Primary Connections

Stage 2 Trial: Research Report

October 2005

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Foreword

School science education is important for the development of a scientifically literate society with citizens having the skills to make informed decisions on issues relevant to their lives, to equip them to operate in workplaces which are increasingly more scientific and technological, and to encourage a desire for further education in these areas. This philosophy underpins the *Primary Connections* project.

The Australian Academy of Science recognises the demands placed on primary school teachers, including the need to devote time to developing students' literacy. Hence its innovative project *Primary Connections: linking science with literacy* aims to improve students' learning outcomes in the areas of both science and literacy simultaneously. This is achieved through a professional learning program supported by quality curriculum resources that enhance teachers' confidence and competence in teaching science and establish meaningful connections between science and literacy learning. The program aims to engage and excite our primary school students in science – in understanding the world around them.

Primary Connections was trialled in 56 schools in eight states and territories during the 2005 school year, and we are indebted to their staff for their co-operation and commitment to the project. A comprehensive research programme to evaluate the trial was undertaken by Professor Mark Hackling (Edith Cowan University) and Associate Professor Vaughan Prain (La Trobe University), authorities in science and literacy education in Australia. This report presents the outcomes of their research and describes the significant gains that have been made during the trial, particularly in the areas of student learning, teacher confidence and attitudinal change.

The Academy's confidence in proceeding to Stage 3 of the project, which will include a national rollout of *Primary Connections*, is based on evidence that the program has been collaboratively developed, well conceptualised, has undergone substantial trialling in the classroom and has been monitored by thorough research. This report arose from our desire to ensure *Primary Connections* is informed by quality research and makes a positive impact on the science and literacy education of primary school students Australia-wide.

This report has been made possible thanks to the support of the Department of Education, Science and Training (DEST) under the Australian Government Quality Teacher Programme, as a quality teacher initiative. It has been guided by its Steering Committee with members from the Australian Academy of Science and DEST, and has benefited from input by its Reference Group which includes representatives from all state and territory jurisdictions. We anticipate that the research presented in this report will be an invaluable resource for the wide range of education professionals who play a vital role in developing and sustaining a scientifically literate community.

Dr Jim Peacock, AC PresAA FRS FTSE
President
Australian Academy of Science

Contents

List of figures

List of tables

Executive summary

Importance of the project

Science plays a crucial role in developing new ideas that can be applied to innovative technologies which can be commercialised and drive the economy. Science education not only plays a role in developing future scientists but also in developing scientifically literate citizens who can contribute to the social and economic well-being of Australia, as well as achieve their own potential. National assessments of Year 6 students' scientific literacy indicate that as few as 54 per cent of the sample in some jurisdictions reached the proficiency standard (MCEETYA, 2005). The national review of the status and quality of science teaching in Australian schools raised concerns about the quality and amount of science taught in our primary schools (Goodrum, Hackling and Rennie, 2001) and there have been long-standing concerns about the confidence and competence of primary teachers for teaching science (eg, Yates and Goodrum, 1990).

Research evidence from the trial of *Primary Connections* demonstrates that this program has had a large and positive impact on teachers' practice, students' learning and the status of science in schools and has the potential to have a significant impact on improving the teaching and learning of primary science throughout Australia.

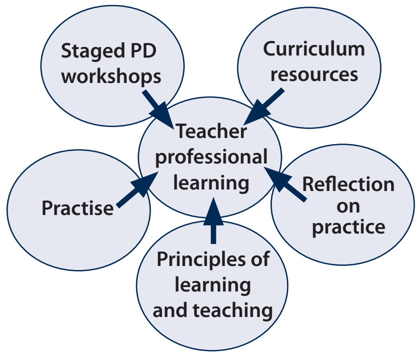
Purpose

The purpose of *Primary Connections* is to improve learning outcomes in science and literacy through a sophisticated professional learning program supported with rich curriculum resources that will improve teachers' knowledge of science and science teaching and thereby improve teachers' confidence and competence for teaching science and the literacies needed for learning science.

Professional learning model

Primary Connections is a professional learning program comprising a number of complementary elements: professional learning workshops, exemplary curriculum resources, opportunity to practise science teaching supported with resources, and reflections on practice. It is also linked to a set of principles of learning and teaching.

Figure 1: The *Primary Connections* professional learning model



Teaching and learning model

A teaching and learning model was created by elaborating the 5Es model (Bybee, 1997) to guide the development of the curriculum resources. The model is based on an inquiry and investigative approach in which students work from questions to undertake investigations and construct explanations. It is therefore consistent with contemporary constructivist learning theory which suggests that learners actively construct knowledge and make personal meaning from their experiences. Students are given opportunities to represent their developing understandings using a wide range of texts such as student journals, posters, tables and captioned diagrams as well as information communication technologies (ICTs) such as powerpoints and digital cameras. Assessment is integrated with teaching and learning. The model is illustrated in Figure 2.

Figure 2: The *Primary Connections* teaching and learning model

Phase	Focus
Engage	Engage students and elicit prior knowledge. *Diagnostic assessment.*
Explore	Provide hands-on experience of the phenomenon.
Explain	Develop science explanations for experiences and representations of developing understandings. *Formative assessment.*
Elaborate	Extend understandings to a new context or make connections to additional concepts through student-planned investigations. *Summative assessment of the investigating outcome.*
Evaluate	Re-represent understandings, reflect on learning journey and collect evidence about achievement of conceptual outcomes. *Summative assessment of conceptual outcomes.*

Key research findings

Effectiveness of the *Primary Connections* teaching and learning model

Anecdotal evidence, questionnaire data and case studies indicate that teachers wholeheartedly support the teaching–learning model and that the model was appropriate and effective because:

- The curriculum units structured and guided teaching and learning, supported the progressive development of understandings, and effectively integrated science and literacy so that learning in both science and literacy were improved.
- The model also facilitated significant changes to teachers' practice so that there was an increase in hands-on activity work, use of diagnostic assessments, and cooperative group work.
- Students developed a wide range of forms of representation of their knowledge (eg, text, drawings, diagrams, tables and graphs) and the increased use of digital cameras extended the ways of capturing and representing data using ICTs.

Impact on teachers, students and schools

The research data indicate that *Primary Connections* has had a profound and positive impact on teachers, students and schools.

Teachers

Initially, many of the trial teachers had low confidence and beliefs about their ability to teach science effectively (self-efficacy). Half of the 106 trial teachers had not completed any science studies beyond Year 12 and half had not attended any science professional learning programs in the previous year. Studies of science and science education and experience of teaching science build pedagogical content knowledge — the complex knowledge of science, curriculum, students, teaching strategies and learning needed to effectively teach science. Teachers with limited pedagogical content knowledge have low confidence and self-efficacy beliefs about their ability to teach science effectively, and tend to avoid teaching science.

> *Primary Connections* significantly increased teachers' confidence with science and literacy teaching strategies and significantly increased teachers' self-efficacy. The number of teachers with low self-efficacy was dramatically reduced.

> *Primary Connections* increased the amount of time devoted to science teaching, and science moved from being an afternoons-only subject to one taught across mornings and afternoons as science and literacy teaching were integrated.

> Teachers integrated science and literacy by developing the literacies of science in literacy lessons and by using science to provide contexts and purpose for literacy learning. Almost 90 per cent of teachers considered the integrated approach had improved science learning and 73 per cent considered that the integrated approach had improved literacy learning.

> By the end of term 2, teachers' concerns had changed from focusing on activities and strategies to focusing on achieving learning outcomes. Teachers attributed improvements in their science teaching to increased confidence and improved pedagogical content knowledge.

> Classroom observations made of case study teachers indicated that as they gained experience teaching with the support of *Primary Connections* units, the teachers' confidence increased and their teaching through inquiry improved.

Students

The research focused on students' engagement with and enjoyment of science and their learning outcomes.

> The student survey data show that a large majority of students enjoyed science and believed that they had learned more science using *Primary Connections* than previously.

Almost 90 per cent of teachers indicated that their students had responded positively or very positively to the *Primary Connections* activities and learning approach. More than 75 per cent indicated their students had learned more science and the quality of science learning was higher with *Primary Connections* than with their previous science program.

These student and teacher perceptions of high learning outcomes were corroborated by student science achievement data which indicated that mean achievement scores for a sample of Year 5 students increased significantly over one unit (more than doubled). Almost 80 per cent of the sample of Year 5 students were working at or above level 3 on the national scientific literacy progress map, which is the national proficiency standard for Year 6 students.

Schools

Teachers also reported many positive impacts of the program at the school level. More than 90 per cent of teachers indicated that *Primary Connections* had a significant impact on their schools increasing students' and teachers' interest in science, the profile of science within the school and local community, and increasing the amount of science being taught in their schools.

Primary Connections supported a large increase in science teaching time and the status of science in the school curriculum.

The increase in science teaching time can be attributed to teachers' increased confidence and self-efficacy, and having a quality curriculum resource to support their teaching.

It should be noted, however, that even with the support of the *Primary Connections* program, a significant number of teachers reported that their schools had inadequate school budgets for science (26 per cent), insufficient equipment and consumables (20 per cent), they had no science coordinator (37 per cent) and did not report science achievement as a separate subject on school reports to parents (30 per cent).

Insights into effective teacher professional learning gained from the trial whole-school roll-out of the professional learning model in the case study schools

Case study 2 provides an account of a very successful whole-school implementation of *Primary Connections* and identifies a number of factors that contributed to the success of the initiative at the school.

Strong support and leadership from the school executive, effective coordination of the program by the deputy principal, and peer support from two trial teachers who had attended the summer school professional learning workshop, engendered involvement and commitment to the project from the whole school staff.

Teachers at this school considered that the one-day professional learning workshop that introduced teachers to the program was effective in helping teachers to teach the science and literacy program; however, follow-up support was needed to assist teachers with emerging issues as they taught the program.

Planning of the professional learning resources for Stage 3 of the project will take account of the feedback from this pilot of a whole-school implementation. Resources are being prepared for a one-day workshop with a smorgasbord of follow-up 1.5 hour workshops that will provide further support in key areas such as implementing and assessing open investigations, developing literacies needed for learning science, and assessment.

Further enhancing the curriculum and professional learning resources for implementation in Stage 3

Almost 90 per cent of the teachers considered the curriculum units to be effective or very effective. Detailed teacher feedback will guide the revision of these units before widespread distribution. The most common suggestions were that the lessons should be shorter, the units should be shorter and the expected literacy demands be moderated for the Early Stage 1 and Stage 1 units.

Almost 90 per cent of teachers indicated that the professional learning program was as good as, or better than, any they had attended. The whole-school one-day professional learning workshop was piloted at the four case study schools and was well-received by teachers. Teachers commented that video clips of teachers working with *Primary Connections* would have enhanced the professional learning experience. Video clips are being prepared for inclusion in the professional learning resources.

Compatibility with jurisdictions' curriculum frameworks and professional learning support structures

Many teachers commented about the flexibility of the curriculum resources and that they found it relatively easy to adapt them to local contexts and needs. Continual monitoring of changes to jurisdictions' curriculum frameworks and the development of a National Statement of Learning for science will guide the development of new units.

Discussions with representatives from the various jurisdictions on the reference group has indicated that the project's design and resources will support a wide range of models of implementation that will be needed as the professional learning support structures vary in different jurisdictions.

Almost 90 per cent of teachers considered the units compatible with their jurisdictions' curriculum frameworks and schools' science programs, and 95 per cent of teachers wanted the Australian Academy of Science to produce additional units.

The quality and flexibility of the program has resulted in the trial being successfully completed in all of Australia's educational jurisdictions and sectors, and in metropolitan, regional and rural schools.

Recommendations

The research conducted as part of the evaluation of the Stage 2 trial of *Primary Connections* indicates that the program has been very successful in terms of its impact on teachers, students and schools. The flexibility of the program has enabled the program to be implemented effectively in different types of schools and sectors throughout Australia. Research evidence demonstrates that *Primary Connections* has the potential to improve the quality of science and literacy teaching and enhance the scientific literacy of young Australians.

The following recommendations are made to guide planning for future developments of the program and more widespread implementation of *Primary Connections*.

Recommendation 1

The research evidence provides a compelling case for the continuation and extension of the project to Stage 3. It is therefore recommended that the Australian Government's Department of Education, Science and Training and state and territory Departments of Education and Training provide further support to the *Primary Connections* initiative so that Stage 3 of the project can be commenced from term 4, 2005. A smooth transition between stages is imperative to maintain momentum and enthusiasm.

Recommendation 2

That Stage 3 of the *Primary Connections* project train professional learning facilitators from each state and territory and develop further curriculum units to support whole-school implementations of *Primary Connections*. Further research should be conducted to evaluate new units being trialled, the effectiveness of the professional learning facilitators and the impact of the whole-school implementations on students, teachers and schools.

Recommendation 3

The reference group agreed that a number of principles should guide the implementation of the *Primary Connections* program in Stage 3 to ensure the quality and sustainability of the ongoing implementation of the program. It is recommended that the following principles guide the implementation of *Primary Connections* in Stage 3:

- whole-school implementation (where possible);
- implementation be based on a combination of professional learning and curriculum resources;
- professional learning workshops to be facilitated by *Primary Connections* trained facilitators;

- professional learning workshops to be presented by facilitator plus a trial teacher where facilitators are not trial teachers;
- team-based school coordination to ensure succession planning;
- ongoing support and coordination for the team of facilitators within each jurisdiction.

Recommendation 4

Feedback from the trial teachers clearly indicates a preference for hardcopy and CD-ROM formats for the curriculum resources. It is therefore recommended that the curriculum resources are made available to schools in hardcopy and CD-ROM formats, and that the professional learning resources are made available in DVD/CD-ROM formats. The *Primary Connections* website should be further developed and funded to enable ongoing upgrading and effective communication with and between all participants, and to ensure currency of resources.

Recommendation 5

Major reform of teaching and learning can only be achieved through ongoing professional learning of inservice teachers; however, new teachers to the profession can have a large impact if properly prepared for implementing initiatives such as *Primary Connections*. It is therefore recommended that an initial teacher education resource pack be developed as part of Stage 3 to provide universities with a set of coherent resources to induct pre-service teachers into the *Primary Connections* teaching and learning model and to develop familiarity with the resources. A one-day professional learning workshop for university science teacher educators would enhance the uptake and impact of the resource pack.

Recommendation 6

It is recommended that Stage 3 further develop connections with Indigenous contexts and knowledge for learning science and the literacies needed for learning science within *Primary Connections* curriculum units to engage Indigenous students and improve their educational outcomes in science and literacy.

Recommendation 7

It is recommended that Stage 3 strengthen links with other national science education initiatives such as SEAR, Learning Objects (The Learning Federation) and the National Statements of Learning, and that further professional learning programs, supported by quality curriculum resources, be prepared to ensure continuity of engagement with science learning across the whole school experience.

Background to the *Primary Connections* project

Primary Connections is an innovative national initiative of the Australian Academy of Science which links the teaching of science with the teaching of the literacies needed for learning science in primary schools. It comprises a sophisticated professional learning program supported with rich curriculum resources and is designed to increase teachers' confidence and competence in the teaching of science and the literacies of science.

Primary Connections is based on an inquiry and investigative approach in which students work from questions through investigations to constructing explanations and is therefore consistent with contemporary constructivist learning theory. Students are given opportunities to represent and re-represent their developing understandings using a wide range of texts and information communication technologies (ICTs). Assessment is integrated with teaching and learning. Students' representations of their developing understandings provide opportunities for teachers to monitor students' learning progress and use this information to facilitate further learning.

The program is being implemented in stages. Stage 1 was funded by the Australian Academy of Science and involved developing a conceptual model for the program and gaining support from jurisdictions. The project model has been developed in partnership with a reference group which was established in December 2003. All states and territories and major groups involved in the teaching of science and literacy in Australia are represented. This group strongly supported the need for such a project.

Stage 2 was funded by the Australian Government Department of Education, Science and Training, who provided $1.8 million under the Australian Government's Quality Teacher Programme (AGQTP). Stage 2 developed and trialled curriculum resources and a professional learning program with 106 teachers from 56 schools drawn from all Australian education jurisdictions and sectors. Funding is currently being sought for Stage 3, to write further curriculum resources and train professional learning facilitators from all states and territories to support the roll-out of the program in schools throughout Australia.

Curriculum resources

To ensure that the curriculum resources would support each of the educational jurisdictions to implement their curriculum frameworks, a curriculum mapping exercise was conducted to identify common content and contexts for learning. From this mapping, a chart was developed mapping the scope of learning across the four common conceptual outcome strands (Earth and Beyond, Energy and Change, Life and Living, and Natural and Processed Materials) and the sequence of learning through the years of schooling. This scope and sequence chart was used to guide the development of the curriculum units.

Mapping also included essential learnings, which describe generic learning outcomes from several jurisdictions' frameworks, and technology from the New South Wales science and technology syllabus. The chart also mapped units against four broad stages of learning and a unifying theme was developed for each stage of learning. Stages were linked to years of schooling and to levels in the national scientific progress map.

A key feature of the *Primary Connections* project is that it has made links to all relevant national science education initiatives. Items from the Science Education Assessment Resources (SEAR) Project and links to the website (www.curriculum.edu.au/sear/) have been included in the curriculum resources. Trial teachers received professional learning on the use of The Learning Federation (TLF) Learning Objects, and opportunities to use Learning Objects were included in *Weather in my world*, an Early Stage 1 unit. The National Scientific Literacy Progress map underpinning SEAR and the national Year 6 scientific literacy assessments (MCEETYA, 2005) has been used to inform *Primary Connections*, and discussions are underway on the alignment of *Primary Connections* with the National Learning Statement for Science.

Eight curriculum units were developed and trialled in the 56 trial schools. These units are mapped against stages of learning and conceptual strands in Figure 3.

Figure 3: The eight units developed and trialled in Stage 2 of the project

	Conceptual context			
Stage	**Earth and Beyond**	**Energy and Change**	**Life and Living**	**Natural and Processed Materials**
Early Stage 1	*Weather in My World*	*On the Move*		
1		*Push-pull Power*		*Material Matters*
2	*Spinning in Space*		*Plants in Action*	
3			*Marvellous Micro-organisms*	*Build it Better*

A unit designed to make connections to Australian Indigenous contexts, *Ochre and Crystals*, was also developed and trialled in two schools in term 2. Further trialling and refinement of this unit and other approaches to make connections with Indigenous culture and knowledge will be required. Further development of professional learning and curriculum resources that will engage Indigenous students in science and improve their learning outcomes in science and literacy are recommended for future stages of this project.

A unit planner and template were also developed and trialled. They were used by teachers to develop their own units based on the *Primary Connections* teaching and learning model. A website and CD-ROMs provided teachers with background science information, assessment resources, sound files and images for use in their teaching.

An additional three units are planned for development late in 2005 so that they are ready for trial in term 2 of 2006.

Participants in the Stage 2 trial

106 teachers were recruited in pairs from 56 schools from all states and territories. The sample included 45 government schools, seven Catholic schools and four independent schools, and two of these schools had high enrolments of Indigenous students. Schools were drawn from metropolitan, regional and rural locations.

Project implementation

The trial teachers were provided with a five-day summer school professional learning workshop in January 2005, which engaged them in deep professional learning about science and literacy teaching practices, familiarised them with the *Primary Connections* teaching and learning model and curriculum resources, and prepared them for teaching the first *Primary Connections* unit in term 1 of 2005. In addition to these 106 teachers implementing the program in their classes at their schools, four of the trial schools undertook a whole-school implementation with all teachers at their schools. These four case-study schools piloted the model of implementation planned for Stage 3 of the project. A one-day professional learning workshop was presented at each of these schools prior to the commencement of term 1 teaching.

Follow-up one-day professional learning workshops were provided for the 106 trial teachers at mid-term 1, end-term 1 and end-term 2 to provide opportunities for reflection, resolving emerging concerns and to extend professional learning to the more complex pedagogical issues of unit writing and assessment.

Teachers taught units prepared by the Australian Academy of Science in terms 1 and 3 and taught a unit they prepared themselves using the planner and template in term 2.

Research and evaluation model

The research program gathered formative data that is being used to revise and improve the curriculum and professional learning component of the program following the Stage 2 trial. It also collected the summative data needed to evaluate the impact of the Stage 2 program on students, teachers and schools. Case studies in four selected schools that piloted a whole-school implementation have provided information that will guide the development of the whole-school model planned for the full roll-out of the program in Stage 3.

The research and evaluation was framed around the following research questions:

1. How workable and effective is the teaching and learning model which has been used in developing the curriculum units and template?
2. What impact has the program had on students, teachers, schools and jurisdictions?
3. What insights into effective teacher professional learning are gained from the trial whole-school roll-out of the professional learning model in the case study schools?

4. How can the curriculum and professional learning resources be enhanced before implementation in Stage 3?
5. Is *Primary Connections* compatible with jurisdictions' curriculum frameworks or professional learning support structures?

Data were gathered by teacher questionnaires, student surveys, teacher focus group discussions, student focus group discussions, classroom observations and analysis of student work samples. Teachers also provided detailed feedback on each unit they taught in the form of annotations on copies of the units.

Acknowledgements

The *Primary Connections* project has been enormously successful due to the collaborative efforts of governments, organisations and people who all brought a vision, expertise, enthusiasm, commitment and resources to the project. A full list of acknowledgements is included in Appendix 1. Special acknowledgement is made here of the following:

Australian Academy of Science

For having the vision and initiative to initiate this project and the organisational skills to implement it so professionally.

Project manager

A great deal of credit for the successful management and implementation of the project is due to the vision, energy, commitment and sheer professionalism of Marian Heard and then to Shelley Peers.

Australian Government Department of Education, Science and Training

For having the vision to recognise the need for this project and providing $1.8 million in funding.

Jurisdictions, education sectors and professional associations

For working so collaboratively and supporting the trial in all states and territories, in government, independent and Catholic schools.

Steering committee

For providing strong oversight of the vision, strategic direction and management of the project.

Reference group

For bringing a wealth of experience, expertise and diverse viewpoints that helped conceptualise and provide direction to the project and its implementation.

Project officer

Every project of this size, involving so many participants, needs a project officer like Claudette Bateup. She has played a leading role in the administration of the project, supporting the trial teachers and writing curriculum resources. Emma Anderson provided valuable administrative support to Claudette and the project.

Writers and editors

A number of writers have provided valuable input to the project by preparing first drafts of the curriculum units and their creativity is gratefully acknowledged. Jean Watson has played a leading role in developing a model unit, on which others were based, and has assisted with revision of units. Maureen Swanage and Alex Chiragakis made an important contribution through editing and layout of the curriculum resources.

Research assistant

Barbara Bowra has acted as research assistant throughout this project assisting with data collection, data coding and analysis; this work has been completed with tremendous efficiency and thoroughness.

Trial teachers and schools

Trial teachers and schools have entered this project with a wonderful spirit of professionalism, collaboration, excitement, energy and enthusiasm. Your support and rich insightful feedback throughout the trial has been invaluable in providing direction for revision of the resources before they are published and made available for widespread distribution throughout Australia. Your work has ensured that the resources will work in real classrooms with real teachers and students.

Edith Cowan and La Trobe Universities

The researchers and consulting co-directors would like to thank our universities for releasing us to work on this project.

Professor Mark Hackling and Associate Professor Vaughan Prain

Chapter 1 | Background and purpose

High-quality teaching of both science and literacy in Australian primary schools is a national priority in order to develop citizens who are scientifically literate and who can contribute to the social and economic well-being of Australia as well as achieve their own potential. Student achievement in science is therefore being monitored nationally through the national Year 6 scientific literacy assessments for which sample testing was undertaken in October 2003 and will be repeated in 2006 (MCEETYA, 2005).

The teaching of science in primary schools has been a cause for concern for some time and despite the recognition of science as a priority area of learning, science teaching has a low status in the primary curriculum. Many primary teachers lack confidence and competence for teaching science (Appleton, 1995; Palmer, 2001; Yates and Goodrum, 1990) and consequently score poorly on self-efficacy scales that measure the extent to which primary teachers feel capable of teaching science effectively (Riggs and Knochs, 1990). The National Review of the Status and Quality of Science Teaching and Learning (Goodrum, Hackling and Rennie, 2001) indicated that the teaching of science in primary classrooms is patchy and recommended that if primary teachers of science are to be effective in improving student learning outcomes, they need access to quality professional learning opportunities which are supported by rich curriculum resources. It also argued that to develop quality science education resources, collaboration between jurisdictions is essential and could reduce wasteful duplication in the preparation of resources.

