing leaders with a vision of science education that is inclusive, learner-centred, and content-rich, and that makes use of community resources and expertise, including informal science institutions such as museums, aquaria, botanic gardens, zoos, and science centres.	http://www.exploratorium.edu/cils/index.html	CILS supports research and develops leadership in the study of informal science learning and institutions, and their relationships to schools. Their influence is increasing as research findings are disseminated and their networks expand. They aim to strengthen science education through graduate, practitioner and research programs that broaden understanding of learning in both formal and informal environments.
UK	Science Community Partnership Supporting Education (SCORE)	Partnership for collective action to strengthen science education (Set up by the UK Royal Society, September 2006)	A partnership of the Institute of Physics, the Royal Society of Chemistry, the Institute of Biology, the Biosciences Federation, the Science Council, the Association for Science Education and the Royal Society.	http://www.science-academy.co.uk/page.asp?id=5216	Initial objective given as "the partners will undertake collaborative projects, conduct joint studies, develop common evaluation procedures and share best practice. They will develop a programme whose focus will be on activities of a type already shown to have an impact and whose principal emphasis will be on providing support for teachers." Aim to work with government to improve A-level physics and chemistry and address the shortage of science teachers.

Overview of Current Science Curriculum in Australia

Note: Responsible authorities in each jurisdiction provide significant resources for school, teachers, students and parents, relating particularly to the interpretation and delivery of curricula and assessment matters. These resources can be accessed by visiting their websites.

Jurisdiction	**Organisation**	**Description**	**Reference/Source**	**Comments**
ACT	Department of Education and Training	Curriculum framework for ACT schools P-10 (currently in trial for implementation in 2008)	http://activated.det.act.gov.au/learning/curri+renewal_framework.htm	The Curriculum Framework aims to improve curriculum delivery across the ACT. It emphasises the purpose of the curriculum and the principles underpinning curriculum for ACT schools. Within the framework are 26 essential Learning Achievements of which three specifically relate to science issues and the inquiry process. Will be mandatory for P-10.
Northern Territory	Department of Employment, Education and Training	NT Curriculum Framework (NTCF) review began in 2006 for K-10. Years 11-12 follow the SACSA Framework	http://www.betterschools.nt.gov.au/students_learning/teaching_learning.shtml	Research and testing has commenced for the review of the NTCF and will be updated throughout 2007. The updated NTCF will be in schools by June 2008.
NSW	NSW Board of Studies	K-12 Curriculum Framework has Syllabus for K-6, 7-10, Stage 6 (11-12). Science is linked with technology in K-6, but is a separate Key Learning Area from Year 7	For K-6: http://k6.boardofstudies.nsw.edu.au/index.html For Years 7-10: http://www.boardofstudies.nsw.edu.au/syllabus_sc/ For Stage 6: http://www.boardofstudies.nsw.edu.au/syllabus_hsc/	The Board of Studies syllabuses for K-6, Years 7-10, and Stage 6 are mandated for use in all NSW schools. Support materials are available to all stakeholders. There is also an Aboriginal Educational Contexts Section of the website for Science Years 7-10 (http://ab-ed.boardofstudies.nsw.edu.au/), and an Assessment Resource Centre (http://arc.boardofstudies.nsw.edu.au/).
Queensland	Department of Education Training and the Arts	Curriculum Framework for Education Queensland Schools Years 1-10, Policy and Guidelines; Science is one of 8 learning areas	http://education.qld.gov.au/public_media/reports/curriculum-framework/index.html	Curriculum is organised around four New Basics organisers (“what is taught”), productive pedagogies (“how it is taught”) and rich tasks (“how kids show it”). The New Basic organisers are life pathways and social futures; multi-literacies and communications media; active citizenship; and environments and technologies.

Jurisdiction	Organisation	Description	Reference/Source	Comments
SA	South Australia Curriculum Standards and Accountability (SACSA)	R-12 SACSA framework; Science as one of 8 learning areas	http://www.sacsa.sa.edu.au/index_fsrc.asp?t=Home	The SACSA Framework identifies five Essential Learnings: Futures, Identity, Interdependence, Thinking and Communication.
Tasmania	Department of Education	K-10 Science Syllabus and standards for use in all government schools (Currently in development)	The new curriculum will be part of the Learning Teaching and Assessment Guide at www.ltag.education.tas.gov.au	Essential Learnings Framework, a curriculum for learners from birth to age 16, is being implemented. It is designed around a set of five Essential Learnings and is published in two Frameworks. Essential Learnings Framework 1 was distributed to educators in 2002. It contains a Values and Purposes Statement, a description of the five Essential Learnings and a set of Learning Teaching and Assessment Principles. Essential Learnings Framework 2 was launched in March 2003 and comprises the set of Outcomes and Standards, aLearners and Learning Provision statement and the Learning Teaching and Assessment Guide.
Victoria	Victorian Curriculum and Assessment Authority (VCAA)	The Victorian Essential Learning Standards (VELS) identify three core and interrelated strands for the P-10 curriculum	http://vels.vcaa.vic.edu.au/essential/index.html	Each strand of the VELS has a number of domains which describe the essential knowledge, skills and behaviours students need to prepare for further education, work and life. The science domain is organized into six levels of achievement, each including a learning focus statement and, from Level 3, a set of standards. The standards for science define what students should know and be able to do at different levels and are written for the dimensions of science knowledge and understanding, and science at work. Victorian schools are currently implementing VELS and will report against the standards from 2008.
WA	Department of Education and Training	K-10 Syllabus; Science as one of 8 learning areas (commenced 2006) .	http://www.det.wa.edu.au/education/curriculum/cip2/pfl_science.asp	Syllabus is not mandated (the Curriculum Council's Curriculum Framework is mandated for all WA schools) but advisory. There will be scope and sequence for all science conceptual and process outcomes that target phases of learning.
WA	Curriculum Council	Curriculum Framework K-10; Science is one of 8 learning areas	http://www.curriculum.wa.edu.au/pages/curric_guides/index.html	Mandated for Western Australian schools. Supported by guides. Years 11-12 have new courses of study being implemented from 2007.