The recently released report on the national assessment of Year 6 students' scientific literacy, indicates that less than 60 per cent of students in six of eight jurisdictions reached the proficiency standard (MCEETYA, 2005).

The *Primary Connections* project

Primary Connections is an innovative national initiative of the Australian Academy of Science which links the teaching of science with the teaching of the literacies needed for learning science in primary schools. It comprises a sophisticated professional learning program supported with rich curriculum resources and is designed to increase teachers' confidence and competence in the teaching of science and the literacies of science.

This approach is based on the assumption that students need to use their everyday literacies to learn the new literacies of science and that they need explicit instruction about science texts. Through these strategies students learn to connect science learning to their everyday world and values. Linking science with literacy will enable a more efficient use of time and resources in the classroom and provide relevant contexts in which students demonstrate learning outcomes in science and literacy. The curriculum resource is based on science concepts common to all state and territory curriculum frameworks.

Primary Connections is based on an inquiry and investigative approach in which children work from questions through investigations to constructing explanations using prior knowledge and literacies, and is therefore consistent with contemporary constructivist learning theory. Students are given opportunities to represent and re-represent their developing understandings using a wide range of texts and information communication technologies (ICTs), and assessment is integrated with teaching and learning. Students' representations of developing understandings provide opportunities for teachers to monitor students' learning progress and to use this information to facilitate further learning.

The program is being implemented in stages. Stage 1, funded by the Australian Academy of Science, involved developing a conceptual model for the program and gaining support from jurisdictions. Stage 2, funded by the Australian Government Department of Education, Science and Training (DEST), developed and trialled curriculum resources and a professional learning program with 106 teachers from 53 schools drawn from all Australian education jurisdictions and sectors. It is hoped that funding will be obtained for Stage 3, which will involve writing further curriculum resources and implementing a full-scale professional learning program.

The project model has been developed in partnership with a reference group which was established in December 2003. All states and territories and major groups involved in the teaching of science and literacy in Australia are represented. This group argued strongly about the need for such a project. The Australian Academy of Science funded the initial proof of concept stage and DEST funded the second stage, providing $1.8 million under the Australian Government Quality Teacher Program (AGQTP).

Chapter 2 | Research on teacher effectiveness and teacher professional learning

The review of the status and quality of teaching and learning of science in Australian schools (Goodrum, Hackling and Rennie, 2001) conducted in 1999–2000 recommended to the Australian government that the primary purpose of science education in the compulsory years of schooling is to develop scientific literacy, a view consistent with major British and North American curriculum documents and reviews (Millar and Osborne, 1998; NRC, 1996).

Scientific literacy is a high priority for all citizens, helping them:

- to be interested in, and understand the world around them;
- to engage in the discourses of and about science;
- to be sceptical and questioning of claims made by others about scientific matters;
- to be able to identify questions, investigate and draw evidence-based conclusions; and
- to make informed decisions about the environment and their own health and well-being.

(Hackling, Goodrum and Rennie, 2001, p. 7)

Scientific literacy therefore encompasses a range of science learning outcomes that enable individuals to navigate their way through life, rather than focusing solely on preparing them for further studies of science in the post-compulsory years.

Effective science teaching

The picture of effective science teaching constructed in this section is based on three seminal Australian research and professional documents: the national review, the professional standards for accomplished teachers of science, and the components of effective science teaching developed in the Victorian Science in Schools (SiS) project.

The national review of the status and quality of science teaching and learning in Australian schools (Goodrum et al., 2001) developed ideal and actual pictures of science education. The ideal picture was developed from the research literature, curriculum documents and from focus group meetings with teachers and curriculum experts. The ideal picture was described in nine themes:

1. The science curriculum is relevant to the needs, concerns and personal experiences of students.
2. Teaching and learning of science is centred on inquiry. Students investigate, construct and test ideas and explanations about the natural world.
3. Assessment serves the purpose of learning and is consistent with and complementary to good teaching.

4. The teaching–learning environment is characterised by enjoyment, fulfilment, ownership of and engagement in learning, and mutual respect between the teacher and students.
5. Teachers are life-long learners who are supported, nurtured and resourced to build the understandings and competencies required of contemporary best practice.
6. Teachers of science have a recognised career path based on sound professional standards endorsed by the profession.
7. Excellent facilities, equipment and resources support teaching and learning.
8. Class sizes make it possible to employ a range of teaching strategies and provide opportunities for the teacher to get to know each child as a learner and give feedback to individuals.
9. Science and science education are valued by the community, have high priority in the school curriculum, and science teaching is perceived as exciting and valuable, contributing significantly to the development of persons and to the economic and social well-being of the nation.

(Goodrum et al., 2001, p. vii)

The national professional standards for highly accomplished teachers of science (Australian Science Teachers Association and Monash University, 2002) describe the professional knowledge, practice and attributes of highly accomplished teachers. The standards specify that teachers need a rich knowledge of science, curriculum, teaching, learning and assessment, and of their students. Furthermore, they are able to transform these components of knowledge into the pedagogical content knowledge that allows them to make subject knowledge comprehensible to their students (Gess-Newsome, 1999). The standards relating to professional practice for highly accomplished teachers include statements that:

1. They design coherent learning programs appropriate for their students' needs and interests.
2. They create and maintain intellectually challenging, emotionally supportive and physically safe learning environments.
3. They engage students in generating, constructing and testing scientific knowledge by collecting, analysing and evaluating evidence.
4. They continually look for and implement ways to extend students' understanding of the major ideas of science.
5. They develop in students the confidence and ability to use scientific knowledge and processes to make informed decisions.
6. They use a wide variety of strategies, coherent with learning goals, to monitor and assess students' learning and provide effective feedback.

(Australian Science Teachers Association and Monash University, 2002, p. 3)

The components of effective science teaching developed in the Science in Schools (SiS) project (Tytler, 2002) describe the pedagogical practices that effectively support student learning and engagement in science. These are:

1. Students are encouraged to actively engage with ideas and evidence.
2. Students are challenged to develop meaningful understandings.
3. Science is linked with students' lives and interests.
4. Students' individual learning needs and preferences are catered for.
5. Assessment is embedded in the science learning strategy.
6. The nature of science is represented in its different aspects.
7. The classroom is linked with the broader community.
8. Learning technologies are exploited for their learning potentialities.

(Tytler, 2002, p. 9)

When these three documents are analysed, they reveal strong convergence around six characteristics of effective science teaching:

1. Students experience a curriculum that is relevant to their lives and interests within an emotionally supportive and physically safe learning environment.
2. Classroom science is linked with the broader community.
3. Students are actively engaged with inquiry, ideas and evidence.
4. Students are challenged to develop and extend meaningful conceptual understandings.
5. Assessment facilitates learning and focuses on outcomes that contribute to scientific literacy.
6. Information and communication technologies are exploited to enhance learning of science.

Integrating science and literacy

In seeking to integrate science and literacy in primary school, the design of *Primary Connections* has been guided by various assumptions about the nature of literacy and science, the relationship between them, and effective pedagogy for learning in both areas. There is growing acceptance by the literacy education community that 'literacy' should be conceptualised as a range of different types of social practices rather than as one universal attribute or individual learner capacity. From this perspective, there are many different literacies, such as community or vernacular literacy, street literacy, visual literacy, computer literacy, and school subject literacies, such as science literacy (Gee, 2004; Street, 1995). Each of these literacies may entail reading and writing, but also involve talking, thinking, viewing and acting for a wide range of purposes.

Researchers such as Norris and Phillips (2003), Gee (2004), Lemke (1998), and Unsworth (2001), have noted that students need to acquire the particular languages and representational practices and vocabulary of a discipline. For Norris and Phillips (2003), science literacy entails being able to interpret and construct science texts. From this perspective, science as a subject entails the integrated use of visual, verbal and mathematical modes to construct scientific concepts, processes and explanations. Taken as a whole, these practices represent the literacies of science, and their acquisition is essential to the development of *science literacy*. Students will therefore need explicit instruction in the form/function of science texts, such as graphs, tables, captioned diagrams, science journals, and reports. From this perspective, the concepts and methods of science cannot be learnt separately from their representation (Gee, 2004; Lemke, 1998).

Given these assumptions about the nature of science and literacy, it was assumed that the integration of science and literacy is enhanced when students are given diverse opportunities to use their community or vernacular literacies to learn the new literacies of science. It was further assumed that science learning is best facilitated in a representation-rich environment where students share understandings, collaborate on investigations, and clarify knowledge through constructing representations of what they have learnt. A further assumption guiding the development of *Primary Connections* is that the students' sense of meaningful learning is promoted when they connect science learning to their everyday worlds and values.

Science education in the compulsory years of schooling is therefore expected to support the development of scientific literacy through achieving the learning outcomes specified in state and territory curriculum frameworks using the effective science teaching practices described in the national review (Goodrum et al., 2001), professional standards (Australian Science Teachers Association and Monash University, 2002) and components of effective science teaching developed in the SiS project (Tytler, 2002), and by scaffolding the development of students' literacies of science which help them represent their understandings using multimodal texts.

All of these documents take a social constructivist perspective to teaching and learning (Driver, Asoko, Leach, Mortimer and Scott, 1994) which highlights the role of learners using prior knowledge and experience to construct their own meaning within the socio-cultural context within which they find themselves, when challenged by teachers to extend and deepen their understandings.

Teacher professional learning

As Anderson and Michener (1994) indicated in their review of research on science teacher education, whilst improved pre-service teacher education is important and influential, it will never be the key impetus for education reform. The potential for significantly improving the education system lies with practising teachers' professional learning. Furthermore, Anderson and Michener (1994) concluded that successful teacher professional learning occurs in the school context with changes initiated in a systemic and sustained manner.

A recent report from England by the Council for Science and Technology (2000) addresses the question of 'What would make a material difference in helping science teachers in primary and secondary schools develop and improve their professional practice, individually and collectively?' Apart from evidence obtained from other English research and Office for Standards in Education (OFSTED) inspections, the Council commissioned a survey (Dillon, Osborne, Fairbrother, and Kurina, 2000). 20 focus groups covering 50 schools all over England, and randomly selected samples of over 900 head teachers and 1500 science teachers from 1300 primary and secondary schools participated in this survey. The Council concluded that:

> We are convinced that there is considerable scope for securing a step change in science teachers' performance and hence in the science education of their pupils, by creating a pro-CPD [continuous professional development] culture, one in which a life time of professional learning is very much the norm and is assisted by modern, effective arrangements.
>
> (Council for Science and Technology, 2000, p. 4)

Loucks-Horsley, Hewson, Love and Stiles (1998) identified a range of strategies that are used to support teacher professional learning. While some of these strategies have greater potential than others in improving teaching and learning, each strategy can make a contribution depending on the special circumstances and settings in which teachers find themselves. The strategies include immersion in industry-based activities, action research (eg, Grundy, 1995), collaborative work with peers or researchers (eg, the *PEEL* project, Baird and Northfield, 1995; and the *Science in Schools* project, Tytler, 2002), curriculum-based initiatives (eg, *Primary Investigations*, Australian Academy of Science, 1994), and other professional learning workshops or courses.

There is an extensive range of professional development courses offered to teachers, from one-off isolated lectures to intensive postgraduate qualifications. Unfortunately, the most common approach is the single, 'stand alone' workshop or seminar that seems to have the least impact in improving teaching practice. In fact they may be perceived as being imposed rather than owned by teachers, lacking credibility, non-sustainable, being brief and a one-off event rather than part of a long-term sustainable and effective program (Guskey and Huberman 1995). The teachers from Ingvarson and Loughran's Australian study (1997) mostly worked in complete isolation from colleagues at their school and consequently had no method of interacting collaboratively and being supported by their peers. The involvement of teachers working collaboratively, reflecting on their current practices, recognising new possibilities and identifying issues to be addressed can engage them in forms of inquiry into their own professional practice. Participative inquiry involves cooperative participation in the construction of professional knowledge relevant to the context of the workplace (Reason, 1998).

Much of the evidence at the Senate Inquiry into the Status of the Teaching Profession (1998) was critical of current professional development arrangements, referring to their 'ad hoc' and 'piecemeal nature'. Research clearly shows that professional development that is independent of the school context or the broader support for curricular or instructional change is unlikely to have an impact on educational practice (Anderson and Michener, 1994). On the basis of the evidence they received, the Senate Inquiry (1998) indicates that successful professional development programs include some of the following features:

- Teachers have significant input into the program.
- It is well structured, long-term and comprehensive.
- It involves a variety of collaborative partners.
- It includes evaluation, feedback and ongoing support.
- The costs are shared between government and schools.
- Courses are accredited or recognised in career structures.
- Courses meet national standards.

Sparks and Loucks-Horsley (1990), in their review of research on staff development, also recognise the importance of leadership from administrators. Good professional development is a balance between systemic leadership and teacher contribution. Neither the imposed curriculum reforms of the 1970s nor the school-based curriculum developments of the 1980s and 1990s have resulted in the system-wide teacher change that had been hoped for. It is suggested that effective teacher change require both systemic leadership and school involvement.

Curriculum development and curriculum implementation are increasingly being used as components of professional development programs. Bybee (1997) explains that curriculum development and professional development are both high risk, high cost activities for a school or system. The potential benefits, however, are significant. In their definitive review of the literature on educational change, Fuller and Steinberger (1991) suggest that substantial educational change is generally the result of systemic efforts and that professional development is an essential ingredient. Curriculum reforms provide the basis for systemic change but without professional development it is unlikely the change will be sustained. In Ohio's *Statewide Systemic Initiative*, aimed at improving middle school science and mathematics, professional development was a key ingredient. Four years into the reform, a comprehensive assessment of its effectiveness found that professional development, a curriculum that focuses on problem-solving, and materials to support student inquiry were given the highest ratings as leading to improved learning in science. Further, professional development sustained over time was recognised by principals and teachers as more beneficial than short-term professional development, especially by teachers who had experienced both types of development (Kahle and Boone, 2000).

Curriculum resource development is more successful when curriculum experts and teachers collaborate. *Primary Investigations*, developed by the Australian Academy of Science, has been cited as a successful example of this approach (Appleton and Symington, 1996; ASTEC, 1997; Fensham, 1998). The project began with extensive research with teachers to determine their needs (Goodrum, Cousins and Kinnear, 1992), and the curriculum resources were developed and trialled extensively with over 500 teachers over a period of 3 years. This teacher input provided the basis of a resource that provides appropriate content and adaptability to local conditions. A sustained school-based professional development program supported the implementation of the resource.

The *Collaborative Australian Secondary Science Program* (CASSP) brought together three complementary components to support teacher professional learning: professional development workshops to explain and model new practices; curriculum resources to exemplify how these practices could be brought together into a coherent learning sequence and to support teachers implement the new practices; and opportunities for collegial reflection on practice and provision of peer support through participative inquiry (Hackling, Goodrum and Deshon, 1999). The CASSP project, funded by DEST, was implemented in 28 schools with 122 teachers and approximately 3000 Year 9 students. The initiative supported many teachers to move from teacher-centred strategies towards more student-centred and investigative approaches and greater use of assessments for learning (Goodrum, Hackling and Trotter, 2003). Case study research demonstrated that, for some teachers, these experiences raised the level and nature of teachers' concerns about their practice and understanding of the new teaching-learning strategies, which facilitated the successful implementation of the new practices (Sheffield, 2004).

The value of curriculum-based professional learning programs has gained further support from a recent meta-analysis of 37 professional learning studies, which demonstrated that curriculum development, replacement and implementation approaches had the highest impact on student learning (Tinoca, 2004).

Teachers' beliefs and professional knowledge

Teachers' professional practice is influenced by a number of factors, including their beliefs, pedagogical content knowledge, the professional climate of their workplace, curriculum frameworks and assessment regimes, and limitations in resources.

Recent Australian studies have illustrated the powerful influence of teachers' beliefs about the nature of science and what constitutes effective science teaching practice on the science teaching practices of both primary and secondary teachers (Keys, 2003; Sheffield, 2004). Having opportunities to explore the rationale for new practices and to engage in deep reflections on their practice are therefore important elements of professional learning programs.

Teachers enact highly complex bodies of professional knowledge for teaching science. This pedagogical content knowledge comprises knowledge of science, science teaching strategies, science curricula and learning outcomes, students and students' learning, assessment strategies, contexts and cultures (Gess-Newsome, 1999). As a consequence of limited studies of science and science curricula in initial teacher education, many primary teachers have limited science pedagogical content knowledge and this is corroborated by an extensive and long-standing body of research that shows that primary teachers have low confidence, competence and self-efficacy beliefs about their ability to teach science effectively (Appleton, 1995; Palmer, 2001; Riggs and Knochs, 1990; Yates and Goodrum, 1990). Enhancing teachers' pedagogical content knowledge is likely to lead to greater confidence and self-efficacy for teaching science. Opportunities for exploring science teaching strategies, principles of effective teaching and learning, the science concepts, investigation skills and literacies of science associated with units of work are therefore important components of effective professional learning programs for primary teachers of science.

The *Primary Connections* program

Primary Connections builds on the research findings from the previous successful Australian professional learning initiatives: *Primary Investigations*, *Science in Schools* and the *Collaborative Australian Secondary Science Program*. As such, *Primary Connections* combines professional learning workshops, exemplary curriculum resources, opportunities for reflection and collegial support, analysis of professional practice based on principles of teaching and learning, and an extended professional engagement, all of which were shown to be effective in these earlier programs. Combined with these proven elements, a number of new elements have been included in the *Primary Connections* approach. Of these, making links between science and literacy, and providing a scaffolded and collegial opportunity to develop new curriculum units using a supplied template based on the *Primary Connections* instructional model, are the most significant.

Primary Connections makes important links with other national initiatives. The curriculum units include some SEAR assessment tasks and the professional learning resources informed teachers about the SEAR resource bank website. The professional learning workshops also explored learning objects that could be integrated with *Primary Connections* units and the pedagogies associated with their use. Further development of curriculum units in the proposed Stage 3 of the project will be informed by the development of the National Statement on Learning for science.

The *Primary Connections* program is based on a sophisticated professional learning model and a sophisticated teaching and learning model. Chapter 3 describes how these models were used to guide the development of the professional learning program and the curriculum resources.

Chapter 3 | Development of the resources

Primary Connections is a professional learning program comprising professional learning workshops with exemplar curriculum resources. This chapter outlines the conceptual models on which the curriculum resources and the professional learning program were developed, and the processes of development that ensured quality.

Curriculum resources

A teaching and learning model was constructed by elaboration of the 5Es model (Bybee, 1997) to guide the development of the curriculum resources. The model is based on an inquiry and investigative approach in which children work from questions through investigations to constructing explanations and is therefore consistent with contemporary constructivist learning theory. Students are given opportunities to represent and re-represent their developing understandings using a wide range of texts and information communication technologies (ICTs), and assessment is integrated with teaching and learning. The model is illustrated in Figure 3.1.

Figure 3.1: The *Primary Connections* teaching and learning model

Phase	Focus
Engage	Engage students and elicit prior knowledge. *Diagnostic assessment*.
Explore	Provide hands-on experience of the phenomenon.
Explain	Develop science explanations for experiences and representations of developing understandings. *Formative assessment*.
Elaborate	Extend understandings to a new context or make connections to additional concepts through student-planned investigations. *Summative assessment of the investigating outcome.*
Evaluate	Re-represent understandings, reflect on learning journey and collect evidence about achievement of conceptual outcomes. *Summative assessment of conceptual outcomes.*

The 5Es

The phases of the learning model are based on the 5Es model developed by Bybee (1997).

Engage

The *Engage* phase activities are designed to engage students' interest in the topic and elicit their existing beliefs and experiences about the topic. This provides an opportunity for the teacher to assess students' prior knowledge, including any science misconceptions, so that the teacher can plan to implement the following lessons in ways that build on students' existing knowledge and address any misconceptions.

Explore

The *Explore* phase provides students with hands-on experiences of science phenomena and ensures all students have a shared experience that can be discussed and explained in the next phase.

Explain

The *Explain* phase involves discussion of experiences and observations, identifying patterns and relationships within observations and using science concepts to develop explanations for the science phenomenon. Students develop a literacy product that represents their developing understandings of the science concepts and skills using literacies of science. The representations enable the teacher to monitor developing understandings and provide feedback to learners.

Elaborate

The *Elaborate* phase requires students to plan and conduct an open investigation in which they test and extend their new conceptual understandings in a new context. Students' reports of their experimental work are used by teachers to assess students' achievement of the investigating outcome.

Evaluate

The *Evaluate* phase requires students to create a literacy product by which they re-represent their conceptual understandings so that the teacher can assess the extent to which they have achieved the conceptual learning outcomes for the unit. Students also reflect on their learning journey.

Assessment

Assessment is integrated with teaching and learning in *Primary Connections* and is linked to the production of literacy products in the *Engage*, *Explain*, *Elaborate* and *Evaluate* lessons. **Diagnostic assessment** is used in the *Engage* phase to elicit students' prior knowledge so that the teacher can take account of this in planning how the *Explore* and *Explain* lessons will be implemented. The literacy product developed in the *Explain* lesson enables the teacher to monitor students' developing understandings and provide feedback that can extend and deepen students' learning through **formative assessment**. The investigation report produced in the *Elaborate* lesson and the presentation developed in the *Evaluate* lesson provide opportunities for **summative assessment** of students' learning of the investigation skills and concepts developed through the unit.

Inquiry and investigative approach

Primary Connections uses an inquiry and investigative approach to learning so that students' curiosity is enhanced, students are actively engaged in the learning process, explanations are developed from experiences and students develop investigation skills and an understanding of the nature of science. These learning outcomes all contribute to developing students' scientific literacy. Activities in the *Explore* phase provide structured hands-on experiences of the science phenomena and students complete open investigations in the *Elaborate* phase so that they can plan and conduct their own investigations, with support from the teacher.

Curriculum mapping and the development of the scope and sequence chart

To ensure the curriculum resources would support each of the educational jurisdictions to implement their curriculum frameworks, a curriculum mapping exercise was conducted to identify common content and contexts for learning. From this mapping, a scope and sequence chart was developed that could guide the development of curriculum units. The scope and sequence chart was constructed around the four common conceptual outcome strands: Earth and Beyond, Energy and Change, Life and Living, and Natural and Processed Materials.

Mapping also included essential learnings from several jurisdictions' frameworks, and technology from the New South Wales science and technology syllabus. The scope and sequence chart is included as Appendix 2. The chart also mapped units against four broad stages of learning and a unifying theme was developed for each stage of learning. Stages were linked to years of schooling and to levels in the national scientific progress map. The relationships between stages, years of schooling and progress map levels are illustrated in Figure 3.2.

Figure 3.2: Relationships between stages, years of schooling and scientific literacy progress map levels

Stage	Years	Levels
Early Stage 1	1	1
1	2-3	1-2
2	4-5	2-3
3	6-7	3-4

National scientific literacy progress map

To ensure that outcomes for each of the units were appropriate for the stage and readiness of the students, outcomes were carefully linked to the national scientific literacy progress map that was developed for the national assessments of Year 6 students' scientific literacy in 2003 and was used as the conceptual framework for the Science Education Assessment Resources project. The progress map is included as Appendix 3.

Literacy focuses progress map

The key literacy practices and products that were addressed in each unit were designated the literacy focuses. Literacy focuses were continually reviewed as the units were written to ensure that literacy practices and products were included across units in an appropriate developmental sequence. A literacy focuses progress map was developed to guide revision of the trial units. The draft literacy focuses progress map is presented in Appendix 4.

Unit planner and template

Early in the unit writing process, one writer worked on developing a sample unit in consultation with the project manager and project directors. Following several rounds of writing, review and revision a sample unit was developed. From this sample unit, an electronic template was constructed which could be used as a guide by other writers.

Later in the project, when teachers were working on writing their own units during professional learning workshops, it became evident that teachers tended to focus on the details of lessons using the template rather than initially planning a unit overview to guide the broad structure and focus of the unit. To overcome this problem, a one-page unit planner was developed which proved very effective. The planner and template were used by *Primary Connections* writers in the writing of the second suite of four units.

The writing process

Potential writers recommended by members of the reference group were approached by the project manger to see if they would be available to work on writing units for the project. Those who were sympathetic to the philosophy of the project and had a good understanding of the pedagogical principles underpinning the project were contracted by the Australian Academy of Science to write units.

Writers were given an initial briefing and a copy of the template and commenced writing first drafts of the units. A meeting between writers, the project manager, project officer and project directors was used to provide a forum at which drafts could be reviewed and feedback provided. Once a revised draft had been submitted, the unit was then reworked by the project officer in close consultation with the project manager and project directors. After a final review by project directors, the unit was edited by the Academy's publications manager, and designed ready for printing.

Units developed in Stage 2

The first suite of four units was prepared for implementation in term 1 of 2005. One unit was written at each stage and in each of the four conceptual contexts. The second suite of four units was written for implementation in term 3 of 2005 and, again, one unit was written at each stage and in each of the four conceptual contexts. Teachers developed their own units for implementation in term 2, using the unit planner and template. In addition to the eight units listed in Figure 3.3 that were trialled in 56 schools, an Indigenous focus unit was developed in collaboration with a writer familiar with Indigenous perspectives and this unit was trialled in two schools. An additional three units are planned for development late in 2005 so that they are ready for trialling in term 2 of 2006.

Figure 3.3: Stage 2 curriculum units

	Conceptual context			
Stage	**Earth and Beyond**	**Energy and Change**	**Life and Living**	**Natural and Processed Materials**
Early Stage 1	*Weather in My World*	*On the Move*		
1		*Push-pull Power*		*Material Matters*
2	*Spinning in Space*		*Plants in Action*	
3			*Marvellous Micro-organisms*	*Build it Better*

Indigenous focus unit

A unit designed to make connections to Australian Indigenous contexts, *Ochre and Crystals*, was developed and trialled in two schools in term 2 of 2005. The results of this limited trial indicate that refinement and further trialling of this unit are required. This trial and further consultation will inform the future stages of the *Primary Connections* project in the best approaches to make connections with Indigenous culture and knowledge of the world, and engage Indigenous students in science through *Primary Connections* and improve their learning outcomes in science and literacy.

By making connections with Indigenous contexts in curriculum resources the *Primary Connections* program will:

- engage and inform both teachers and students about Indigenous culture and contexts for learning science and the literacies of science;
- improve Indigenous student performance on major science tests such as the national Year 6 scientific literacy assessments through increased engagement with science learning.

Part of the professional learning program will include exploring aspects of teaching science and literacy in Indigenous contexts such as developing awareness of the diversity of Indigenous perspectives, and encouraging and guiding teachers to draw on their local Indigenous families and communities to enhance learning opportunities.

Other curriculum resources

In addition to the unit overview and lesson outlines in the curriculum units, a range of other resources were provided to support teachers in implementing their science programs.

Resource sheets

Resource sheets were provided to scaffold students' work (eg, investigations, recording of observations).

'How tos'

Short guides called 'How tos' were developed. These could be used by teachers or by students, for example 'How to write a science journal'; 'How to use a KWLH chart'; 'How to draw a graph'.

Assessment resources

Assessment resources were provided in digital form on the *Primary Connections* website. These resources included checklists and tags to record levels of achievement that could be attached to work samples generated in the *Evaluate* lessons. The resources were provided in digital form so that teachers could tailor them to their local jurisdictional outcomes and school reporting schemas.

Science background CD-ROM

A CD-ROM resource initially developed by the Victorian Department of Education and Training was made available for use in the project. This CD-ROM provided science background information suitable for primary teachers in searchable form. The resource contained small learning objects that, for example, simulated processes such as pollination.

Website

The *Primary Connections* website (www.science.org.au/primaryconnections) was developed to communicate information about the *Primary Connections* initiative. It contains a number of pages, including information about the project (eg, background information, 5Es constructivist model, and the curriculum resource) and the 2005 trial (including the 2005 professional learning program and the research and evaluation component). There is a section that allows people to register their interest in the program so that they can receive further information.

The website includes a password protected section for teachers involved in the trial. This password-protected section includes a moderated discussion board forum to maintain the collegiality and learning community that had been developed during the January 2005 professional learning program. Trialling teachers could post information about approaches they had taken to implementing activities, new ideas and experiences with their classes.

Professional learning resources

The *Primary Connections* professional learning program was based on a model comprising a number of complementary elements: professional learning workshops, exemplary curriculum resources, opportunity to practise science teaching supported with resources, and reflections on practice. It is linked to a set of principles of learning and teaching.

Professional learning workshops

The professional learning workshops introduced, explained and modelled the teaching and learning model, how to develop literacies needed for learning science, using ICTs and learning objects, pedagogical principles, investigation and assessment strategies, using the planner and template for writing new units, and how to facilitate the professional learning of colleagues. Professional learning was staged, with an initial five-day workshop in January and follow-up one-day workshops at the middle and end of term 1 and at the end of term 2.

Curriculum resources

Exemplary curriculum resources were provided to show how the various teaching and learning strategies could be brought together in a coherent program of learning. The resources provided concrete exemplification of the 5Es model, assessment and other strategies.

Reflection on practice

Opportunities were provided at the end of each day in the five-day professional learning workshop for reflection and journaling. Deep reflection was facilitated by basing the reflection process on the 5Rs model (Bain, Ballantyne, Mills and Lester, 2002). Reflections were also a key feature of the follow-up one-day professional learning workshops.

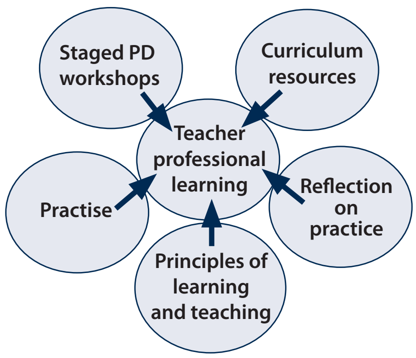
Practise

Teachers practised the new approaches to teaching science and literacy supported with curriculum units. The extended engagement with science teaching using the *Primary Connections* model and resources enabled teachers to integrate the new approaches into their practice.

Principles of teaching and learning

A set of principles of teaching and learning were embedded in the professional learning program and provided a focus for reflection on practice.

Figure 3.4: The *Primary Connections* professional learning model



In Stage 2, which involved 106 trial teachers, the professional learning program comprised a five-day workshop conducted in January of 2005 and three one-day workshops conducted in mid-term 1, end of term 1 and end of term 2.

The extended January professional learning workshop (summer school) was designed to prepare a group of curriculum leaders who could:

- support the development of science in their schools;
- have sufficient understanding of the program to effectively trial the curriculum resources; and
- provide informed advice on improvements that could be made to the resources, so they could be revised prior to national dissemination.

Professional learning program team

A professional learning program team was assembled to plan and deliver the summer school program. The team comprised the project directors Professor Mark Hackling (Edith Cowan University) and Associate Professor Vaughan Prain (La Trobe University), and Professor Denis Goodrum (University of Canberra), Professor Russell Tytler (Deakin University) and Ms Lea Chapuis (ACT Department of Education and Training).

This team was assembled to bring together some of the best expertise available in Australia relating to investigation work in science, assessment, developing literacies of science, questioning technique, cooperative learning strategies, principles of learning and teaching, auditing practice and use of learning objects. The summer school professional learning program was planned collaboratively at meetings of the professional learning program team, the project manager and the project officer, and in consultation with the reference group.

Development of professional learning resources for Stage 3

Professional learning resources are being prepared to support the roll-out of *Primary Connections* in 2006, which will represent Stage 3 of the project.

Resources are being prepared to support trained professional learning facilitators to deliver professional learning workshops in the schools which implement *Primary Connections* in 2006. Resources will be provided in digital form and will comprise workshop program outlines, workshop handouts, PowerPoint presentations and video clips to illustrate various teaching strategies.

Chapter 4 | Implementation of the program

Overview

Stage 2 of the *Primary Connections* project involved recruiting 56 schools and 106 trial teachers from all states and territories who participated in a five-day professional learning workshop in Canberra during January 2005. In term 1 of 2005 these teachers taught a *Primary Connections* unit. Further support was provided at one-day workshops in the middle and at the end of term 1. The teachers developed their own science units using the *Primary Connections* planner and template and these were implemented in term 2. An end of term 2 one-day workshop prepared teachers for implementing in term 3 a second *Primary Connections* unit developed by the Australian Academy of Science.

Recruitment and participation of trial schools

The recruitment of trial schools was coordinated through the government, Catholic and independent school sector representatives on the reference group. A stratified sampling frame was developed to ensure a balanced representation from the states and territories, government, Catholic and independent schools, metropolitan, regional and rural locations and to ensure that some schools with high enrolments of Indigenous students were included in the sample. Details of the sample are reported in Chapter 6.

Each school was asked to commit to making science a priority in their school, to move towards a whole-school implementation of *Primary Connections* in 2006, and to nominate two teachers who would attend the professional development workshops and teach *Primary Connections* in their classes during 2005. Schools were provided with a resource allowance to provide additional resources needed to support the *Primary Connections* program in their school.

Professional learning workshop, January 2005

A five-day professional learning workshop (summer school) was conducted in Canberra during January 2005.

The program was framed around the 5Es model. The first day focused on engaging participants and eliciting prior beliefs and understandings. The second day focused on exploring the curriculum units and the third day helped teachers explain and conceptualise some important principles and practices. The fourth day enabled teachers to elaborate their understandings by analysing the *Primary Connections* teaching and learning model and commence writing their own science unit, and the final day involved, in part, evaluating their experiences at the summer school.

The final session of each day involved teachers working in collegial stage-based groups reflecting on the day's experiences, engaging in journal writing and sharing reflections with colleagues. To facilitate deep reflections on practice, the reflections and journalling were scaffolded for teachers using the 5Rs model (Reporting, Responding, Relating, Reasoning and Reconstructing), developed by Bain, Ballantyne, Mills and Lester (2002). An overview of the January 2005 professional learning workshop program is presented in Figure 4.1 and the full details are attached as Appendix 5.

Figure 4.1: An overview of the summer school program

Monday Jan 17	Tuesday Jan 18	Wednesday Jan 19	Thursday Jan 20	Friday Jan 21
Engage	**Explore**	**Explain**	**Elaborate**	**Elaborate and Evaluate**
Letters of consent, initial data collection.	Exploring the curriculum units in stage-based groups.	Using technologies effectively. Effective pedagogies surrounding the learning objects.	Improving assessment practice.	Component mapping.
Morning tea	**Morning tea**	**Morning tea**	**Morning tea**	**Morning tea**
Welcome. What is good science teaching like? Introduction to pedagogical principles.	Trying out the activities, making observations, discussing findings and developing explanations.	The 5Es model, cooperative learning strategies, effective questioning techniques.	Unit planner and template, overall design of units.	Working with others, managing change through audit and action planning processes.
Lunch	**Lunch**	**Lunch**	**Lunch**	**Lunch**
Exploring literacy practices.	Overview of concepts and conceptual development in the units.	Open investigations and inquiry.	Reflection, journalling and discussion in stage-based groups.	Reflections. Evaluation of workshop. Celebration, closure and drinks.
Afternoon tea	**Afternoon tea**	**Afternoon tea**	**Afternoon tea**	**Afternoon tea**
Reflection, journalling and discussion in stage-based groups.	Reporting back to whole group. How pedagogical principles are demonstrated in the units. Reflection, journalling and discussion in stage-based groups.	Reflection, journalling and discussion in stage-based groups.		

One-day professional learning workshops

Follow-up one-day professional learning workshops were held in state/territory-based groups in Perth (WA teachers), Adelaide (SA and NT teachers), Melbourne (Vic and Tas teachers), Sydney (NSW and ACT teachers) and Brisbane (Qld teachers).

The one-day workshops were designed to allow opportunities for teachers to review progress, reflect on practice, identify and resolve emerging concerns, and to provide further professional learning in a staged manner. All workshops commenced with teachers completing questionnaires so that data could be gathered to asses the impact of the program on teachers, students and schools.

An overview of the one-day workshops is presented in Figure 4.2.

Figure 4.2: An overview of the one-day professional learning workshops

Workshop	Mid-term 1	End-term 1	End-term 2
Session 1	Questionnaire Review progress and resolve concerns	Questionnaire Review progress and resolve concerns	Questionnaire Review progress and resolve concerns
Session 2	Review 5Es and inquiry teaching Discussion board	Assessment, recording and reporting achievement	Explore term 3 units
Session 3	Planning units for term 2	Planning units for term 2	Try out activities from term 3 units

Whole-school case study schools

Of the 56 schools involved in the Stage 2 trial, four elected to pilot a whole-school implementation to provide insights into the implementation of *Primary Connections* using the professional learning model planned for Stage 3. Two of these were small schools based in regional areas of Victoria and two were large metropolitan schools in Western Australia. These schools were sites for case studies.

All four schools participated in a whole-school, one-day professional learning workshop held on a pupil-free day at the beginning of term 1 and then all classroom teachers taught from supplied *Primary Connections* units in terms 1 and 3, and from teacher-developed units in term 2. Follow-up professional learning support was provided by that State's science education policy officer and by one of the project directors.

An overview of the one-day professional learning workshops provided for the case study schools is presented in Figure 4.3.

Figure 4.3: One-day professional learning workshops conducted at the case study schools

Session	Activity
Session 1	Elicitation of beliefs and concerns about teaching science Background to the *Primary Connections* project
Session 2	Explore *Primary Connections* units in stage-based groups Develop a poster to represent the pedagogical emphases of the 5E phases
Session 3	Analysis of literacy focuses of the units and how they are developed Analysis of the science learning outcomes and how they are developed through the phases Development of a school action plan to support implementation of *Primary Connections*

Chapter 5 | The evaluation model

Introduction

The purpose of the *Primary Connections* program is to improve students' learning outcomes in science and literacy. This is achieved through an innovative professional learning program, supported with rich curriculum resources, that is used to enhance teachers' science pedagogical content knowledge and thereby improve their confidence, competence and self-efficacy for science teaching.

Figure 5.1: Components of primary science pedagogical content knowledge

Knowledge of curriculum, outcomes and standards	Primary science pedagogical content knowledge
Knowledge of science concepts, processes and the nature of science	
Knowledge of literacy practices and forms of representation relating to science	
Knowledge of science teaching and assessment pedagogies	
Knowledge of students and their learning	

The research program provided formative data that is being used to revise and improve the curriculum and professional learning component of the program following the Stage 2 trial in 56 schools, and summative data to indicate the impact of the Stage 2 program on students, teachers, schools and jurisdictions. Case studies in four selected schools that piloted a whole-school roll-out provided information that will guide the development of the whole-school model planned for Stage 3 of the project.

The evaluation is framed around the following research questions:

1. How workable and effective is the teaching and learning model which has been used in developing the curriculum units and template?
2. How can the curriculum and professional learning resources be revised and improved before implementation in Stage 3?
3. What impact has the program had on students, teachers, schools and jurisdictions?
4. What insights into effective teacher professional learning are gained from the trial whole-school roll-out of the professional learning model in the case study schools?
5. What changes are needed to enhance compatibility with jurisdictions' curriculum frameworks or professional learning support structures?

Method

A mix of quantitative and qualitative approaches were used to gather data from key participants and stakeholders. Triangulation of data and perspectives increase the credibility and trustworthiness of findings. Data were gathered from all teachers using a sequence of five questionnaires (see Appendix 6). Case studies involving classroom observations, interviews and focus groups were conducted in selected case study schools implementing a whole-school roll-out of the program. Questionnaire data were also gathered from all students at one large case study school, and a sample of students' science journals and work samples from the same large case study school were analysed to assess the gains made in achievement over one term.

Table 5.1: Schedule of data collections

Data gathering instrument/ method	Focus of data gathering	Research question
Teacher questionnaires		
Initial questionnaire	Demographic data. Beliefs about science teaching. Self-efficacy for science teaching. Amount and type of science taught, strategies used. Areas in which professional growth sought. Audit of organisation and delivery of science at their schools.	1 and 3
Summer school evaluation form	Self-efficacy for teaching science and literacy practices. Feedback on summer school program and initial reaction to the curriculum resources and the teaching and learning model.	1, 2 and 3
Mid-term 1 questionnaire	Feedback on teaching and learning model and the curriculum resource and any modifications made to improve implementation. Adequacy of summer school PD as a preparation for teaching the unit. Changes to practice. Reaction of students. Emerging concerns.	1, 2, 3 and 4
End-term 1 questionnaire	Self-efficacy for teaching science and literacy practices. Beliefs about ideal practice. Audit of actual practice and science teaching time. Concerns about science teaching. Feedback on mid-term 1 PD. Feedback on the teaching and learning model and the curriculum resource, modifications made during implementation, improvements that are required before further implementation, and concerns about compatibility with jurisdictions' curriculum framework. Extent to which the unit has engaged students and amount of learning that has occurred.	1, 2, 3, 4 and 5
End-term 2 questionnaire	As for end term 1 questionnaire plus feedback on the unit template.	1, 2, 3, 4 and 5
Annotation of curriculum units	All teachers will be provided with two copies of each curriculum unit they teach. Teachers will be asked to annotate the second copy with suggestions about how the unit can be improved.	1 and 2
Survey of trial school principals	Impact on the status of science at their school and on the professional learning of teachers.	3 and 4
Case studies	Two Western Australian and two Victorian schools provided potential sites for case studies of whole-school roll-out	
Classroom observations	Implementation of resources, strategies used.	1 and 3
Student questionnaire	Changes in experience of science, amount, enjoyment, learning.	3
Teacher focus group discussions	Impact on practice, professional learning and children's enjoyment of and learning from science. Feedback on the instructional approach, curriculum resources and on the professional learning model, integration across learning areas.	1, 2, 3 and 4
Student focus group discussions	Experience and enjoyment of science and learning from science.	3
Analysis of student work samples from Engage and Evaluate lessons	Level of achievement in relation to scientific literacy progress map and national literacy standards.	3

Data analysis

Questionnaire data

The questionnaires comprised closed objective items, Likert scale items and open response questions. For each of the questionnaires a detailed coding manual was developed to guide the coding of participants' responses. All questionnaires in a set were first read to identify the range of responses given to the open-ended questions. The lists of response types for each question were then aggregated into broader and meaningful response categories. The complete set of response categories for objective, rating scale and open-ended questions were then included in the coding manual which specified the codes and relationship to variable names in an SPSS spreadsheet.

All of the coding was performed by a trained and experienced research assistant. Codes were entered into an SPSS spreadsheet and then analysed for descriptive statistics such as frequencies, percentages, means and standard deviations. In some cases, mean scores were compared for some variables using Wilcoxon signed ranks or t-tests as appropriate.

Other data

Case studies were compiled from analysis of documents, classroom observations, focus group discussions with teachers and student focus group discussions. Data were reviewed to identify emerging themes that were used to structure the case studies and develop assertions.

Chapter 6 | Analysis of quantitative data

Research data gathered during the study is reported in Chapters 6 and 7. This chapter reports and analyses quantitative data and the following chapter reports case study data. This chapter considers demographic data for the trial teachers and schools; teachers' feedback on the summer school and professional learning workshops; teachers' rating of the curriculum resources; changes to teachers' self-efficacy, confidence and teaching practice; integration of science and literacy; changes to science teaching time, status and resources; students' response to *Primary Connections* and achievement; and, impact on schools.

Demographic data for trial teachers and schools

106 teachers participated in the trial. Teachers were recruited in pairs from 56 primary schools across all states and territories. The number of teachers participating from each state and territory are summarised in Table 6.1; numbers ranged from two from the Northern Territory to 22 from New South Wales.

Table 6.1: Origin of trial teachers by jurisdiction (n=106)

State	Number	Per cent
ACT	5	5
NSW	22	21
NT	2	2
Qld	18	17
SA	16	15
Tas	4	4
Vic	18	17
WA	21	20

Of the 56 schools, 45 were government schools, seven were Catholic schools and four were independent schools. Two of the schools had high enrolments of Indigenous students. Schools were drawn from metropolitan, regional and rural geographic locations; the number of schools from these locations is summarised in Table 6.2.

Table 6.2: Regional location of trial teachers (n=106)

Location of teachers	Number	Per cent
Metropolitan	61	57
Regional	24	24
Rural	21	20

Key finding 1. The sample of teachers and schools participating in the trial were broadly representative of all jurisdictions, sectors and regional locations, and included a sample of schools with high Indigenous enrolments.

When recruiting participants for the trial, schools were asked to nominate a pair of teachers, one of whom was an experienced teacher of science and the other an inexperienced teacher of science. This strategy was adopted to ensure a range of teaching and science teaching experience amongst the sample. The experience of teachers in the sample is summarised in Table 6.3, which reveals that experience ranged from those commencing their teaching career to those who had taught for more than 35 years.

Table 6.3: Teaching experience of trial teachers (n=106)

Years of teaching experience	Number	Per cent
New to teaching	2	2
5 or less	25	24
6 to 10	9	8
11 to 15	10	9
16 to 20	16	15
21 to 25	16	15
26 to 30	19	18
31 to 35	4	4
More than 35	3	3
No response	2	2

Key finding 2. Approximately one-third of the teachers had taught for less than 10 years, about one-quarter for 10-20 years and a further third for 20-30 years.

Qualifications and prior professional learning

23 per cent of the trial teachers were three-year trained (eg, Diploma of Teaching), 71 per cent were four-year trained (ie, Bachelor of Education or undergraduate degree such as BA and a Diploma of Education) and 6 per cent were four-year trained and had completed or were studying a Master degree.

The teachers were asked about their highest level of science discipline studies. 13 per cent had only completed science up to Year 10, another 34 per cent had science up to Year 12, 37 per cent had completed at least one undergraduate science unit, and 6 per cent indicated they had completed at least one postgraduate science unit.

Most teachers were not currently enrolled in any formal university studies (88 per cent), 3 per cent were enrolled in a graduate certificate and 5 per cent were enrolled in a Master degree. 45 per cent of teachers had not attended any science professional learning activities in 2004. 26 per cent had attended up to 10 hours of science professional learning in 2004 and 22 per cent had attended more than 10 hours of science professional learning.

The teachers were also asked what aspects of their science teaching they were seeking to improve. The most frequent responses were pedagogy, knowledge of science, new ideas, programming, resources, assessment, and all aspects.

Key finding 3. The majority of trial teachers were four-year trained and not currently enrolled in further university studies, about half had no science discipline studies beyond Year 12 and almost half had not attended any science professional learning workshops in 2004. Most teachers wished to improve their science teaching pedagogy and their knowledge of science.

Feedback on the summer school and professional learning workshops

Of the 106 teachers who attended the summer school, 104 completed the summer school evaluation form. This questionnaire collected data regarding teachers' rating of the extent to which the goals for the summer school had been achieved, how well they felt prepared for teaching the first unit in term 1, and their confidence regarding aspects of teaching science.

Summer school

The teachers were asked to rate the extent to which the goals of the summer school had been achieved for them, using a five-point scale ranging from *to a little extent* up to *a large extent*. The teachers' ratings are summarised in Table 6.4.

Table 6.4: Teachers' ratings of the extent to which 'the goals of summer school have been achieved for you' (n=104)

	Per cent of teachers				
	To a limited extent		OK		To a large extent
Goals	1	2	3	4	5
1. To develop understanding of the philosophy and approach of *Primary Connections*.	0.0	1.0	10.6	44.2	44.2
2. To develop understanding of the characteristics of effective primary science teaching.	1.0	1.9	8.7	48.1	40.4
3. To develop understanding of how to use the *Primary Connections* curriculum resources to support effective primary science teaching.	0.0	1.9	11.5	49.0	37.5
4. To further develop knowledge of science concepts and processes.	1.0	2.9	27.9	52.9	15.4
5. To develop knowledge and skills of supporting colleagues' professional learning.	1.0	11.5	36.5	39.4	11.5
6. To develop skills of using the template to plan science units.	1.9	7.7	27.9	44.2	18.3

A large majority (>86 per cent) gave a positive rating (ie, 4 or 5 on the five-point scale) for achievement of goals 1-3 relating to understanding the philosophy and approach of *Primary Connections*, understanding the characteristics of effective science teaching, and understanding how *Primary Connections* supports effective science teaching. More than two-thirds of teachers gave a positive rating for goal 4 regarding developing knowledge of science concepts and processes.

A majority of teachers gave positive ratings to goals 5 and 6 regarding supporting colleagues' professional learning and using the template for developing new units; however, approximately 10 per cent of teachers gave negative ratings for achievement of these goals. These two goals present a higher level of challenge for teachers and this may explain the less positive ratings for them. Further opportunities for developing skills of planning units of work using the template were provided in the mid and end of term 1 professional learning workshops.

Teachers were also asked: 'How well prepared do you feel for teaching the first *Primary Connections* unit in term 1?' The teachers responded on a five-point scale ranging from *Very poorly prepared* up to *Very well prepared*. The teachers' ratings are summarised in Table 6.5.

Table 6.5: Teachers' responses to the question: 'How well prepared do you feel for teaching the first *Primary Connections* unit in term 1?' (n=104)

Per cent of teachers				
Very poorly prepared	Poorly prepared	OK	Well prepared	Very well prepared
0	0	20	57	23

None of the teachers gave a negative response to this question and 80 per cent indicated that they were either well prepared or very well prepared for teaching the first unit.

Teachers were also asked to rate their confidence with certain science teaching strategies following the summer school. These strategies were considered to be important for successful implementation of a quality science program. Teachers rated their confidence on a five-point scale from No confidence to Very confident. These data are summarised in Table 6.6.

Table 6.6: Teachers' ratings of their confidence with science teaching strategies at the end of the summer school (n=104)

Teaching strategy	Per cent of teachers				
	NC*	LC	OK	C	VC
1. Engaging students' interest in science.	0.0	0.0	4.8	64.4	30.8
2. Managing hands-on group activities in science.	0.0	0.0	11.5	61.5	26.9
3. Managing discussions and interpretation of science observations.	0.0	0.0	30.8	60.6	8.7
4. Explaining science concepts.	0.0	4.8	39.4	44.2	11.5
5. Teaching science processes.	0.0	3.8	33.7	49.0	13.5
6. Developing literacy skills needed for learning science.	0.0	1.0	15.5	58.3	25.2
7. Assessing children's learning in science.	0.0	4.9	35.0	52.4	7.8
8. Using computers and ICTs in science.	0.0	14.4	29.8	34.6	21.2
9. Using a constructivist model to plan science units of work.	0.0	1.9	29.8	50.0	18.3

*NC = No confidence; LC= Limited confidence; C = Confident; VC = Very confident.

Teachers expressed greatest confidence (ie, >80 per cent confident + very confident) with engaging students' interest in science, managing activities and developing literacy skills for learning science. More than two-thirds of teachers were confident or very confident with managing discussions and interpretations of observations, and using the constructivist 5Es model to plan units of work. More modest levels of confidence (ie, >60 per cent to <65 per cent confident + very confident) were expressed about teaching science processes and assessing children's learning in science. The lowest levels of confidence were for explaining science concepts (55 per cent) and using computers and ICTs in science (55 per cent). Indeed, 14 per cent of teachers expressed low confidence in using computers and ICTs.

Key finding 4. The teachers believed the summer school was very successful in achieving its goals and preparing the teachers to teach the first unit in term 1. A substantial majority of teachers expressed confidence with important science teaching strategies, however, the data suggest that further support may be needed with some strategies.

Professional learning workshops conducted in terms 1 and 2

At each successive workshop, teachers were asked to rate how helpful the previous workshop had been in supporting them in teaching *Primary Connections*. Table 6.7 presents teachers' ratings that were made on a five-point scale.

Table 6.7: Teachers' responses to the question: 'How helpful was the professional learning workshop in supporting your teaching of *Primary Connections*?'

	Per cent of teachers who answered the question		
Rating of how helpful	Summer school workshop (n=100)	Mid-term 1 workshop (n=100)	End term 1 workshop (n=97)
Very helpful	33.0	41.0	33.0
Helpful	53.0	42.0	39.2
OK	11.0	14.0	15.5
Little help	2.0	1.0	5.2
Very little help	0	0	2.1
Didn't attend	0	2.0	5.2

A large majority of teachers rated the workshops as very helpful or helpful with slightly less positive ratings for the end of term 1 workshop, which might be related to the teachers' growing confidence and skills. More confident teachers may not have valued as highly the opportunities to gain collegial support for resolving concerns and for further professional learning as earlier in the program when they were less confident. A key measure of teachers' perceptions of usefulness was the high rate of attendance at the workshops . The small number of teachers who failed to attend later workshops had quite genuine reasons for their absence.

Key finding 5. **The one-day professional learning workshops had a very high rate of attendance by teachers and a large majority of teachers rated them as helpful or very helpful.**

Overall rating of the professional learning program

The teachers were asked to give an overall rating of the professional learning program and to rate the usefulness of a range of aspects of the program. Teachers' rating of the program are summarised in Table 6.8.

Table 6.8: Teachers' responses to the question, 'How highly do you rate your involvement in the *Primary Connections* program as a professional learning experience?' (n=100)

Rating	Per cent of teachers
Better than any other professional learning program I have experienced	43
As good as the best professional learning programs I have experienced	45
OK	11
I have experienced better professional learning programs	1
It is one of the least useful professional learning programs I have experienced	0

The ratings were very positive with 88 per cent indicating that the program was better or as good as the best professional learning programs they had experienced.

Table 6.9: Teachers' responses to the question 'Which aspects of the program have been useful?' (n=101)

Aspect of the program	Frequency of responses (n=101)			
	Very useful	Useful	Not useful	No response
Summer school in January	80	20	1	0
The supplied curriculum units	80	19	2	0
Resource sheets	59	36	3	3
The template and writing my own unit	42	44	10	5
Science Background CD	35	56	7	3
Assessment resources	33	48	10	5
Website	19	69	9	4

Teachers' ratings for all aspects of the program, including the resources, were very positive with a large majority indicating the aspects were useful or very useful. The strongest endorsements were for the summer school and the supplied curriculum units.

Key finding 6. Almost 90 per cent of the teachers rated the professional learning program as good as or better than any they had previously participated in, and gave very strong endorsement for the summer school and curriculum resources.

Teachers' rating of the *Primary Connections* curriculum resources

Teachers provided feedback on the *Primary Connections* units taught in term 1 at the end of the term 1 questionnaire.

Table 6.10: Teachers' responses to the question 'How effective are the *Primary Connections* curriculum units in supporting teaching and learning?' (n=100)

Teachers' rating of the effectiveness of the units (per cent of teachers)				
Very ineffective	Ineffective	OK	Effective	Very effective
0	0	11	36	53

Almost 90 per cent of teachers considered the units to be effective or very effective in supporting teaching and learning.

The teachers were also asked why the units were effective. The wide range of responses were coded into categories and the frequencies of responses in these categories are summarised in Table 6.11. The most frequent responses related to the scaffolding of teaching and learning by the resources, the support given to teachers of all levels of experience and the flexibility of the resources.

Table 6.11: Teachers' reasons for 'Why the *Primary Connections* curriculum units are effective in supporting teaching and learning.' (n=89)

Reason	Number of responses	Per cent of teachers with this response
Everything	1	1.1
Good scaffold for teaching and learning	41	46.1
Supports all levels of teacher experience	26	29.2
Resources, teachers' guide	20	22.5
Allows for teacher input and flexibility	12	13.5
Students are engaged and progressing	8	9.0
Sequencing is good	5	5.6
Other	26	29.2
Total number of responses	139	n=89

When asked which curriculum resources they preferred to teach science from (given the options of an Academy-prepared *Primary Connections* unit, their own *Primary Connections* unit, or other units/resources they had used previously), 89 per cent of teachers ranked *Primary Connections* units prepared by the Academy of Science first or second, 27 per cent ranked the *Primary Connections* units they had developed themselves first. Very few teachers preferred to use other science curriculum resources. 95 per cent of teachers wanted the Academy to prepare further *Primary Connections* units.

More specific information was elicited from teachers about assessment resources and electronic resources. More than 72 per cent of teachers considered the assessment tasks easy to use and 70 per cent indicated that the tasks provided useful information for assessment purposes.

When asked about their use of resources provided on CD-ROM and the 'How Tos', about half of the teachers had used these supplementary resources.

Key finding 7. Almost 90 per cent of the teachers rated the curriculum resources as effective or very effective in supporting learning. The main reasons given for their effectiveness were effective scaffolding of teaching and learning, they gave support to teachers at all levels of experience and were flexible. 95 per cent of teachers wanted the Academy of Science to prepare further curriculum units.

Compatibility with state and territory curriculum frameworks

The curriculum resources were based on a scope and sequence chart that was developed through a mapping of state and territory curriculum frameworks. The project reference group had signed-off on the scope and sequence chart and it was therefore anticipated that teachers would be able to make connections between the units and their state and territory frameworks.

Only 5 per cent of teachers indicated that they had difficulty with matching units to their state/territory curriculums and 5 per cent indicated that the unit they were teaching that term did not fit their schools' existing scope and sequence charts. Almost 90 per cent of teachers found the units compatible with their jurisdictions' curriculum frameworks.

Changes to curriculum units and preferred formats for resources

The end of term 1 questionnaire asked teachers about changes they would like made to the units. The most common response was to reduce the size of the units and to make lessons shorter, and to indicate which lessons were core and optional. These changes were included in the second suite of units supplied to teachers for term 3.

In addition to this questionnaire data, teachers provided detailed comments on each unit they taught. Teachers were provided with an extra copy of their unit so they could annotate this extra copy with their experiences of teaching the unit and suggestions for improving the unit. Extensive feedback was provided, analysed and summarised. A sample summary of this teacher feedback is included as Appendix 7.

Table 6.12: Teachers' responses to the question 'List any changes that you think would make the *Primary Connections* curriculum units more effective.' (n=95)

Change suggested	Number of responses	Per cent of teachers with this response
Shorter, break up lessons	29	30.5
Less content, smaller unit for term 1	15	15.8
Unit specific	13	13.7
More hands-on, less talk	10	10.5
Indicate core lessons that cannot be omitted	8	8.4
Change teachers' guide to be more concise	5	5.3
None identified yet	14	14.7
Other	28	29.5
Total responses	122	n=95

Key finding 8. Almost 90 per cent of teachers indicated that they had no difficulty with the compatibility of units with their jurisdictions' curriculum frameworks. The most common suggestion for improving units was that they should be shorter.

When asked about the format/medium in which they would prefer to be supplied with various resources, most teachers indicated a preference for hard copy over all other formats, except for the Science Background CD-ROM which needs to be searchable and interactive to be effective. Some resources were designed to be supplied in digital form so that teachers can modify them to suit local contexts and needs (eg, worksheets, assessment resources); in these cases teachers indicated a preference for CD-ROM over online delivery, which may indicate that access to the internet is still inconvenient or problematic in primary schools.

Table 6.13: Teachers' responses to the question, 'In what format would you prefer to be supplied with *Primary Connections* resources?' (n=101)

	Number of responses						
Resource	Hard copy	CD-ROM	Online	All formats	Hard copy and CD	CD and online	Hard copy and online
Curriculum units	41	6	2	9	25	9	9
Background information about the structure and philosophy of the program	26	30	16	1	16	5	6
Resource worksheets	28	16	7	3	25	13	9
Assessment resources	25	20	7	7	21	12	9
Science Background CD-ROM	14	49	6	2	12	14	4

Key finding 9. Teachers would prefer the curriculum resources to be supplied as hard copy and on CD-ROM. Few teachers requested online delivery, which may indicate internet access is inconvenient or problematic.

The professional learning program and the curriculum resources were designed to enhance teachers' confidence and competence for science teaching through supporting further growth in their pedagogical content knowledge. The next section considers the impact of the program on teachers' confidence and self-efficacy.

Changes to teachers' confidence and self-efficacy

It has long been recognised that many primary teachers lack confidence and competence for teaching science (Appleton, 1995; Palmer, 2001; Yates and Goodrum, 1990) and self-efficacy scales have been developed to provide a measure of the extent to which primary teachers feel capable of teaching science effectively (Riggs and Knochs, 1990). This section summarises changes to trial teachers' confidence with using important science and literacy teaching strategies, and their ratings of self-efficacy. A 10-item self-efficacy scale was assembled using items selected from Riggs and Knochs (1990) *Science Teaching Efficacy Belief Instrument* and this scale was included in all teacher questionnaires.

Confidence with science and literacy teaching strategies

Teachers rated their confidence with nine science and literacy teaching strategies that are considered essential for effective science teaching, on a five-point scale. Table 6.14 summarises these data for the 89 teachers who completed all of the surveys. On the initial survey: the teachers had greatest confidence with *Engaging students' interest in science*, *Managing hands-on group activities*, and *Developing literacy skills needed for learning science*; and, least confidence with *Assessing children's learning in science*, *Using a constructivist model to plan science units of work*, and *Using computers and ICTs in science*. After the summer school confidence had increased for all nine strategies, however, by mid-term 1 after teaching science for a few weeks confidence had fallen back a little for five of the strategies. Confidence scores then increased from mid-term 1 for all strategies on the following surveys with further experience and support from professional learning workshops.

Table 6.14: Mean teacher ratings of confidence with science teaching strategies for each survey (n=89)

Aspect of teaching	Mean rating of confidence (/5)*				
	Initial survey (=2004)	End of summer school	Mid-term 1, 2005	End term 1	End term 2
Engaging students' interest in science	3.89	4.29	4.10	4.38	4.45
Managing hands-on group activities in science	3.82	4.19	4.22	4.24	4.37
Developing literacy skills needed for learning science	3.57	4.07	3.89	3.99	4.27
Managing discussions and interpretation of science observations	3.46	3.79	3.88	3.94	4.13
Teaching science processes	3.28	3.73	3.73	3.84	4.02
Explaining science concepts	3.26	3.63	3.67	3.75	3.90
Using a constructivist model to plan science units of work	2.89	3.88	3.56	3.80	3.88
Assessing children's learning in science	3.01	3.64	3.42	3.48	3.72
Using computers and ICTs in science	2.84	3.63	3.36	3.53	3.64
Mean total confidence score (/45)	**3.34****	**3.87**	**3.76**	**3.88**	**4.04****

* Confidence was rated on a five-point scale: No confidence = 1; Limited confidence = 2; OK = 3; Confident = 4; and Very confident = 5.
** $p<0.05$.

At the end of term 2, mean confidence scores were greater than 3.0 (ie, OK) for all strategies and above 4.0 (ie, Confident) for five of the nine strategies. The four strategies with which teachers had modest confidence (ie, 3.6–4.0) included *Explaining science concepts, Using a constructivist model to plan science units of work, Assessing children's learning in science* and *Using computers and ICTs in science*. Of these, the first three require rich pedagogical content knowledge which takes time to develop, and the use of computers and ICTs requires opportunity for regular practice of the skills and this opportunity may be limited by resources within the schools.

Mean total confidence scores were calculated by adding the mean confidence scores for the nine items. A paired t-test shows that the mean total confidence score at the end of term 2 (4.04) was significantly greater than the mean total confidence score (3.34) on the initial survey ($p<0.05$).

Key finding 10. The *Primary Connections* program brought about a significant increase in teachers' confidence with science and literacy teaching strategies.

Self-efficacy

Table 6.15 summarises changes to teachers' responses to the 10-item self-efficacy scale. Mean agreement scores are reported for the initial, end of summer school, mid-term 1, end-term 1 and end-term 2 surveys for the 89 teachers who completed all of the questionnaires. Teachers rated their self-efficacy on a five-point scale and it should be noted that some items are expressed in positive terms (1, 3, 7, 10) while others are expressed in negative terms (2, 4, 5, 6, 8, 9).

Items 2, 4, 5, 6, 7, 9 and 10 indicate a progressive increase in self-efficacy at each subsequent data collection, that is, self-efficacy was increased by the summer school and further increased by experiences of teaching science and by the professional learning workshops held during terms 1 and 2.

Items 1 and 3 showed a sharp increase in self-efficacy following the summer school, which was tempered by experiences of science teaching early in term 1. However, these scores increased with further teaching experience and with the support of further workshops.

Table 6.15: Teachers' mean self-efficacy ratings for each survey (n=89)

	Mean score (/5)*				
Aspect of self-efficacy	Initial survey (=2004)	End of summer school	Mid-term 1, 2005	End term 1	End term 2
1. I am continually finding better ways to teach science.	3.76	4.30	4.20	4.30	4.37
2. Even when I try very hard, I don't teach science as well as I do most subjects.**	2.76	2.38	2.18	2.07	2.03
3. I know the steps necessary to teach science concepts effectively.	3.37	4.04	3.93	4.00	4.09
4. I am not very effective in monitoring science experiments.**	2.78	2.38	2.24	2.19	1.99
5. I generally teach science ineffectively.**	2.40	2.10	2.00	1.94	1.76
6. I find it difficult to explain to students why science experiments work.**	2.62	2.54	2.25	2.16	2.08
7. I am typically able to answer students' science questions.	3.51	3.71	3.76	3.92	3.94
8. Given a choice, I would not ask the Principal to evaluate my science teaching.**	2.93	2.88	2.64	2.62	2.54
9. When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.**	2.40	2.25	2.10	2.08	1.92
10.When teaching science, I usually welcome student questions.	4.35	4.42	4.47	4.47	4.62

* 5 = Strongly agree; 4 = Agree; 3 = Undecided; 2 = Disagree; 1 = Strongly disagree.
** These items are negative, low agreement scores indicate high self-efficacy.

A total self-efficacy score was calculated for each teacher by summing scores over the 10 items and reversing item scores for negative items. The distribution of scores in self-efficacy bands over the five surveys is presented in Table 6.16.

Table 6.16: Frequency of total self-efficacy scores on each survey (n=89)

Total self-efficacy score**	Initial survey (= 2004)	End of summer school	Mid-term 1, 2005	End term 1	End term 2
1-10	0	0	0	0	0
11-20	2	0	0	0	0
21-30	20	10	4	3	1
31-40	50	49	52	54	49
41-50	17	30	33	32	39
Mean total self-efficacy score for all teachers	35*	38	39	40	41*
S.D.	6.8	5.4	4.5	4.6	4.5

* $p<0.05$

** Total self-efficacy score = sum of 10 self-efficacy item scores for each teacher, (/50), with the most positive response given the value of 5 and the least positive the value of 1 on a five-point agreement scale, ie, scores have been reversed for negative items.

The mean total self-efficacy score for all teachers increased from 35 to 41/50 between the initial and end-term 2 surveys. A paired t test indicates that the difference between the initial mean score (35, std dev 6.6) and the end-term 2 mean (41, std dev 4.5) is significant ($p<0.05$).

Of educational significance is the number of teachers with low self-efficacy (<30), and this number decreased from 22 at the initial survey to 1 at the end-term 2 survey. Teachers with low self-efficacy are likely to be reluctant teachers of science and will tend to avoid teaching science. Reducing the number of teachers with low self-efficacy is likely to lead to an increase in the amount of science taught and an increased opportunity for students to learn science.

Key finding 11. The *Primary Connections* program brought about a significant increase in teachers' mean self-efficacy and reduced the number of teachers with low self-efficacy from 23 to 1.

Changes to practice

Use of teaching strategies

The frequency with which teachers used a number of important strategies was also monitored so that a comparison could be made between the use of strategies in 2004 and during the trial in term 1 of 2005, teaching from a supplied *Primary Connections* unit. These data are summarised in Table 6.17.

The strongest increase in strategy use was recorded for developing literacy skills needed for learning science, which suggests that teachers recognised the importance of these skills and had the resources and confidence to teach these skills.

Table 6.17: Frequency with which teachers used strategies in 2004 and at the end of term 1 2005, while using *Primary Connections* (per cent of respondents) (n=94)

Teaching strategy	Never used		Some or a few lessons		All or most lessons	
	2004	2005	2004	2005	2004	2005
1. Students did hands-on activities.	0	0	24	15	76	85
2. Students followed the procedure I planned for the investigation.	1	1	39	19	60	80
3. Students worked out their own question and procedure for the investigation.	13	10	71	74	16	16
4. I demonstrated the experiment for the children.	9	6	64	65	28	29
5. Students used computers in their science lessons.	23	20	60	65	17	15
6. We used a digital camera in science lessons.	24	10	47	50	29	40
7. Students developed PowerPoint presentations for science.	48	59	40	34	12	8
8. We developed literacy skills needed for learning science in science lessons.	2	0	54	32	44	68
9. Students developed posters in science.	26	22	60	64	14	14
10. I used diagnostic assessments of students' science misconceptions.	52	23	44	64	4	13
11. I developed cooperative group skills.	0	0	30	19	70	81
12. We went on science excursions.	23	72	62	23	15	5
13. Children did activities outdoors.	1	4	83	79	16	17
14. We had members of the community talk to the class about science.	40	63	51	33	9	4

Teachers responded on a five point scale: All = In all science lessons; Most = In most science lessons; Some = In some science lessons; Few = In few science lessons; and Never = Never in science.

There was also a strong increase in the frequency of use of diagnostic assessment as a consequence of it being scaffolded into *Engage* lessons. Increased frequency of doing hands-on activities and students following experimental procedures devised by the teacher were recorded; however, there was only a slight increase in frequency of students planning their own investigations.

There was an increased use of digital cameras, a very slight increase in use of computers yet a decrease in use of PowerPoint. Teaching cooperative group skills increased in frequency. It was most interesting to note decreases for taking students on science excursions and for using visiting speakers, which may be strategies teachers use when they lack confidence in teaching science themselves.

Digital cameras

The professional learning workshops conducted during terms 1 and 2 provided most interesting anecdotal evidence of the use of digital cameras. Teachers used digital cameras to capture images of their practices and of children's work to share with colleagues during the workshops and these images facilitated representation and sharing of practices. Teachers also described a number of ways in which the cameras were used in their classrooms. These included using a photo to engage students in writing a recount and then attaching a word-processed recount to the photo; rather than drawing a plant by hand and labelling its parts, importing a photo into Word and using text boxes to label the parts in Word; using photos to provide exemplification of words in a word wall; and importing photos into PowerPoint to illustrate science phenomena in the presentation.

Cooperative learning

When asked about their use of the cooperative learning strategies and their effectiveness in helping manage group activities, 85 per cent of teachers indicated they had used the recommended cooperative learning strategies and 72 per cent said they had helped with managing group work. 13 per cent of teachers indicated more appropriate group role badges were needed for older students, 7 per cent indicated that the group roles were not appropriate for K-1 students and 8 per cent suggested that specific lessons were needed to teach students about the roles.

Key finding 12. The frequency with which teachers taught literacy skills needed for learning science, used diagnostic assessments, did hands-on activities with students, used digital cameras in their teaching and used cooperative learning strategies was greater with *Primary Connections* than in previous science teaching.

Teaching practice

To determine what impact *Primary Connections* had on teachers' practice, teachers were asked which aspects, if any, had changed during term 1 with *Primary Connections* (Table 6.18).

This question elicited a large number of responses. The most frequent responses related to increased hands-on practical work, inquiry and investigations, focussing on one topic for a whole term, the 5Es structure, more time on science, increased confidence and the better sequencing and flow between lessons. When asked about aspects of the program that were most beneficial the teachers most frequently commented about the 5Es model providing a framework for learning and the resources being a good guide that was flexible in use.

Table 6.18: Teachers' responses to the question 'Which aspects of teaching with *Primary Connections* this term, if any, have been different from your previous science teaching?' (n=101)

Differences to previous teaching	Number of responses	Per cent of teachers with this response
Everything	1	1.0
More time on investigate inquire, hands-on	27	26.7
Greater focus on literacy	24	23.8
One topic for the whole term	23	22.8
5Es structure	15	14.9
More time on science	11	10.9
I feel more directed and confident in teaching science	11	10.9
There is a better sequence and flow in lessons	10	9.9
Using more technology	10	9.9
More links to other learning areas, more integration	8	7.9
More cooperative group work	8	7.9
No differences	3	3.0
No response	5	5.0
Other	19	18.8
Total responses	170	n=101

Key finding 13. At the end of term 1, teachers indicated that their science teaching had improved through increased hands-on practical work, inquiry and investigations, focusing on one topic for a whole term, the 5Es structure, more time on science, increased confidence and better sequencing and flow between lessons.

A further question at the end of term 2 focused on improvements in teaching practice brought about as a result of participating in the *Primary Connection* program. Again, this question generated a large number of responses and these were organised into categories. The most frequent responses related to a greater awareness of, and focus on, student learning, rather than just managing interesting activities, and improved lessons which are more student-centred and engaging. It is interesting to note that between terms 1 and 2, the focus of teachers had shifted from issues of implementation of practice to concerns about student learning outcomes, which is an important indicator of professional growth.

Table 6.19: Teachers' responses to the question: 'What (if any) improvements to your teaching practice have been made as a result of participating in the *Primary Connections* program?' (n=93)

Improvement	Number of responses	Per cent of teachers with this response
More aware/focused on developing student understanding	32	34.4
Better lessons: more variety, enthusiasm, students more engaged	28	30.1
More student-centred, more student discussion	15	16.1
Programs are better	13	14
More focus on literacy	10	10.8
More integration	10	10.8
Better at organising group learning	7	7.5
Better questioning skills	6	6.5
Other	22	23.7
Total responses	143	n=93

When asked 'Has your science teaching improved as a result of participating in the *Primary Connections* program?' at the end of the term 2 questionnaire, 96 out of 97 teachers responded 'Yes'. When asked to explain how their science teaching had improved, teachers identified aspects of their knowledge, confidence and practice that had improved as a result of participating in the program. These data are summarised in Table 6.20.

Table 6.20: Teachers' responses to the question 'Explain how your science teaching has improved as a result of participating in the *Primary Connections* program?' (n=97)

Response	Frequency	Per cent of respondents
More confident	31	32
Better understanding of importance of concepts and process	21	22
Doing more, more enthusiasm	20	21
Better programs	14	14
More aware of literacy	13	13
More focus on depth, full development of outcomes	12	12
New strategies and ideas	9	9
More integration	8	8
More student-centred	4	4
More reflective on own teaching	3	3
Better at assessing	3	3
More funds	2	2
No response	9	9
Total responses	149	n=97

Almost a third of teachers indicated they were now more confident, corroborating other evidence about confidence and increased self-efficacy. A fifth indicated they had a better understanding of the concepts and processes of science, which is indicative of improved pedagogical content knowledge. Improving teachers' pedagogical content knowledge was an important aim of the program.

Key finding 14. **At the end of term 2, almost 100 per cent of teachers reported that their science teaching had improved as a result of participating in the *Primary Connections* program. Improvements were attributed to a greater focus on student learning made possible by increased teacher confidence and pedagogical content knowledge.**

69 of 97 teachers indicated that participating in the *Primary Connections* project had improved their teaching of literacy. The main ways in which their literacy teaching had improved were teaching literacies specifically for science; using science to complement an existing strong literacy focus; using science as a context for literacy; and improved integration (Table 6.21).

Table 6.21: Teachers' responses to the question 'Explain how your literacy teaching has improved as a result of participating in the *Primary Connections* program.' (n=97)

Response	Frequency	Per cent of respondents
Teaching literacy skills specifically for science	26	27
Complements an already strong literacy focus	18	19
Now have context for literacy	16	17
More integration of literacy in all areas	14	14
Linked to science better now	12	12
Already good at literacy (doesn't help)	9	9
Greater variety of literacy tasks used	3	3
Only for science literacy	1	1
No response	7	7
Total responses	106	n=97

Key finding 15. **71 per cent of teachers reported their teaching of literacy had improved through participating in the *Primary Connections* program. Improvement related to teaching literacies specifically for science; using science to complement an existing strong literacy focus; using science as a context for literacy; and improved integration.**

Integration of science and literacy

An important feature of the *Primary Connections* teaching and learning model is the integration of science and literacy. Community literacies are needed to engage with and learn the literacies of science, which are essential for representing understandings in science. The teachers were asked how they integrated science and literacy and how the integration affected learning of science and literacy.

Table 6.22: Teachers' responses to the question 'Are/how are you integrating the literacy focuses of your *Primary Connections* unit with your literacy programming?' (n=98)

Method of integration	Number of responses	Per cent of teachers with this response
Teach literacy focus in literacy lessons	34	34.7
Continuous interchange between science and literacy	15	15.3
Texts for literacy are based on science topic	15	15.3
Primary Connections topic is the theme for the term	8	8.2
Used literacy skills learnt in science in other learning areas	7	7.1
Doesn't fit with school literacy program	7	7.1
As outlined in units	5	5.1
Spelling, vocabulary	3	3.1
Assessed literacy from work in science	2	2.0
Other	18	18.4
Total responses	114	n=98

The most common methods of integration were developing the literacy focuses in literacy time, basing literacy texts on the science topic and a continual interchange between the two areas.

Key finding 16. Teachers integrated science and literacy by developing literacy focuses in literacy lessons, basing literacy texts on science contexts and a continual interchange between the two areas.

Most teachers (88 per cent) considered that the integrated approach was effective or very effective for promoting learning in science (Table 6.23).

Table 6.23: Teachers' responses to the question 'How effective is the integration of science and literacy in *Primary Connections* for supporting learning in science?' (n=100)

Teachers' responses (per cent of teachers)				
Very ineffective	Ineffective	OK	Effective	Very effective
2	0	10	51	37

When asked to explain why the integrated approach was effective in promoting science learning the teachers suggested that literacy is necessary for learning science concepts, students see the connection between science and literacy and they transfer their literacy learning to learning science, and the explicit learning of literacy skills helps science learning (Table 6.24).

Table 6.24: Teachers' responses to the question 'Why is the integration of science and literacy in the *Primary Connections* program effective/ineffective for supporting learning in science?' (n=72)

Reason	Number of responses	Per cent of teachers with this response
Literacy supports development of science concepts	26	36.1
Students see the connection between science and literacy	24	33.3
Explicit learning of literacy skills	13	18.1
Each supports other	8	11.1
More time for science	5	6.9
Other	7	9.7
Number of responses	83	n=72

Key finding 17. Almost 90 per cent of teachers considered that the integrated approach improved science learning. They attributed the benefits to students developing the literacies needed to learn science, students see the connections between literacy and science, and transfer their literacy learning to science learning.

When asked about the effectiveness of integration for promoting literacy learning, most teachers (73 per cent) thought that it was effective or very effective; a positive response but not quite as positive as the perceived benefits for science learning.

Table 6.25: Teachers' responses to the question 'How effective is the integration of science and literacy in *Primary Connections* program for supporting learning of literacy?' (n=100)

Teachers' responses (per cent of teachers)				
Very ineffective	Ineffective	OK	Effective	Very effective
1	1	25	38	35

The reasons given by teachers for the effectiveness of integration for learning literacy included providing a real purpose and context for writing so that science becomes a vehicle for learning literacy and providing opportunities for working with new text types/genres.

Table 6.26: Teachers' responses to the question 'Why is the integration of science and literacy in the *Primary Connections* program effective/ineffective for supporting learning of literacy?' (n=77)

Reason	Number of responses	Per cent of teachers with this response
Students get real writing/literacy experiences	27	35.1
Science is the vehicle for the development of literacy	8	10.4
Another writing genre	7	9.1
Science uses all literacies	6	7.8
Science is a motivator to improve literacy	5	6.5
Each supports other	5	6.5
More exposure to literacy	5	6.5
Not enough literacy	4	5.2
Vocabulary has improved	4	5.2
Other	12	16.0
Total responses	83	n=77

Key finding 18. 73 per cent of teachers believed that the integrated approach had improved literacy learning. The improvement was attributed to providing a real purpose and context for writing so that science becomes a vehicle for learning literacy and provides opportunities for working with new text types/genres.

Teachers indicated that they integrated science with a range of learning areas in addition to literacy, most commonly mathematics, art, society and environment, and technology (Table 6.27).

Table 6.27: Learning areas that teachers have made links to from a *Primary Connections* curriculum unit

Learning area	Number of responses	Per cent of teachers with this response
All areas	3	3.4
Maths	54	61.4
Art	44	50
SOSE	26	29.5
Technology	23	26.1
Personal development and life skills	7	8
English	4	4.5
Religious education	4	4.5
Drama, debating	3	3.4
Physical education	3	3.4
Music	2	2.3
LOTE	1	1.1
Limited as yet	1	1.1
None	2	2.3
Number of responses	177	n=88

Key finding 19. In addition to literacy, science was integrated most frequently with mathematics, art, society and environment and technology.

Science teaching time, status and resources

Despite the very high priority given to science by DEST and by parents (ASTEC, 1997), science has often had very low priority in the primary school curriculum. The national review of the status and quality of science teaching in Australian schools (Goodrum, Hackling and Rennie, 2001) expressed concern about the lack of science teaching in many schools. Data were therefore gathered about the time allocated to science and its priority in the school curriculum. These data are summarised in the following tables.

Table 6.28: Minutes of science taught per week by teachers in 2004 and terms 1 and 2 in 2005

Minutes of science taught per week	Per cent of respondents		
	2004 (n=91)	Term 1, 2005 (n=91)	Term 2, 2005 (n=85)
60 minutes or more	30.8	72.5	62.4
30 and 60 minutes	40.7	26.4	27.1
Less than 30 minutes	27.5	1.1	10.6

The amount of science taught increased dramatically as a result of the trial. The amount of science taught was greatest in term 1 of the trial when teachers were working with supplied units; however, even when working from teacher-developed units in term 2, the percentage of teachers teaching less than 30 minutes per week was reduced from 27 per cent to 11 per cent. Time on task has always been recognised as the fundamental variable influencing learning as it determines learning opportunity. Clearly this program has given students in the trial schools far more opportunity to learn science.

Table 6.29: Teachers' responses to the question 'What time of day did you mainly teach science?' in 2004 compared to the end of term 1 in 2005 (n = 88)

Time of day	Per cent of respondents	
	2004	2005
Morning	6.8	8.0
Afternoon	69.3	18.2
Morning and afternoon	23.9	73.9

Primary teachers recognise that the quality of learning varies with time of day. Traditionally, high priority subjects are taught in the mornings while students are fresh and attentive, and lower status subjects such as science are typically taught in the afternoon. The time of day at which science was taught was therefore a focus of this research.

Table 6.29 indicates a large shift from afternoon-only science teaching to teaching science in the mornings and afternoons which suggests that science contexts may have been used to support literacy teaching in the mornings and a more integrated approach to science teaching. These data may also imply an increased status for science in the school curriculum.

Key finding 20. Participating in *Primary Connections* brought about a large increase in science teaching time and science shifted from being almost exclusively taught in afternoons to being taught in mornings and afternoons.

The status of science was explicitly addressed in the teacher questionnaires. Teachers were asked to rank science in importance relative to nine other learning areas. The number of teachers who ranked science in the three most important subjects in 2004 and during 2005 in their school is summarised in Table 6.30. The percentage of teachers indicating science was in the top three subjects doubled as a result of the *Primary Connections* trial in their schools.

Table 6.30: Teachers' ranking of the status of science in 2004 compared to 2005 (n=91)

Rank	**Number of respondents**	
	2004	2005
1	6	11
2	4	18
3	14	21
Total number who ranked science 1, 2 or 3	24	50
Per cent of respondents who ranked science 1, 2 or 3	**26.4**	**55.0**

Key finding 21. *Primary Connections* raised the status of science in many trial schools.

The status of a subject in the school curriculum may also have an influence on the resources and budget allocated to that subject. Previous research (eg, Keys, 2003) has often indicated that availability of resources and budget are important factors limiting the quality of science teaching in primary schools. In the initial survey teachers were asked to rate the 2004 level of equipment and budget for science teaching in their schools, and again at the end of term 1, 2005. It should be noted that trial schools were provided with supplementary funding to provide additional resources for science teaching.

Table 6.31: Teachers' responses to the question 'How well equipped is your school for teaching science?' for 2004 compared to end of term 1 in 2005 (n=91)

My school is …	**Per cent of respondents**	
	2004	2005
well equipped	16.5	32.0
adequately equipped	44.0	47.3
poorly equipped	39.6	19.7

Prior to the trial, almost 40 per cent of teachers indicated that their school was poorly equipped for teaching science. After the first term of the trial in 2005, the percentage of poorly equipped schools had been halved. This may have been a consequence of the change to the status of science in the school as it had assumed a higher priority brought about by the commitment to *Primary Connections* or as a result of supplementary funding provided to trial schools to support the purchase of additional science resources.

Table 6.32: Teachers' responses to the question 'How do you rate the budget for science equipment and consumables at your school?' for 2004 compared to end of term 1 in 2005 (n=91)

Budget rating	**Per cent of respondents**	
	2004	2005
Very good	11.0	22.0
Good	18.7	18.7
Satisfactory	33.0	33.0
Inadequate	35.2	23.1
No budget	2.2	3.3

Prior to the commencement of the trial, teachers were asked to rate the 2004 science budget of their school. Only 30 per cent of teachers rated their school's science budget as good or very good while almost 40 per cent indicated their science budget was inadequate or there was no designated budget for science at their school.

Teachers were asked to rate the 2005 science budget of their school at the end of term 1, 2005. The number of schools with very good budgets doubled from 11 per cent to 22 per cent and the number with inadequate budgets or no budgets decreased from 37 per cent to 26 per cent. While these shifts are positive it is concerning that even when schools have given science a higher priority, and the project had provided some supplementary funding for science resources, a quarter of schools are considered by their teachers to be inadequately resourced for science.

Key finding 22. *Primary Connections* made a positive impact on levels of equipment and budgets for science; however, despite these positive impacts, 20 per cent of schools were considered to be poorly equipped and 25 per cent had inadequate science budgets.

Not all resources are material, the most important resources in schools are human resources and expertise, and, of these, subject coordination and leadership can make an important contribution to effective teaching and learning. An important indicator of the level of school coordination of science is whether there is a designated coordinator for the subject.

Table 6.33: Teachers' responses to the question 'Was there a science coordinator at your school?' for 2004 and for the end of term 1 in 2005 (n=91)

Science coordinator present	Per cent of respondents	
	2004	2005
Yes	63.7	62.6
No	36.2	37.4

Data presented in Table 6.33 show that more than one-third of schools did not have a designated science coordinator before or during the trial and that participation in the trial had little impact on the number of schools with coordinators. The value of strong coordination and leadership was amply demonstrated in one of the case study schools which implemented *Primary Connections* on a whole-school basis. In this school, a deputy principal acted as science coordinator to great effect. All teachers participated in implementing *Primary Connections*, a team of parents was assembled to assist with setting-up and maintaining a science store with boxes of equipment for each unit, and one of the directors of the project was called into the school as necessary to provide support where required.

Key finding 23. *Primary Connections* had a negligible impact on the number of schools with a science coordinator; more than one-third of schools lacked a science coordinator.

Reporting of achievement in science

An important indicator of the accountability teachers have within a school for teaching science is whether science is reported as a separate subject on the end of year school report to parents. Telephone interviews with primary teachers during the national review of the status and quality of science teaching in Australian schools (Goodrum et al., 2001) indicated that in some jurisdictions it is common to report science achievement within a category called integrated studies. Under these circumstances there is less accountability to parents to teach science. The teachers in the *Primary Connections* trial indicated that in 2004 almost 30 per cent of schools did not report science as a separate subject. There was a small reduction in this figure in 2005.

Key finding 24. Almost 30 per cent of schools do not report science achievement to parents as a separate subject, thus limiting accountability for science teaching and learning.

Teachers' rating of students' responses to *Primary Connections* and students' learning

Teachers were asked to rate students' responses to the *Primary Connections* activities and to the learning approach. Tables 6.34 and 6.35 summarise these data.

Table 6.34: Teachers' rating of students' responses to the *Primary Connections* activities (n=100)

Students' responses to activities (per cent of teachers)				
Very negative	Negative	OK	Positive	Very positive
1	2	10	37	50

Table 6.35: Teachers' rating of students' responses to the *Primary Connections* learning approach (n=99)

Students' response to learning approach (per cent of teachers)				
Very negative	Negative	OK	Positive	Very positive
0	0	12	53	34

87 per cent of teachers indicated that students responded positively or very positively to the learning approach.

Students' responses to the activities and learning approach are influenced both by the *Primary Connections* approach and resources and by the skilfulness of the teachers' implementation of the program. The resources and the professional learning program appear to have supported the trial teachers in a successful implementation of science so as to gain a positive response from students. A positive response from students is very important to teachers, especially those who have low or modest self-efficacy, as a negative response is likely to discourage these teachers from persisting with teaching science.

Key finding 25. Almost 90 per cent of teachers indicated that their students had responded positively or very positively to the *Primary Connections* activities and learning approach.

Teachers' rating of students' learning

Teachers were asked to compare the amount and quality of science learning between 2004 and term 1 of 2005 when using *Primary Connections*, and the contribution made by *Primary Connections* to literacy learning. Teachers' responses to these questions are summarised in the following tables.

Table 6.36: Teachers' rating of the amount of science learning (n=91)

Amount of science learning (per cent of teachers)		
Less than last term	Same as last term	Better than last term
1	22	76

Table 6.37: Teachers' rating of the quality of science learning (n=91)

Quality of science learning (per cent of teachers)		
Less than last term	Same as last term	Better than last term
1	20	78

Table 6.38: Teachers' rating of contribution to literacy learning (n=97)

Contribution to literacy learning (per cent of teachers)		
Less than last term	Same as last term	Better than last term
2	39	59

Teachers' perceptions of the amount and quality of learning using *Primary Connections* were very positive. More than three-quarters of the teachers believed that their students had learned more science than previously and that the quality of science learning was better using *Primary Connections*.

Key finding 26. More than three-quarters of the teachers believed that their students had learned more science than previously and that the quality of science learning was better using *Primary Connections*.

59 per cent of teachers indicated that science had made a greater contribution to literacy learning with *Primary Connections* compared with previous science teaching. Teachers were also asked to explain how *Primary Connections* contributed to literacy learning; their responses are summarised in Table 6.39.

Table 6.39: Teachers' responses to the question 'How has *Primary Connections* contributed to literacy learning?' (n=101)

Response	Frequency	Per cent of respondents
Purpose for literacy, in context, real	25	21.7
Increased range of literacies taught	23	20.0
Reinforces, more exposure to literacy	13	11.3
Students better at literacy skills	10	8.9
Students see need for different literacies	6	5.2
Other	15	14.9
No reason given	23	26.7
Total responses	115	n=101

Teachers explained that science gave a purpose and context for learning literacies, increased the range of literacies being developed, provided more opportunities for literacy in the curriculum resulting in improved learning.

Key finding 27. 59 per cent of teachers indicated that literacy learning had improved with *Primary Connections*. Linking science and literacy gave a context and purpose for literacy and increased the range of literacies taught.

Students' rating of *Primary Connections*

Most students (n=538) at one of the *Primary Connections* case study schools completed an anonymous survey at the end of term 1. Students were asked to compare their experience of science this term (term 1, 2005) with the previous term (2004). Table 6.40 provides a summary of students' responses.

Table 6.40: Students' responses to the end of term 1 survey

Per cent of cohort with this response				
Unit studied	*Weather* n=132	*Push, Pull Power* n=108	*Plants in Action* n=160	*Build it Better* n=138
Have you enjoyed science this term?				
Yes	82	63	77	49
OK	11	27	221	41
No	8	10	2	10
How much have you learned in science this term?				
Lots	71	70	68	38
Some	15	23	30	50
Little	14	6	3	12
How much science have you done this term?				
More than usual	NA*	NA	69	52
Same as usual	NA	NA	28	36
Less than usual	NA	NA	3	12
Has science been different this term?				
Better	NA	NA	72	49
Same as usual	NA	NA	16	30
Not as good as usual	NA	NA	8	21

* NA (not applicable) indicates that these questions were not included on the survey of the junior primary students studying these units.

Given that previous surveys of primary students have indicated that 30 per cent of students are often or always bored in science and that 35 per cent are sometimes bored in science (Goodrum, Hackling and Rennie, 2001), Table 6.40 shows that students were very positive about their experience of *Primary Connections*. At least 90 per cent of students gave a positive or neutral response to the question 'Have you enjoyed science this term?' At least 86 per cent of students gave a positive or neutral response to the question 'How much have you learned in science this term?'

The middle and upper primary students who completed Stages 2 and 3 units were also asked how much science they had done in this term, and whether science had been different this term. In both cases, a majority of students indicated they had done more science than last term and science had been better than last term. These data corroborated teachers' perceptions of how much students had enjoyed science, how much they had learned and the amount of science taught. It is interesting to note that the science and technology unit, *Build it Better*, received less positive ratings by the students than the other three science units. This unit was rather long and contained less science than other units.

Key finding 28. **A large majority of students gave a positive rating of *Primary Connections* in terms of enjoyment and amount of science learning.**

Achievement gains

To provide a measure of learning achievement, the science journals of three classes of students who completed the *Plants in Action* unit at one of the case study schools were analysed. The students represented two intact classes of Year 5 students and the Year 5 students from a combined Year 4/5 class. The work samples generated in the *Engage* and *Evaluate* lessons were rated against levels in the national scientific literacy progress map. To provide a more fine-grained analysis, levels of achievement were further subdivided into the sublevels — developing, consolidating and achieved. Explicit criteria for levels and sublevels were defined and dual coding by consensus of two experienced coders ensured a high level of coding reliability.

Table 6.41: Changes in levels of achievement between the initial *Engage* lesson and the final *Evaluation* lesson for Year 5 students studying the *Plants in Action* unit at one case study school

Achievement level	Number of students (n=72)	
	Engage	*Evaluate*
1a	11	0
2d	16	3
2c	41	5
2a	3	8
3d	1	15
3c	0	22
3a	0	15
4d	0	4
Mean score	2.54*	5.51*
s.d.	0.855	1.473

Levels of achievement were assigned the following scores: 1a = 1; 2d = 2; 2c = 3; 2a = 4; 3d = 5; 3c = 6; 3a = 7; 4d = 8 where d = developing; c = consolidating; a = achieved.

* Mean scores are significantly different ($p<0.05$) using the Wilcoxon signed ranks test.

Levels were converted to scores to facilitate calculation of means and statistical comparison of *Engage* and *Evaluate* mean scores. These data are presented in Table 6.41.

At the beginning of the unit the modal level of achievement was 2c and at the end of the unit it had risen to 3c. The mean score had more than doubled over the course of the unit and at the end of the unit 78 per cent of these Year 5 students were working at or beyond level 3, which is the national benchmark for Year 6 students.

Key finding 29. **The mean achievement score for a sample of Year 5 classes more than doubled over the course of the *Plants in Action* unit, and at the end of the unit 78 per cent of these Year 5 students were working at or beyond level 3, which is the national benchmark for Year 6 students.**

To ensure that the achievement gains were not the result of one outstanding class or teacher, data were disaggregated by teacher/class and these data by class are presented in Table 6.42.

Table 6.42: Changes in levels of achievement between the initial *Engage* lesson and the final *Evaluation* lesson for three classes of Year 5 students studying the *Plants in Action* unit at one case study school

Level	Teacher 1		Teacher 2		Teacher 3		Teacher 4	
	Engage	*Evaluate*	*Engage*	*Evaluate*	*Engage*	*Evaluate*	*Engage*	*Evaluate*
	n=28		n=25		n=19		n=72	
1a	1		6		4		11	0
2d	6		4	2	6	1	16	3
2c	19	1	13	2	9	2	41	5
2a	2	2	1	5		1	3	8
3d		7	1	5		3	1	15
3c		6		8		8	0	22
3a		9		2		4	0	15
4d		3		1			0	4

Table 6.42 shows that all three teachers obtained consistent improvements in student achievement scores teaching from the *Plants in Action* unit; the improvements cannot therefore be attributed to one outstanding teacher or class.

Key finding 30. Consistent improvement in the levels of science achievement of students were found across sample Year 5 classes.

There is strong corroboration from three independent data sources (teacher perception, student perception and work samples) of a significant impact of *Primary Connections* on student learning.

Impact on schools

The end of term 2 questionnaire sought teachers' views about the impact of *Primary Connections* on their schools. 91 per cent of the teachers were unequivocal that the program had had a positive impact on their schools. The main impacts were on teachers' interest in science, an increased profile for science within the school and its local community, more science is being taught and other teachers at their school had adopted the program.

Key finding 31. 91 per cent of the teachers were unequivocal that the program had had a positive impact on their schools. The main impacts were on teachers' interest in science, an increased profile for science within the school and its local community, and more science is being taught in their schools.

Summary

This chapter has presented an analysis of teacher questionnaire data, student survey data and student achievement data. The following key findings have emerged from the analysis of data:

Demographic data

Key finding 1. The sample of teachers and schools participating in the trial were broadly representative of all jurisdictions, sectors and regional locations, and included a sample of schools with high Indigenous enrolments.

Key finding 2. Approximately one-third of the teachers had taught for less than 10 years, about one-quarter for 10-20 years and a further third for 20-30 years.

Key finding 3. The majority of trial teachers were four-year trained and not currently enrolled in further university studies, about half had no science discipline studies beyond Year 12 and almost half had not attended any science professional learning workshops in 2004. Most teachers wished to improve their science teaching pedagogy and their knowledge of science.

Feedback on the professional learning program

Key finding 4. The teachers believed the summer school was very successful in achieving its goals and preparing the teachers to teach the first unit in term 1. A substantial majority of teachers expressed confidence with important science teaching strategies, however, the data suggest that further support may be needed with some strategies.

Key finding 5. The one-day professional learning workshops had a very high rate of attendance by teachers and a large majority of teachers rated them as helpful or very helpful.

Key finding 6. Almost 90 per cent of the teachers rated the professional learning program as good as or better than any they had previously participated in, and gave very strong endorsement for the summer school and curriculum resources.

Teachers' rating of the *Primary Connections* curriculum resources

Key finding 7. Almost 90 per cent of the teachers rated the curriculum resources as effective or very effective in supporting learning. The main reasons given for their effectiveness were effective scaffolding of teaching and learning, they gave support to teachers at all levels of experience and were flexible. 95 per cent of teachers wanted the Academy of Science to prepare further curriculum units.

Key finding 8. Almost 90 per cent of teachers indicated that they had no difficulty with the compatibility of units with their jurisdictions' curriculum frameworks. The most common suggestion for improving units was that they should be shorter.

Key finding 9. Teachers would prefer the curriculum resources to be supplied as hard copy and on CD-ROM. Few teachers requested online delivery, which may indicate internet access is inconvenient or problematic.

Changes to teachers' confidence and self-efficacy

Key finding 10. *The Primary Connections* program brought about a significant increase in teachers' confidence with science and literacy teaching strategies.

Key finding 11. The *Primary Connections* program brought about a significant increase in teachers' mean self-efficacy and reduced the number of teachers with low self-efficacy from 23 to 1.

Changes to practice

Key finding 12. The frequency with which teachers taught literacy skills needed for learning science, used diagnostic assessments, did hands-on activities with students, used digital cameras in their teaching and used cooperative learning strategies was greater with *Primary Connections* than in previous science teaching.

Key finding 13. At the end of term 1, teachers indicated that their science teaching had improved through increased hands-on practical work, inquiry and investigations, focusing on one topic for a whole term, the 5Es structure, more time on science, increased confidence and better sequencing and flow between lessons.

Key finding 14. At the end of term 2, almost 100 per cent of teachers reported that their science teaching had improved as a result of participating in the *Primary Connections* program. Improvements were attributed to a greater focus on student learning made possible by increased teacher confidence and pedagogical content knowledge.

Key finding 15. 71 per cent of teachers reported their teaching of literacy had improved through participating in the *Primary Connections* program. Improvement related to teaching literacies specifically for science; using science to complement an existing strong literacy focus; using science as a context for literacy; and improved integration.

Integration of science and literacy

Key finding 16. Teachers integrated science and literacy by developing literacy focuses in literacy lessons, basing literacy texts on science contexts and a continual interchange between the two areas.

Key finding 17. Almost 90 per cent of teachers considered that the integrated approach improved science learning. They attributed the benefits to students developing the literacies needed to learn science, students see the connections between literacy and science, and transfer their literacy learning to science learning.

Key finding 18. 73 per cent of teachers believed that the integrated approach had improved literacy learning. The improvement was attributed to providing a real purpose and context for writing so that science becomes a vehicle for learning literacy and provides opportunities for working with new text types/genres.

Key finding 19. In addition to literacy, science was integrated most frequently with mathematics, art, society and environment and technology.

Science teaching time, status and resources

Key finding 20. Participating in *Primary Connections* brought about a large increase in science teaching time and science shifted from being almost exclusively taught in afternoons to being taught in mornings and afternoons.

Key finding 21. *Primary Connections* raised the status of science in many trial schools.

Key finding 22. *Primary Connections* made a positive impact on levels of equipment and budgets for science; however, despite these positive impacts, 20 per cent of schools were considered to be poorly equipped and 25 per cent had inadequate science budgets.

Key finding 23. *Primary Connections* had a negligible impact on the number of schools with a science coordinator; more than one-third of schools lacked a science coordinator.

Key finding 24. Almost 30 per cent of schools do not report science achievement to parents as a separate subject, thus limiting accountability for science teaching and learning.

Teachers' rating of students' responses to *Primary Connections* and students' learning

Key finding 25. Almost 90 per cent of teachers indicated that their students had responded positively or very positively to the *Primary Connections* activities and learning approach.

Key finding 26. More than three-quarters of the teachers believed that their students had learned more science than previously and that the quality of science learning was better using *Primary Connections*.

Key finding 27. 59 per cent of teachers indicated that literacy learning had improved with *Primary Connections*. Linking science and literacy gave a context and purpose for literacy and increased the range of literacies taught.

Students' rating of *Primary Connections*

Key finding 28. A large majority of students gave a positive rating of *Primary Connections* in terms of enjoyment and amount of science learning.

Achievement gains

Key finding 29. The mean achievement score for a sample of Year 5 classes more than doubled over the course of the *Plants in Action* unit, and at the end of the unit 78 per cent of these Year 5 students were working at or beyond level 3, which is the national benchmark for Year 6 students.

Key finding 30. Consistent improvement in the levels of science achievement of students were found across sample Year 5 classes.

Impact on schools

Key finding 31. 91 per cent of the teachers were unequivocal that the program had had a positive impact on their schools. The main impacts were on teachers' interest in science,an increased profile for science within the school and its local community, and more science is being taught in their schools.

Based on the data gathered to date and the key findings, the following assertions can be made about the *Primary Connections* program.

6.1 The sample of 106 teachers and 56 schools participating in the trial was broadly representative of all jurisdictions, sectors and regional locations. The sample included some schools with high Indigenous enrolments and comprised a mix of inexperienced, experienced and very experienced teachers who were mostly four-year trained, half had no science studies beyond Year 12 and half had not attended science professional learning in the previous year.

6.2 Teachers rated the summer school highly for achieving its goals and preparing them for teaching science, the one-day workshops had high rates of attendance and most teachers considered them helpful or very helpful. Almost 90 per cent of teachers rated the program as good or better than any they had attended and gave very strong endorsement of the summer school and curriculum units.

6.3 Almost 90 per cent of teachers rated the curriculum resources as effective or very effective because they were flexible and suitable for teachers of a wide range of experience, scaffolded learning and were compatible with their local curriculum frameworks. 95 per cent of teachers wanted the Academy of Science to develop additional units. Teachers would prefer the curriculum resources to be supplied as hard copy and CD-ROM.

6.4 *Primary Connections* significantly increased teachers' confidence with science and literacy teaching strategies and significantly increased teachers' self-efficacy, and, of educational significance, the number of teachers with low self-efficacy was dramatically reduced. The increase in confidence and self-efficacy can be attributed to teachers' increased pedagogical content knowledge and being supported with a quality curriculum resource.

6.5 *Primary Connections* made large changes to teachers' practice (eg, increased frequency of teaching literacy skills needed for learning science, increased use of diagnostic assessment, increased frequency of hands-on activity work, use of digital cameras and cooperative learning strategies) and had improved their science teaching. By the end of term 2, teachers' concerns had changed from focusing on activities and strategies to focusing on achieving learning outcomes. Teachers attributed improvements in their science teaching to increased confidence and improved pedagogical content knowledge.

6.6 Teachers integrated science and literacy by developing the literacies of science focuses in literacy lessons and by using science to provide contexts and purpose for literacy learning. Almost 90 per cent of teachers considered the integrated approach had improved science learning and 73 per cent considered that the integrated approach had improved literacy learning. In addition to literacy, science was integrated with mathematics, art, society and environment, and technology.

6.7 *Primary Connections* supported a large increase in science teaching time and status of science in the school curriculum. Science shifted from being an afternoons-only subject to being a mornings and afternoons subject. The increase in science teaching time can be attributed to teachers' increased confidence and self-efficacy, and having a quality curriculum resource to support their teaching. The shift in time of day at which science was taught can be attributed to the integration of science with literacy.

6.8 Even with the support of *Primary Connections*, there remained a number of concerns about resourcing and accountability for science teaching. 20 per cent of teachers considered their school to be poorly equipped, 25 per cent considered their school had an inadequate science budget, and 30 per cent indicated that their school did not report students' science achievement to parents as a separate subject.

6.9 Almost 90 per cent of teachers indicated that their students had responded positively or very positively to the *Primary Connections* activities and learning approach, more than 75 per cent indicated their students had learned more science and the quality of science learning was higher with *Primary Connections* than with their previous science program.

6.10 Students themselves gave *Primary Connections* high ratings for enjoyment and learning.

6.11 Student mean achievement scores increased significantly over one unit (more than doubled) and almost 80 per cent of a sample of Year 5 students were working at or above level 3 on the national scientific literacy progress map, which is the national benchmark for Year 6 students.

6.12 More than 90 per cent of teachers indicated that *Primary Connections* had a significant impact on their schools increasing students' and teachers' interest in science, an increased profile of science within the school and local community, and increasing the amount of science being taught in their schools.

Chapter 7 | Case studies

Case study 1: Literacy learning in *Primary Connections*

Overview

Current Australian state and national curriculum documents for English specify various developmental learning outcomes for the first seven years of schooling. However, there is a lack of consistency in these documents in the conceptualisation of key dimensions to literacy learning, progression goals and outcomes, and success indicators for this learning. While some general literacy goals relevant to science learning are identified in each document, such as the capacity to construct and interpret different kinds of texts, there is currently no agreed developmental progress map for learning the literacies of science across all levels of primary education in Australia. In other words, there is no agreed understanding in these documents about expected standards in students' capacity to interpret and construct a science journal or different kinds of factual reports, tables, graphs, and diagrams as students progress through primary school. This case study provides insights into participant teachers' planning practices; provides an indicative sample of student literacy products from different units in *Primary Connections*; and reports on general findings in relation to literacy learning.

Teacher planning

In integrating literacy and science in each unit, many participant teachers planned learning sequences that explicitly linked science concepts, literacy activities and products, and different assessment methods. While each curriculum unit document explicitly links science and literacy learning outcomes, the participant teachers were invited to customise the unit to suit their own preferred teaching and learning strategies, classroom resources, and to cater for the learning needs of their particular students. The following teacher planning document for the start of the unit, *Spinning in Space*, for students in Stage 2 (Years 4-5), is an indicative example of the integration of science and literacy, where students' ideas about the Sun, Moon and Earth, were explored and clarified through various literacy processes, such as cooperative group discussion, journal writing, and mind map construction:

Figure 7.1: A teacher planning document

Literacy & Science

Lesson	Lesson at a glance	Literacy Focus	Assessment
1 **Interesting Ideas**	**KEY LESSON OUTCOMES** **Science** **Students will be able to represent their current beliefs about:** - the relative positions and movements of the Sun, Moon & Earth - how day & night are caused on Earth At a Glance **Students represent their ideas about the Sun, Moon & Earth using a diagnostic assessment task, and individual mind maps, through cooperative learning teams & whole group discussion.** Discuss students ideas about the Sun, Moon & Earth Draw their ideas about Sun, Moon & Earth Begin Mind map Begin KWLH chart Begin Word wall	- Participate effectively In whole class/small group discussions. - Understand the purpose, structure and features of a **mind map** and represent ideas using a mind map - Engage in discussion to compare ideas about the Sun, Moon & Earth. - Demonstrate, through **science journal** entries, their understanding of the Sun, Moon & Earth, & their movements **- Label a diagram** **- Create a Word wall**	• Diagnostic Assessment task • Mind map • Cooperative group skills • Drawings of positions of Sun, Moon & Earth
2 **Shapes & Sizes**	**KEY LESSON OUTCOMES** **Science** **Students explore the spherical shapes, the different sizes & the relative positions of the Sun, the Moon & the Earth:** - describe the spherical shape of the Sun, the Moon & the Earth: - explain that the sun is larger than the Earth and that the Earth is larger than the Sun. - explain that the Sun looks the same size as the Moon because it is further away from the Earth	**Students will be able to:** - participate effectively in whole class and small group discussions to compare ideas about the shape and relative size of the **Sun, the Moon & the Earth** - use oral written & visual language to report and reflect on the relative sizes of the **Sun, the Moon & the Earth:**	• Cooperative group skills • Recording of ideas & reasons in science journals
3 **Shadow play**	**KEY LESSON OUTCOMES** **Science** - Observe & describe changes in direction & length of shadows during the day - Describe the apparent movement of the Sun across the sky from east to west - Describe how a shadow is formed by an object that blocks the light	**Students will be able to:** **Write a Summary** - use oral written & visual language to record & discuss observations of light & shadows - participate effectively in whole class & small group	• Sharing of Moon observation record • Writing a summary • Observation of moon chart • Discussions of observations

Examples of students' science literacy products

Over 100 primary school teachers and their students participated in the trial of eight units in *Primary Connections*, including the implementation of two units for each stage. The trial has resulted in the production of a rich range of literacy processes, practices and products. Much of the literacy activity in each unit has entailed focused talk to guide inquiry, including whole-class discussion, small-group investigations, and individual and group presentations and demonstrations. While teachers have drawn heavily on individual observation to evaluate students' development of viewing, listening, reading, speaking and cooperative learning performance and outcomes, this evaluation is not easily standardised across different contexts. Current broadly-used literacy tests in Australian schools, such as the AIM, Burt and Torch tests, do not address directly student learning of the literacies of science.

The following textual examples of student literacy learning therefore represent a very small sample of the range of literacy learning outcomes of the program in terms of language modes, and are indicative of a very selective sample of written and visual texts. In *Primary Connections* students are expected to produce a wide range of literacy texts to represent emerging and consolidated science understandings at each year level in primary school. These texts include science journals, surveys, posters, illustrated recounts, role-plays, procedural texts, reports, botanical and other drawings, labelled diagrams, flowcharts, tables, pictographs, and bar, column and line graphs, with varying degrees of complexity and sophistication depending on the year level and the unit. Students are also expected to demonstrate effective use of new multi-modal technologies in representing science ideas and findings, including the use of digital cameras, PowerPoint presentations, and data loggers.

The following textual examples are drawn from student work in three units: *Plants in Action* (Stage 2); *Build it Better* (Stage 3); and a teacher-devised unit on chemistry. They are not presented as exemplary work in these topics, but rather as indicative of the variety of textual demands for students in constructing and demonstrating their understandings of the science concepts and processes in each unit. These demands include understanding the subject-specific vocabulary of each topic, understanding the form/function of different kinds of science texts, using oral, written, and visual language effectively, integrating these modes with mathematics to represent an understanding of key concepts and processes in a topic, and developing critical capacities in interpreting and constructing science texts.

In the *Build it Better* unit, as part of the initial outcomes of the unit, students were expected to explain the relationship between types pf materials, their observable properties, and what they are used for; and plan and conduct tests of a property of a material, make and record observations, and record measurements in simple tables. The following work examples include a table to investigate design, and a teacher's report to parents, incorporating a Year 5 student's observations and findings in tabular form.

Figure 7.2: Work samples from the *Build it Better* unit

Anna 2/2/05 ☺ very well done

	What is it?	What is it used for?	What is it made from?	Why is it made from that?	What shapes are used?	Why are those shapes used?
	Product.	Purpose	Material	Properties	Structure	Function
1. Glue Bottle	Glue Bottle	To hold liquid	Waxed paper Plastic	It's ~~chep~~ and good to store stuff in.	Cone and Cylinder	easy to make.
2 metal can	Metal Can	Storing food for a long time	~~Alum~~ Aluminum. paint. paper	light, strong and easy to make	cylinder	Strong.
3 duster	Duster	Wiping Black Bourds	Recycled Material	It is chep	Rectangle	easy to grep on to.
Suitable alternatives	~~Glass Bottle~~ Metal can	Holding Spaggiti	easy to in stok	It's good to recycle		Glue Bottle Glass
Unsuitable alternatives	Metal can	Storing water	Tishoe Paper			Tissue Paper

What makes your suitable alternatives suitable? Its strong. It can store gluer.

What makes your unsuitable alternatives unsuitable? It is weak and too thine.

Investigating design

Science / Technology Term 1 2005

Build it Better

This term the children have undertaken a unit of work titled, 'Build it Better'

The unit provided the opportunity for students to explore the properties of materials and structural shape.

- They developed an understanding of the properties of materials and the characteristics that make it suitable for a particular purpose.
- They used their understanding of material and structural shape to design, make and evaluate/ appraise a product for a particular purpose.

Strengthening the Square

In this session students predicted and tested the effects of bracing has on the strength of a square.

Yes

on each corner. In the strobest bridges you can find Triangles, arches, squares, cylenders and semi-circles.

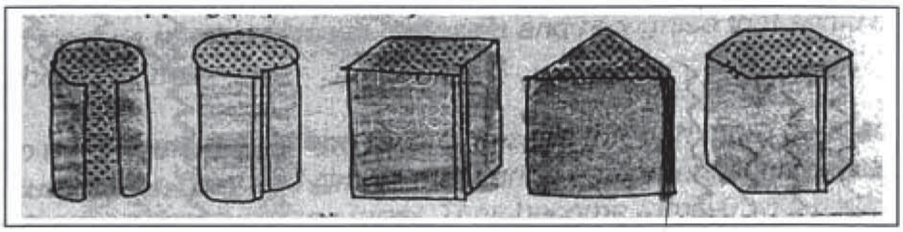
Finding Strong Structures

In these sessions the children first predicted then investigated structural form using paper to 'bridge' a space. They folded paper to simulate trusses, columns and beams.

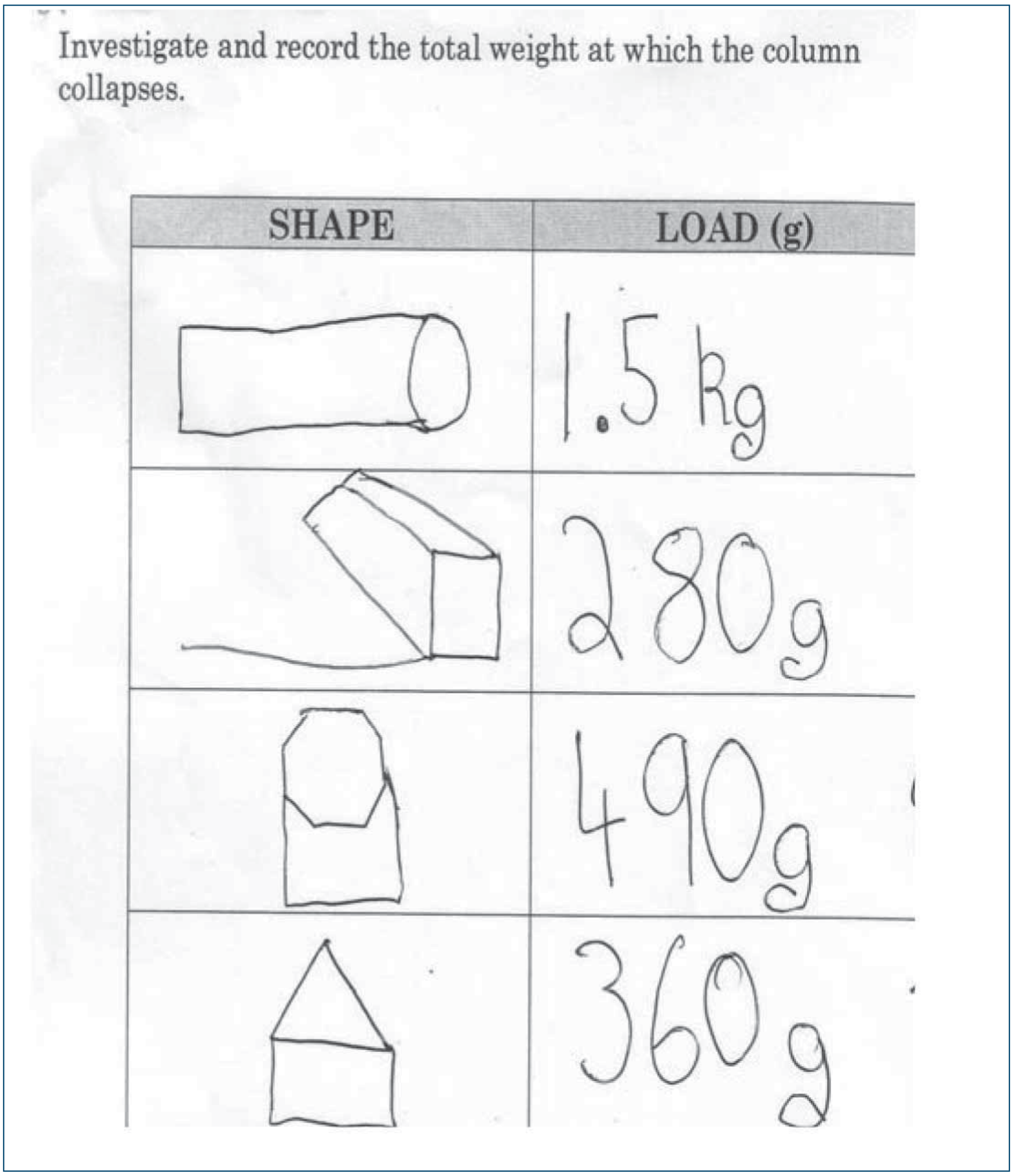
Each shape was tested for weight bearing and data was collected and recorded.

Shape	Load
	430g
	150g
	80g
	110g

In this experiment we had to fold paper to test how much weight it would hold. We found out that some shapes could hold a lot more than others.

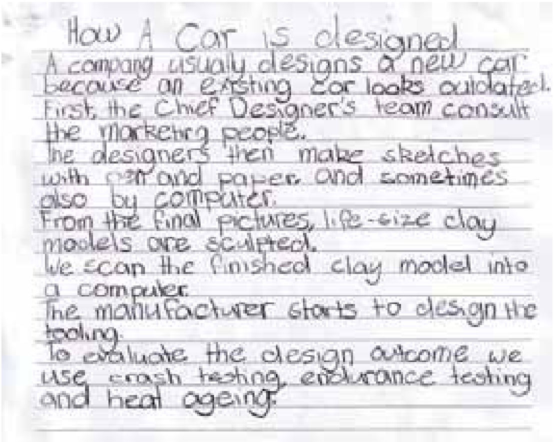


There a columns everywhere.
I found the cylinder to be the strongest.
It held 1.5kgrams.



In this unit students were also expected to identify that the design process includes aspects of investigating, designing, making and appraising. The following individual Year 5 student's text was produced after a process of teacher-directed guided reading of a text about car design, where key points were highlighted, and then students worked collaboratively in groups of three to identify key points for a summary of a procedure and constructed a flow-chart.

Figure 7.3: Summary of a procedure and flow chart

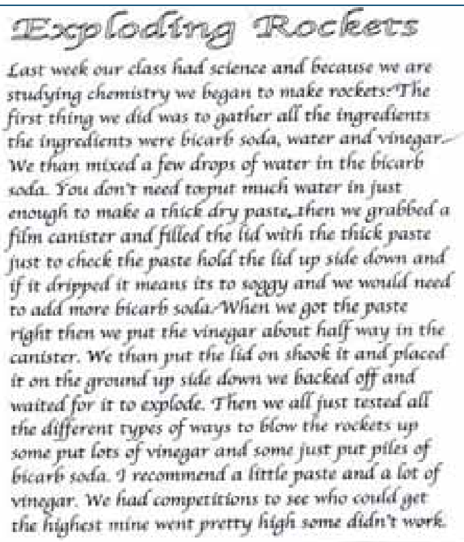


How A Car is designed

A company usualy designs a new car because an existing car looks outdated. First, the Chief Designer's team consult the marketing people. The designers then make sketches with pen and paper and sometimes also by computer. From the final pictures, life-size clay models are sculpted. We scan the finished clay model into a computer. The manufacturer starts to design the tooling. To evaluate the design outcome we use crash testing, endurance testing and heat ageing.

In a unit on chemicals, students were expected to investigate the effects of combining different chemicals. The following Year 5 student text recounts an investigation, incorporating the procedures used:

Figure 7.4: Recount of procedures used in an investigation

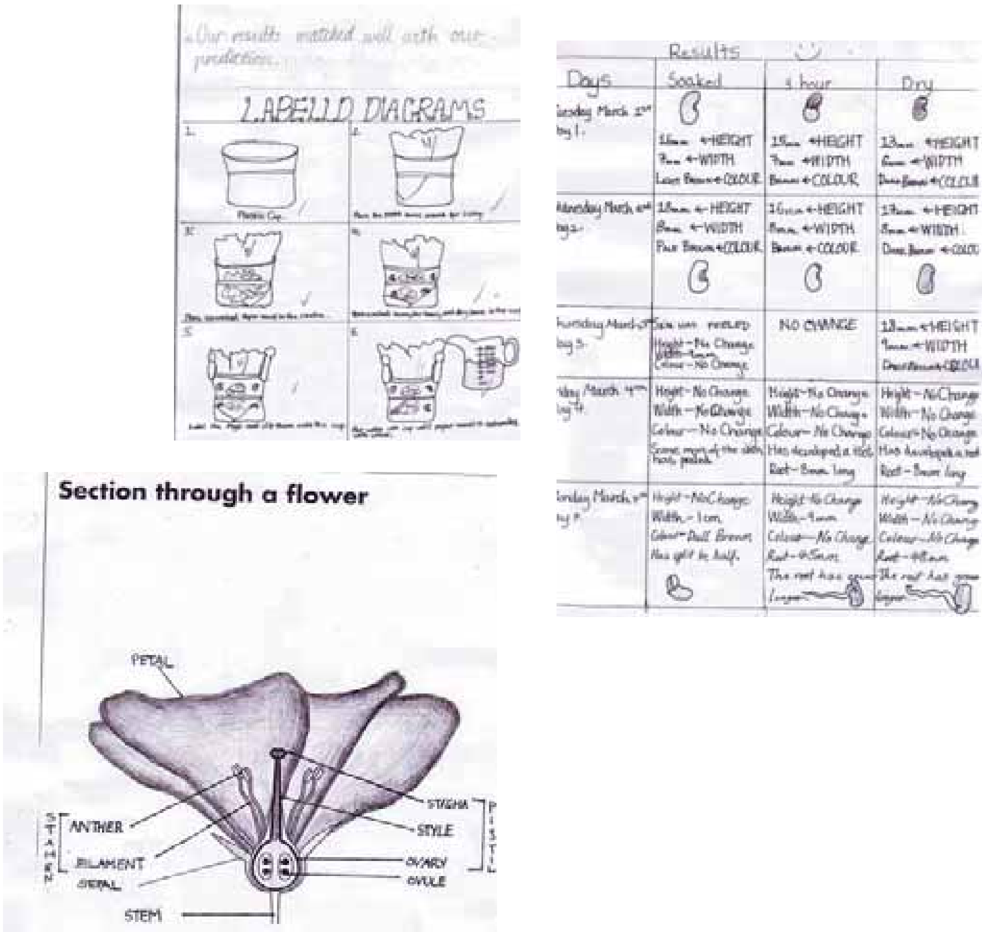


Exploding Rockets

Last week our class had science and because we are studying chemistry we began to make rockets. The first thing we did was to gather all the ingredients the ingredients were bicarb soda, water and vinegar. We than mixed a few drops of water in the bicarb soda. You don't need to put much water in just enough to make a thick dry paste, then we grabbed a film canister and filled the lid with the thick paste just to check the paste hold the lid up side down and if it dripped it means its to soggy and we would need to add more bicarb soda. When we got the paste right then we put the vinegar about half way in the canister. We than put the lid on shook it and placed it on the ground up side down we backed off and waited for it to explode. Then we all just tested all the different types of ways to blow the rockets up some put lots of vinegar and some just put piles of bicarb soda. I recommend a little paste and a lot of vinegar. We had competitions to see who could get the highest mine went pretty high some didn't work.

As part of the outcomes of the *Plants in Action* unit, students were expected to describe changes to a seed during germination, identify parts of a seedling and flower, investigate some variables, and make and record observations. The following Year 4 work examples were produced as part of the lesson sequence.

Figure 7.5: Sample diagrams and a chart from the *Plants in Action* unit



Science literacy products framework

A draft science literacy products framework has been developed to ensure a developmental approach is taken to scaffolding into units the science literacy focuses. This will ensure a developmental approach is taken to supporting students construct these science literacy products. Following further consultation, the framework will be enhanced and then used to guide the revision of trial units.

Figure 7.6: Draft science literacy products framework

Stage	Science journal	Factual texts	Diagrams	Tables	Graphs
Early Stage 1	Teacher-modelled whole class science journal	First-person student oral presentation/ demonstration	Teacher-captioned student drawing	Teacher-constructed whole class table	Teacher-scaffolded whole class pictograph
1	Teacher-modelled whole class science journal Individual student science journal	First-person student written recounts including illustrations Teacher-guided whole class poster Individual role play	Student-captioned drawing using some conventions such as arrows	Student-recorded data in teacher-supplied table	Individual student pictographs
2	Individual student science journal	Procedural texts Summaries Posters Reports incorporating multi-modal representations	Student-drawn cross-section with labelled parts Mind maps	Teacher-supported individual student-constructed simple tables	Individual student bar and column graphs
3	Individual student science journal with increasing focus on multi-modal representation and reflection	Investigation reports incorporating third-person, passive voice construction oral presentation supported by 2D and 3D representations such as posters, powerpoints, models and demonstrations	Student scale drawings from different perspectives Cutaways Flowcharts Concept maps	Individual student tables	Graphs including teacher-supported individual student simple line graphs

Assertions about literacy learning outcomes

Based on the data reported in Chapter 6 and this case study, the following assertions can be made about the impact of *Primary Connections* on student learning in relation to the literacies of science.

Primary Connections has:

7.1 made large changes to teachers' practice, eg, increased frequency of teaching literacy skills needed for learning science;

7.2 supported the production of a large range of science texts; and

7.3 according to both teachers and students, increased the quality and amount of learning of the literacies of science.

Case study 2: An example of whole-school implementation of *Primary Connections*

Introduction

Four of the trial schools conducted a pilot of whole-school implementation of *Primary Connections*; these included two small regional schools in Victoria and two large metropolitan schools in Western Australia. This case study describes a successful whole-school implementation at a large primary school of approximately 650 students. This school has been given the pseudonym of Suburban Primary School. Suburban Primary School is a relatively new school in an outer metropolitan area, close to a light industrial area.

Suburban Primary School was very keen to participate in the trial and to pilot the whole-school implementation of *Primary Connections*. As with other trial schools, two teachers attended the five-day summer school professional learning workshop. In addition the school requested funds from the district office of the Education Department to send a deputy principal to the summer school so that the person who would coordinate the program at their school would fully understand the program and be able to provide support to teachers at his school.

Professional learning

All teachers at Suburban Primary School, including the two teachers who had attended the five-day professional learning summer school in Canberra, attended a one-day professional learning workshop on a pupil-free day at the beginning of term 1, 2005. A science policy officer, who had also attended the summer school, the two trial teachers and the deputy principal supported one of the project directors in facilitating the workshop. The project director was impressed by the interest shown by all teachers in the innovation and by their existing knowledge of learning by inquiry. The project director offered to provide short after-school follow-up workshops for teachers who needed further support with implementing *Primary Connections*. The deputy principal called the project director into the school on one occasion in term 3 to help the Years 4 and 5 teachers with explanations of some astronomy concepts.

Support from the school executive

Sheffield's (2004) case studies of the Collaborative Australian Secondary Science Program (CASSP) demonstrated the importance of support from the school executive for a successful professional learning innovation. In this *Primary Connections* case study, it was evident that the school principal and both deputy principals were highly supportive of the *Primary Connections* initiative. All members of the school executive kept themselves up-to-date with what was happening in the classrooms. They allowed time for staff to attend a whole-school professional learning workshop. A deputy principal was assigned as project coordinator and he attended the summer school in Canberra, gave practical support and advice to teachers in their classrooms, provided regular reports on progress to the district superintendent, prepared a poster display for a literacy conference, and coordinated access by research staff to classrooms and teachers.

Commitment demonstrated by school staff

All of the teachers at Suburban Primary School were involved in the professional learning day at the beginning of term 1, including specialist art and computing (information technology) teachers who would not teach science and literacy themselves but were interested in how they could integrate studies in their learning area with the science and literacy program.

All classroom teachers followed the *Primary Connections* program in term 1. Teachers committed themselves to following the program as set down in the curriculum units, even when they were doubtful of the methods and activities suggested. Later, a number commented that they had been surprised as to how well the program worked and they could now see how the model worked. They were very pleased with the learning outcomes achieved by their students.

Teachers were observed to frequently discuss science and literacy amongst themselves at morning tea and lunch breaks and especially within their teaching teams. The teachers were eager to share their experiences of the *Primary Connections* units with university researchers, often catching them in corridors to share vignettes. Many staff commented that their students 'were loving science'. They willingly participated in small group discussions and were very cooperative about collecting student work samples, allowing researchers to observe their classes and administering research surveys to their students.

Classroom observations

A research assistant spent one day per week in Suburban Primary School during term 1 and most of this time was devoted to observing teaching of science. Two teachers were the focus of these classroom observations, T1 and T2.

Teacher T1

T1 is in her fourth year of teaching and so is relatively new to teaching. She is currently teaching a Year 5 class. She regards the class as average with quite a few academically weak and difficult students.

T1 has a positive attitude towards the *Primary Connections* program and is the science coordinator in the school. She has a science background and prior to taking up teaching, worked in biological research for a number of years. She commented, 'As a scientist, I bring to the school a logical, concise, down to earth approach to doing science'.

Use of inquiry-based learning. T1 is comfortable with inquiry-based learning and uses it confidently. When posing questions for students, she listens to their responses and gives non-judgmental responses such as 'Yes, an interesting idea' or 'Mm-hmm, that's possible, thank you X'. T1 is conscious of the need for students to think for themselves. She made good use of space inside and outside the classroom to give students 'their own work space' when ordering diagrams for the plant life cycle in the *Engage* lesson. Whilst T1 teaches from an inquiry-based perspective, at times she provides too much scientific explanation too soon in the learning sequence. For example, she explained pollination before students were ready for it, which confused some students.

Integration of science and literacy. T1 integrates literacy with science and vice-versa. Spelling and grammar concepts were continually reinforced in science lessons. For example, in an early lesson she gave a short aside on the different forms of 'to' (to, two, too) in relation to using the verb 'to grow'. As new science words were encountered they were written on cards and stuck on the classroom wall to create a word wall. The word wall in the class was extensive and referred to frequently. For journal writing, T1 provided a series of sentence leaders to help students scaffold their writing. For example, 'I wonder why…, I noticed..., I checked this by..., The most difficult part was...'. T1 integrated literacy into her teaching in all learning areas.

Factors leading to successful lessons. The following factors contributed to T1's lessons being successful: the positive attitude of teacher; the teacher being organised; the teacher valued all student responses; explicit links were made between lessons; good modelling of activities for students; expected outcomes made very clear for students; good relationships with students and the teacher managed behavioural problems effectively.

Factors limiting lesson success. The following factors limited the success of T1's lessons: questioning and discussion was sometimes too drawn out (especially in the initial lessons) and students got bored; giving repeated step by step instructions to students about each activity, to the point that they lost interest in listening (not giving responsibility to students); reading instructions to students directly from the teachers' guide (only in the early stages); not creating a sense of mystery about the topic – being too matter of fact (this changed); and conducting class discussions at the end of the day when students were tired.

Changes to practice. Over the term, T1's approach to teaching science showed a number of marked changes. T1 reduced the amount of detailed instruction she gave to students about doing an activity. Initially she had been almost pedantic in her explanations of 'what to do' rather than getting the students to use their initiative and skill to follow the procedure independently. However, near the end of the third lesson, realising that she hadn't achieved what she planned, she took a punt and set them free to complete a series of tasks, calling it 'speed learning'. The students responded with energy and enthusiasm and completed the tasks well, to T1's surprise.

After the third lesson, T1 realised she needed to look ahead in the teachers' guide to see where the topic was heading. This enabled her to give more direction to her overall planning and teaching. As T1's confidence in her own ability to teach science using the program increased, she started to adapt and add to the program to meet the needs of the class. For example, she realised that students didn't understand what a cycle was and that the concept of a cycle was not explicitly explained in the unit (*Plants in Action*). So, she added a lesson on finding other cycles in reference books and then did a follow-up lesson where students created the life cycle of their own imaginary organism.

By the middle of the unit, T1 commented that she felt she now had more of a 'handle on the unit' and her lessons appeared more relaxed, yet at the same time the students were working well and were clear on the expected outcomes. In summary, T1 has implemented the first unit effectively, has learnt from her experience and admitted she would approach it more confidently next time.

Teacher T2

T2 is an experienced teacher and has taught a variety of year groups in her 19 years of teaching. She is currently teaching a Year 5 class at Suburban Primary School. She regards the class as very average, with quite a few weak students.

T2 has a very positive attitude towards the program and has said that she likes the sequential approach and how it develops student understanding. She has embraced the *Plants in Action* unit and made it the focus of her whole term's programming.

Use of inquiry-based learning. T2 is comfortable with inquiry-based learning and uses it confidently. In the *Engage* phase she sought students' views on seeds and plant growth, listened to their predictions but did not make evaluate their answers. She left it up to them to find the answers through doing the activities. She posed questions for them that encouraged them to think about why they were doing something. For example, she asked 'Which way is up for a bean?' and 'Why three seeds per cup?' when they were setting up their bean germinations.

When students asked questions that were extensions of work in progress, she gave them a response that empowered them to find out for themselves. For example, in response to the question 'Why do some plants grow faster than others?', she responded 'Well, I don't know, how could we find out?' which led to other students suggesting 'books, internet, ask some scientists'. One student in her class actually said 'the difference with science this year with Mrs T2 is that she does not give us the answers, she lets us find them out for ourselves', during a student small group discussion on the program.

Integration of science and literacy. T2 used the *Plants in Action* unit as her theme for the term. She used the *Primary Connections* material for literacy exercises in English/language lessons. Conversely, in science sessions, there was much discussion about grammar and spelling of new words when students were writing in their science workbooks. The word wall was prominent in the class and constantly referred to by the teacher.

T2 confidently tried new approaches to linking literacy to science and had the learning skills teacher lead part of the *Explain* lesson. This consisted of a group activity where a plastic cube with questions on it, such as 'Something interesting I've learned is…', was passed around the group and students had to respond with reference to the *Primary Connections* topic.

Factors leading to successful lessons. These factors contributed to T2's lessons being successful: positive attitude of teacher; the teacher being organised; the teacher valued all student responses; explicit links were made between lessons; clear instructions were given in a variety of formats (oral, written); the teacher modelled activities (eg, she pretended to be a dithering student making observations and asked them to critique this); the teacher was willing to try new ideas; and, the teacher knew students well.

Factors limiting lesson success. The following factors limited the success of T2's lessons: questioning and discussion was sometimes too drawn out (especially in the initial lessons) and students got bored; only one task given at a time; early finishers had nothing to go on with (especially in initial lessons); teacher difficulty in understanding of fair tests, variables and replication led to some confusion in the lesson on planning their own investigations; and some worksheets developed in the school were not helpful to the task.

Overall changes. Over the term, T2 became more confident and capable at scaffolding student activities. Initially she was very prescriptive as to how they should do tasks but as time passed she was able to give sufficient guidance but still allow for student initiative and independence. She also learnt to cater for early finishers better by giving them the freedom to go further on their own.

In general, T2 has implemented the program very effectively. She was willing to follow the program as is, despite concerns, and wait until the end of the program to make a judgement as to the value of the program. She has understood the key aims of the program and comfortably uses a constructivist approach in her teaching.

Teacher interviews

A focus group discussion was held with six teachers from Suburban Primary School at the end of term 1, 2005. The focus group comprised teachers T1 and T2, who attended the summer school and the follow-up one-day professional learning workshops, and four other teachers (T3, T4, T5 and T6) who only attended the one-day workshop held at their school at the beginning of term 1. All teachers had taught one unit at the time of the focus group discussion.

How effective is the teaching-learning model?

The teachers were very supportive of the model and made the following comments:

T2 *It has worked well but bear in mind some of the kids have had to learn to work in groups, so these skills have had to be taught before starting.*

T3 *Model itself is good but main problem is doing this as a separate unit.*

I don't think we realised how broad the model actually is; from that point of view the model is really good, to do it again we would use it as part of thematic approach.

T1 *...very flexible, not hierarchical but definitely follows a logical order and allows learning to occur at quite a deep level.*

Does model need any changes?

The only change suggested related to the size of the units and the time needed to complete them.

T2 *...once you got a really good discussion started, you don't want to stop*

Have you used the cooperative learning groups?

All of the focus group teachers had used the cooperative learning groups, and made the following comments

T4 *I have noticed that some students have started to work better as a team, particularly today when they needed to finish planning for building tomorrow. Students needed to have the same ideas down, they really worked very hard to make sure everyone knew what was needed , they were all listening to one another, speaking well, very focused. That's probably the first time I've seen that this term.*

T3 *Group size, we used four per group, but next time we would definitely use three per group.*

T1 *Students have responded well to clearly defined roles, helped them stay on task.*

T4 *For example a young boy in my class who struggles to get through two sentences in half an hour, and can't write anything down, has been able to get a lot of information down, because he is working in a group, and he' very happy with the fact that he can do that, it's made him feel really good about himself, he's participating really well in the group.*

Linking science and literacy

T2 *For me, it became my whole program, spelling, maths, reading.*

T5 *Great, as makes better use of time.*

T3 *...it's been interesting listening them using different words to describe materials. They have progressed naturally from using their own words to using the words given in the glossary such as non-porous, opaque.*

T1 *The students are now quite good at writing short observational dot points as opposed to writing everything is whole sentences, which really has helped some of my students who have a problem with literacy because 'creating the whole sentence takes me so long, that when the time given is up, …I haven't finished, whereas quick dot points is like using telegraph language, I don't have to worry so much, I can keep up.' I've found that really rich.*

T1 *When I asked the children what a summary was, not one could tell me, and they're in Year 5.*

Did the one-day PD workshop prepare teachers at the school for teaching *Primary Connections*?

T6, T5 *It was very good.*

T4 *Good, but I don't think it can fully prepare you for actually teaching the unit.*

T1 *Yes I think it did, but that's partly due to the fact that this school is already very well up on outcomes models like this, embedded teaching, integrated teaching, literacy, the first steps model, because it slotted easily into what we already do but I don't know that it would have been necessarily been enough for teachers in schools that were not doing that.*

What has been the impact on the school?

T2 *More talk amongst staff, more seeking help from each other… More collaboration, more science being done.*

T1 *Students totally enthused about science, visiting other classes to see other students work/plants, talk in playground, talk with parents.*

T1 *When we talk science, we all know what we mean now because we're all doing the same program… It's also fostered a lot more communication about science and between teachers that are not traditionally seen as science focused.*

Assertions from case study 2

This case study has provided insights into the pilot whole-school implementation of *Primary Connections* at one large outer metropolitan primary school. The research assistant and project director have visited this school regularly and judge this to be a most successful implementation of the program. The data gathered support the following assertions about the implementation of *Primary Connections*:

7.4 strong support from the school executive and strong leadership and coordination from the deputy principal contributed to the success of the implementation of the program;

7.5 strong leadership and coordination engendered commitment to the initiative from the whole teaching staff;

7.6 both case study teachers became more confident and capable of teaching through inquiry;

7.7 focus group teachers regarded the *Primary Connections* teaching-learning model, the integration of science and literacy and cooperative group learning to be effective;

7.8 focus group teachers believed that the one-day whole-school professional learning workshop was very good for preparing the school staff for *Primary Connections*; however, additional support may be needed by some teachers; and,

7.9 the program had had many positive impacts on students, teachers and the school.

Chapter 8 | Conclusions and recommendations

The *Primary Connections* professional learning program was designed to increase teachers' confidence and competence in the teaching of science and the literacies of science so that learning outcomes in science and literacy are improved. The professional learning program was based on a series of professional learning workshops complemented with a rich curriculum resource and opportunities for reflection and collegial support. The research into and evaluation of the program was framed around the following research questions:

1. How workable and effective is the teaching and learning model which has been used in developing the curriculum units and template?
2. How can the curriculum and professional learning resources be revised and improved before implementation in Stage 3?
3. What impact has the program had on students, teachers, schools and jurisdictions?
4. What insights into effective teacher professional learning are gained from the trial whole-school roll-out of the professional learning model in the case study schools?
5. What changes are needed to enhance compatibility with jurisdictions' curriculum frameworks or professional learning support structures?

Data gathered through teacher questionnaires, student surveys, focus group discussions, classroom observations, document analysis, discussions with teachers at professional learning workshops and detailed feedback provided by teachers on the curriculum units has provided a rich picture of the impact of the program on teachers, students and schools, and insights into the effectiveness of the teaching-learning model, the professional learning workshops and the curriculum resources. Insights have also been gained into how the effectiveness of the whole-school implementation of *Primary Connections* can be maximised in the proposed Stage 3 of the project.

The analysis of the quantitative data in Chapter 6 generated a number of key findings which were interpreted and generalised into a number of assertions. Case study data in Chapter 7 were also interpreted to generate further assertions.

Assertions developed from quantitative data in Chapter 6

6.1 The sample of 106 teachers and 56 schools participating in the trial was broadly representative of all jurisdictions, sectors and regional locations. The sample included some schools with high Indigenous enrolments and comprised a mix of inexperienced, experienced and very experienced teachers who were mostly four-year trained, half had no science studies beyond Year 12 and half had not attended science professional learning in the previous year.

6.2 Teachers rated the summer school highly for achieving its goals and preparing them for teaching science, the one-day workshops had high rates of attendance and most teachers considered them helpful or very helpful. Almost 90 per cent of teachers rated the program as good or better than any they had attended and gave very strong endorsement of the summer school and curriculum units.

6.3 Almost 90 per cent of teachers rated the curriculum resources as effective or very effective because they were flexible and suitable for teachers of a wide range of experience, scaffolded learning and were compatible with their local curriculum frameworks. 95 per cent of teachers wanted the Academy of Science to develop additional units. Teachers would prefer the curriculum resources to be supplied as hard copy and CD-ROM.

6.4 *Primary Connections* significantly increased teachers' confidence with science and literacy teaching strategies and significantly increased teachers' self-efficacy, and, of educational significance, the number of teachers with low self-efficacy was dramatically reduced. The increase in confidence and self-efficacy can be attributed to teachers' increased pedagogical content knowledge and being supported with a quality curriculum resource.

6.5 *Primary Connections* made large changes to teachers' practice (eg, increased frequency of teaching literacy skills needed for learning science, increased use of diagnostic assessment, increased frequency of hands-on activity work, use of digital cameras and cooperative learning strategies) and had improved their science teaching. By the end of term 2, teachers' concerns had changed from focusing on activities and strategies to focusing on achieving learning outcomes. Teachers attributed improvements in their science teaching to increased confidence and improved pedagogical content knowledge.

6.6 Teachers integrated science and literacy by developing the literacies of science focuses in literacy lessons and by using science to provide contexts and purpose for literacy learning. Almost 90 per cent of teachers considered the integrated approach had improved science learning and 73 per cent considered that the integrated approach had improved literacy learning. In addition to literacy, science was integrated with mathematics, art, society and environment, and technology.

6.7 *Primary Connections* supported a large increase in science teaching time and status of science in the school curriculum. Science shifted from being an afternoons-only subject to being a mornings and afternoons subject. The increase in science teaching time can be attributed to teachers' increased confidence and self-efficacy, and having a quality curriculum resource to support their teaching. The shift in time of day at which science was taught can be attributed to the integration of science with literacy.

Assertions developed from case study 1 in Chapter 7

7.1 made large changes to teachers' practice, eg, increased frequency of teaching literacy skills needed for learning science;

7.2 supported the production of a large range of science texts; and

7.3 according to both teachers and students, increased the quality and amount of learning of the literacies of science.

Assertions developed from case study 2 in Chapter 7

7.4 strong support from the school executive and strong leadership and coordination from the deputy principal contributed to the success of the implementation of the program;

7.5 strong leadership and coordination engendered commitment to the initiative from the whole teaching staff;

7.6 both case study teachers became more confident and capable of teaching through inquiry;

7.7 focus group teachers regarded the *Primary Connections* teaching-learning model, the integration of science and literacy and cooperative group learning to be effective;

7.8 focus group teachers believed that the one-day whole-school professional learning workshop was very good for preparing the school staff for *Primary Connections*; however, additional support may be needed by some teachers; and,

7.9 the program had had many positive impacts on students, teachers and the school.

This chapter draws on these assertions in developing the main conclusions to the research and then these are used to suggest a number of recommendations for further action.

Conclusions

The conclusions are developed by synthesising the assertions into broader generalisations which are reported in relation to the five research questions.

How workable and effective is the teaching and learning model which has been used in developing the curriculum units and template?

The program was based on a teaching-learning model which integrates the constructivist, inquiry-based 5Es model; diagnostic, formative and summative assessments; representation and re-representation of understandings; use of ICTs; scaffolding the development of literacies of science; open investigations; and cooperative learning strategies.

The anecdotal evidence from informal discussions at all the professional learning workshops indicates that the teachers wholeheartedly support the teaching-learning model. Questionnaire data (Assertions 6.3, 6.5, 6.6, 6.9) and case studies (Assertions 7.2, 7.7) provide evidence that the model was appropriate and effective. The teachers considered that the curriculum units based on the model were very effective because they scaffolded learning, supported the progressive development of understandings, and effectively integrated science and literacy so that learning in both science and literacy were improved. Working with the model also facilitated significant changes to teachers' practice so that there was an increase in hands-on activity work, use of diagnostic assessments, use of digital cameras and cooperative group work, and students developed a wide range of forms of representation of their knowledge.

How can the curriculum and professional learning resources be revised and improved before implementation in Stage 3?

Teachers provided extremely detailed feedback on each of the curriculum units (eg, Appendix 7). Almost 90 per cent of the teachers considered the units to be effective or very effective (Assertion 6.3). The annotations made by teachers on the unit booklets made suggestions about how each of the lessons could be fine-tuned to make them easier to implement. This detailed information is being used to guide the revision of these units before they are made available for widespread distribution. The most common suggestions are that the lessons should be shorter, the units should be shorter and the expected literacy demands be moderated for the Early Stage 1 and Stage 1 units (Key finding 8, Chapter 6).

The teachers gave very positive feedback about the professional learning workshops. Almost 90 per cent of teachers indicated that the professional learning program was as good as or better than any they had attended (Assertion 6.2). The whole-school one-day professional learning workshop was piloted at the four case study schools and was well-received by teachers (Assertion 7.8). Teachers commented that video clips of teachers working with *Primary Connections* would have enhanced the professional learning experience. Video clips are currently being collected for inclusion in the professional learning resources.

What impact has the program had on students, teachers, schools and jurisdictions?

The research data indicate that *Primary Connections* has had a profound impact on teachers, students and schools.

Teachers

Initially, many of the trial teachers had low confidence and self-efficacy for science teaching. Half of the trial teachers had not completed any science studies beyond Year 12 and half had not attended any science professional learning programs in the previous year (Assertion 6.1). *Primary Connections* significantly increased teachers' confidence with science and literacy teaching strategies and significantly increased teachers' self-efficacy, and, of educational significance, the number of teachers with low self-efficacy was dramatically reduced. The increase in confidence and self-efficacy can be attributed to teachers' increased pedagogical content knowledge and being supported with a quality curriculum resource (Assertion 6.4).

Primary Connections supported a large increase in science teaching time. Science shifted from being an afternoons-only subject to being a mornings and afternoons subject. The increase in science teaching time can be attributed to teachers' increased confidence and self-efficacy, and having a quality curriculum resource to support their teaching. The shift in time of day at which science was taught can be attributed to the integration of science with literacy (Assertion 6.7).

Primary Connections made large changes to teachers' practice (eg, increased frequency of teaching literacy skills needed for learning science, increased use of diagnostic assessment, increased frequency of hands-on activity work, use of digital cameras and cooperative learning strategies) and had improved their science teaching. Teachers integrated science and literacy by developing the literacies of science in literacy lessons and by using science to provide contexts and purpose for literacy learning. Almost 90 per cent of teachers considered the integrated approach had improved science learning and 73 per cent considered that the integrated approach had improved literacy learning (Assertion 6.6).

By the end of term 2, teachers' concerns had changed from focusing on activities and strategies to focusing on achieving learning outcomes. Teachers attributed improvements in their science teaching to increased confidence and improved pedagogical content knowledge (Assertion 6.5). Classroom observations made of case study teachers indicated that as they gained experience teaching with the support of *Primary Connections* units, the teachers' confidence increased and their teaching through inquiry improved (Assertion 7.6).

Students

The student survey data show that a large majority of students enjoyed science and believed that they had learned more science using *Primary Connections* than previously (Assertion 6.10). Almost 90 per cent of teachers indicated that their students had responded positively or very positively to the *Primary Connections* activities and learning approach, more than 75 per cent indicated that their students had learned more science and the quality of science learning was higher with *Primary Connections* than with their previous science program (Assertion 6.9). These student and teacher perceptions of high learning outcomes were corroborated by student science achievement data which indicated that mean achievement scores, for a sample of Year 5 students, increased significantly over one unit (more than doubled) and almost 80 per cent of the sample of Year 5 students were working at or above level 3 on the national scientific literacy progress map, which is the national proficiency standard for Year 6 students (Assertion 6.11).

Schools

Teachers also reported many positive impacts of the program at the school level (Assertion 7.9). More than 90 per cent of teachers indicated that *Primary Connections* had a significant impact on their schools; increasing students' and teachers' interest in science, the profile of science within the school and local community, and increasing the amount of science being taught in their schools (Assertion 6.12).

It should be noted, however, that even with the support of the *Primary Connections* program, a significant number of teachers reported that their schools had inadequate school budgets for science (26 per cent), insufficient equipment and consumables (20 per cent), they had no science coordinator (37 per cent) and did not report science achievement as a separate subject on school reports to parents (30 per cent) (Assertion 6.8).

What insights into effective teacher professional learning are gained from the trial whole-school roll-out of the professional learning model in the case study schools?

Case study 2 provides an account of a very successful whole-school implementation of *Primary Connections* and identifies a number of factors that contributed to the success of the initiative at the school. Strong support and leadership from the school executive, effective coordination of the program by the deputy principal, and peer support from two trial teachers who had attended the summer school professional learning workshop, engendered involvement and commitment to the project from the whole school staff (Assertions 7.4, 7.5).

Teachers at this school considered that the one-day professional learning workshop that introduced teachers to the program was effective in helping teachers to teach the science and literacy program; however, follow-up support was needed to assist teachers with emerging issues as they taught the program (Assertion 7.8). Planning of the professional learning resources is taking account of the feedback from this pilot of a whole-school implementation in that resources are being prepared for a one-day workshop with a smorgasbord of follow-up 1.5 hour workshops that will provide further support in key areas such as implementing and assign investigations, and developing literacies of science.

What changes are needed to enhance compatibility with jurisdictions' curriculum frameworks or professional learning support structures?

Almost 90 per cent of teachers considered the units compatible with their jurisdictions' curriculum frameworks and schools' science programs, and 95 per cent of teachers wanted the Australian Academy of Science to produce additional units (Assertion 6.3). Many teachers commented on the flexibility of the curriculum resources and that they found it relatively easy to adapt them to local contexts and needs. Continual monitoring of changes to jurisdictions' curriculum frameworks and the potential development of a national statement of learning for science will ensure that the project's scope and sequence chart can be continually updated to guide the development of new units.

Discussions with representatives from the various jurisdictions on the reference group has indicated that the project's design and resources will support a wide range of models of implementation that will be needed in different jurisdictions, where the professional learning support structures vary from one jurisdiction to the next. Indeed, the quality and flexibility of the program has resulted in the trial being successfully completed in all of Australia's educational jurisdictions.

Recommendations

The research conducted as part of the evaluation of the Stage 2 trial of *Primary Connections* indicates that the program has been very successful in terms of its impact on teachers, students and schools. The flexibility of the program has enabled the program to be implemented effectively in different types of schools and sectors throughout Australia. Research evidence demonstrates that *Primary Connections* has the potential to improve the quality of science teaching and the scientific literacy of young Australians.

The following recommendations are made to guide planning for future developments of the program and more widespread implementation of *Primary Connections*.

Recommendation 1

The research evidence provides a compelling case for the continuation and extension of the project to Stage 3. It is therefore recommended that the Australian Government's Department of Education, Science and Training and state and territory Departments of Education and Training provide further support to the *Primary Connections* initiative so that Stage 3 of the project can be commenced from term 4, 2005. A smooth transition between stages is imperative to maintain momentum and enthusiasm.

Recommendation 2

That Stage 3 of the *Primary Connections* project train professional learning facilitators from each state and territory and develop further curriculum units to support whole-school implementations of *Primary Connections*. Further research should be conducted to evaluate new units being trialled, the effectiveness of the professional learning facilitators and the impact of the whole-school implementations on students, teachers and schools.

Recommendation 3

The reference group agreed that a number of principles should guide the implementation of the *Primary Connections* program in Stage 3 to ensure the quality and sustainability of the ongoing implementation of the program. It is recommended that the following principles guide the implementation of *Primary Connections* in Stage 3:

- whole-school implementation (where possible);
- implementation be based on a combination of professional learning and curriculum resources;
- professional learning workshops to be facilitated by *Primary Connections* trained facilitators;
- professional learning workshops to be presented by facilitator plus a trial teacher where facilitators are not trial teachers;
- team-based school coordination to ensure succession planning;
- ongoing support and coordination for the team of facilitators within each jurisdiction.

Recommendation 4

Feedback from the trial teachers clearly indicates a preference for hardcopy and CD-ROM formats for the curriculum resources. It is therefore recommended that the curriculum resources are made available to schools in hardcopy and CD-ROM formats, and that the professional learning resources are made available in DVD/CD-ROM formats. The *Primary Connections* website should be further developed and funded to enable ongoing upgrading and effective communication with and between all participants, and to ensure currency of resources.

Recommendation 5

Major reform of teaching and learning can only be achieved through ongoing professional learning of inservice teachers; however, new teachers to the profession can have a large impact if properly prepared for implementing initiatives such as *Primary Connections*. It is therefore recommended that an initial teacher education resource pack be developed as part of Stage 3 to provide universities with a set of coherent resources to induct pre-service teachers into the *Primary Connections* teaching and learning model and to develop familiarity with the resources. A one-day professional learning workshop for university science teacher educators would enhance the uptake and impact of the resource pack.

Recommendation 6

It is recommended that Stage 3 further develop connections with Indigenous contexts and knowledge for learning science and the literacies needed for learning science within *Primary Connections* curriculum units to engage Indigenous students and improve their educational outcomes in science and literacy.

Recommendation 7

It is recommended that Stage 3 strengthen links with other national science education initiatives such as SEAR, Learning Objects (The Learning Federation) and the National Statements of Learning, and that further professional learning programs supported by quality curriculum resources be prepared to ensure continuity of engagement with science learning across the whole school experience.

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NSW Department of Education and Training

NT Department of Employment, Education and Training

Education Queensland

SA Department of Education and Children's Services

TAS Department of Education and Training

VIC Department of Education and Training

WA Department of Education and Training

National Catholic Education Commission

Independent Schools Council of Australia

Australian Science Teachers Association

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Trial schools

ACT	Evatt Primary School	Government	Indigenous focus
	Narrabundah Primary School	Government	Indigenous focus
NSW	Adamstown Public School	Government	
	Bowning Public School	Government	
	Breadalbane Public School	Government	
	Broughton Anglican College	Independent	
	Collector Public School	Government	
	Griffith Public School	Government	
	Hill Top Public School	Government	
	Holy Cross Primary School	Catholic	
	Mt Brown Public School	Government	
	Rydalmere EastPublic School	Government	
	St Gregory's Primary School	Catholic	
	Tarago Public School	Government	
	Tirranna Public School	Government	
	Undercliffe Public School	Government	
	Wee Waa Public School	Government	
NT	Larapinta Primary School	Government	Indigenous focus
Qld	Albany Hills State School	Government	
	Bribie Island State School	Government	
	Caboolture State School	Government	
	Clinton State School	Government	
	Darling Heights State School	Government	
	Ironside State School	Government	
	Jamboree Heights State School	Government	
	St Joseph's Tobruk Memorial School	Catholic	
	Urangan Point State School	Government	
SA	All Saints Catholic Primary School	Catholic	
	Balaklava Primary School	Government	
	Klemzig Primary School	Government	
	Marryatville Primary School	Government	
	Reidy Park Primary School	Government	
	St Patrick's School	Catholic	
	St Peter's Woodlands Grammar School	Independent	
	West Lakes Shore Schools	Government	

Tas	Latrobe Primary School	Government	
	Mt Faulkner Primary School	Government	
Vic	Bannockburn Primary School	Government	
	Churchill Primary School	Government	
	Cobram Primary School	Government	
	Commercial Road Primary School	Government	
	Gunbower Primary School	Government	Whole school trial
	Haileybury College, Edrington	Independent	
	Nunawading Primary School	Government	Whole school trial
	Sherbourne Primary School	Government	
	St Christopher's Syndal	Catholic	
WA	Bibra Lake Primary School	Government	Whole school trial
	Challis Primary School	Government	
	Huntingdale Primary School	Government	
	Marmion Primary School	Government	
	Perth College	Independent	
	Ranford Primary School	Government	Whole school trial
	Rossmoyne Primary School	Government	
	Sawyers Valley Primary School	Government	
	St Mary's Catholic School	Catholic	
	Woodlupine Primary School	Government	

Appendix 2 | Scope and sequence chart: Overview of units

Stage	SL level	Year of schooling	EB	EC	LL	NPM
Early 1	**< 1**	**1**	Stage theme: Investigating my surroundings and me			
			Weather in my World Weather effects me and my surroundings.	**On the Move** Movement of children, animals and toys.	Caring for living things, their needs and living spaces.	Types of materials in my surroundings and their properties.
1	**1-2**	**2 and 3**	Stage theme: Organising my world			
			What's Up Features of the day and night sky	Forms of energy and how we use them, heat, insulation, food, growth, movement	Plants, animals, living and non-living, life processes	**Material Matters** Natural and made materials; solids, liquids and gases; wood, metal, plastic
			Living spaces, types of resources and caring for the environment	**Push-pull Power** Floating and sinking, flight	Plant nutrition and growth, roles of roots, leaves and stems	Rubbish and recycling. Re-use of materials.
2	**2-3**	**4 and 5**	Stage theme: Changes, patterns and relationships in my world			
			Spinning in Space Changes brought about by the rotation of the Earth; Moon, Sun, stars and shadows	Sights and Sounds Light, shadows, reflection Vibrations and sounds	**Plants in Action** Plant life cycles, flowers and germination	Cooking and chemistry of food. Mixing, dissolving, melting. Heating and cooling changes substances. Reversible and irreversible changes
			Structure of the Earth and changes at its surface. Soils.	Energy sources, energy audit, patterns of use, transport, reducing waste	Structure and function of body systems, breathing, circulation, energy and exercise	Investigating properties and uses of materials e.g. paper and plastic. Testing strength, transparency, absorbency, biodegradability
3	**3-4**	**6 and 7**	Stage theme: Systems and how they work			
			Recording and analysing weather data. Seasonal changes	Electrical circuits and current	**Marvellous Micro-organisms** Yeast and bread making, moulds and penicillin	**Build it Better** Materials, structure, properties, design
			Our solar system, relationships between Earth, Sun, Moon and the lunar cycle	Forces and motion, sliding, rolling, gears, levers	Human impact on natural systems, pollution, interdependence, food chains, water	Physical and chemical changes to matter. Formation of new substances and conservation of matter e.g. combustion.

Appendix 3 | National scientific literacy progress map

Level	Domains of scientific literacy		
	Domain A Formulating or identifying investigable questions and hypotheses, planning investigations and collecting evidence	**Domain B** Interpreting evidence and drawing conclusions, critiquing the trustworthiness of evidence and claims made by others, and communicating findings	**Domain C** Using understandings for describing and explaining natural phenomena, and for interpreting reports
1	Responds to the teacher's questions, observes and describes.	Describes what happened.	Describes an aspect or property of an individual object or event that has been experienced or reported.
2	Given a question in a familiar context, identifies a variable to be considered, observes and describes or makes non-standard measurements and limited records of data.	Makes comparisons between objects or events observed.	Describes changes to, differences between or properties of objects or events that have been experienced or reported.
3	Formulates scientific questions for testing and makes predictions. Demonstrates awareness of the need for fair testing. Makes simple standard measurements. Records data as tables, diagrams or descriptions.	Displays data as tables or bar graphs, identifies and summarises patterns in science data. Applies the rule by extrapolating or predicting.	Explains the relationships between individual events that have been experienced or reported and can generalise and apply the rule by predicting future events.
4	Identifies the variable to be changed, the variable to be measured and several variables to be controlled. Uses repeated trials or replicates.	Calculates averages from repeat trials or replicates, plots line graphs where appropriate. Conclusions summarise and explain the patterns in the data. Able to make general suggestions for improving an investigation (eg. make more measurements).	Explains interactions, processes or effects, that have been experienced or reported, in terms of a non-observable property or abstract science concept.

Level	Domains of scientific literacy		
	Domain A Formulating or identifying investigable questions and hypotheses, planning investigations and collecting evidence	**Domain B** Interpreting evidence and drawing conclusions, critiquing the trustworthiness of evidence and claims made by others, and communicating findings	**Domain C** Using understandings for describing and explaining natural phenomena, and for interpreting reports
5	Formulates scientific questions or hypotheses for testing and plans experiments in which most variables are controlled. Selects equipment that is appropriate and trials measurement procedure to improve techniques and ensure safety.	Conclusions explain the patterns in the data using science concepts, and are consistent with the data. Critiques reports of investigations noting any major flaw in design or inconsistencies in data.	Explains phenomena, or interprets reports about phenomena, using several abstract scientific concepts.
6	Uses scientific knowledge to formulate questions, hypotheses and predictions and to identify the variables to be changed, measured and controlled. Trials and modifies techniques to enhance reliability of data collection.	Selects graph type and scales that display the data effectively. Conclusions are consistent with the data, explain the patterns and relationships in terms of scientific concepts and principles, and relate to the question, hypothesis or prediction. Critiques the trustworthiness of reported data (eg. adequate control of variables, sample or consistency of measurements), and consistency between data and claims.	Explains complex interactions, systems or relationships using several abstract scientific concepts or principles and the relationships between them.

Note 1: It is anticipated that the national standard for scientific literacy for Year 6 students will be set in Level 3.

Note 2: This map was developed for the Primary Science Assessment Project and the Science Education Assessment Resources Project funded by the Australian Government's Department of Education, Science and Training.

Appendix 4 | Draft literacy focuses progress map

Stage	Science Journal	Factual Texts	Diagrams	Tables	Graphs
ES1	Teacher-modelled whole class science journal	First-person student oral presentation/demonstration	Teacher-captioned student drawing	Teacher-constructed whole class table	Teacher-scaffolded whole class pictograph
S1	Teacher-modelled whole class science journal Individual student science journal	First-person student written recounts including illustrations Teacher-guided whole class poster Individual role play	Student-captioned drawing using some conventions such as arrows	Student-recorded data in teacher-supplied table	Individual student pictographs
S2	Individual student science journal	Procedural texts Summaries Posters Reports incorporating multi-modal representations	Student-drawn cross-section with labelled parts Mind maps	Teacher-supported individual student-constructed simple tables	Individual student bar and column graphs
S3	Individual student science journal with increasing focus on multi-modal representation and reflection	Investigation reports incorporating third-person, passive voice construction Oral presentation supported by 2D and 3D representations such as posters, PowerPoints, models and demonstrations	Student scale drawings from different perspectives Cutaways Flowcharts Concept maps	Individual student tables	Graphs including teacher-supported individual student simple line graphs

Literacy focus text

- **Science journals (S1, S2, S3)**

A **science journal** is a written record of observations, experiences and reflections gathered during science lessons. It contains a series of chronological entries, each with the date on which the entry was made and a heading. Entries can consist of written text, labelled diagrams, tables of results and graphs.

- **Word Wall (ES1, S1, S2, S3)**

A **Word Wall** is an organised collection of words displayed in large letters on the wall or in a large display space. It supports the development of vocabulary related to a particular topic and provides reference support for students during reading and writing.

- **Data chart (ES1, S1, S3)**

A **data chart** is used to organise information logically, so that the reader can access the information more easily. It consists of a chart title, columns with headings, and information organised under the appropriate headings.

- **Labelled diagram (ES1, S1, S2)**

A **labelled diagram** is used to illustrate the shape and features of an object more clearly than can be achieved with a word description. It has a title, drawing and labels to identify the main features.

- **Letters (ES1)**

A **letter** is a written form used to transfer or request information. It includes the address of the writer, the date the letter was written, an opening greeting, the information or request to be communicated, a closing greeting, and the name of the writer.

- **Interview (ES1)**

An **interview** is a series of orally-delivered questions designed to elicit information. Interviews may be conducted in person or by telephone. The three major types of interviews are: (1) structured, where all questions to be asked by the interviewer are specified in advance; (2) semi-structured, where the interviewer can ask other questions and prompts in addition to the specified questions; and (3) unstructured, where the interviewer has a list of topics, but no or few specified questions.

- **Summary (S2, S3)**

A **summary** is a brief statement that presents the main points in an efficient, concise form. The purpose of a summary is to provide the main information in an organised, logical way.

- **Flowchart (S3)**

A **flowchart** is a graphic organiser used to describe a sequence of events, stages or phases. A linear flowchart arranges the information in one line and uses arrows to indicate the order in which to read the text.

- **Factual text (ES1, S2)**

A **factual text** presents information or ideas to inform, instruct or persuade the reader. In science, factual texts are multimodal using printed text, visual text and text organisers to present information. They include titles, labels, highlighted keywords, diagrams, maps, and photographs.

- **Narrative text (ES1, S1)**

A **narrative text** presents an imaginative experience to entertain, interest and engage the reader. A narrative may also seek to inform, explain (myths and legends) or instruct (fables). The general structure of a narrative includes an orientation (establishment of time, setting, main characters), a series of events and complication, and a resolution where the complication is resolved satisfactorily. Language features of narrative texts include descriptive language, dialogue, use of first or third person pronouns, and normal past tense.

- **Recount text (S1)**

A **recount text** describes or reconstructs past experiences. They are typically based on the author's direct experiences, and may include personal feelings or interpretations. A recount begins with an orientation followed by events in sequential (or chronological) order, and often conclude with an evaluative comment reflecting on the author's feelings. Language features of recount texts include reference to specific participants, written in past tense, and connective language to link events and times.

- **Procedural text (S2, S3)**

Procedural texts are used to describe how something is done, and include directions and instructions. They include a goal or aim, a list of requirements or materials needed to complete the task, and a sequence of steps written in the order needed to complete them.

Appendix 5 | Professional learning workshop, 17-21 January 2005, Canberra

Monday Jan 17 University House and The Shine Dome	Tuesday Jan 18 CSIRO Discovery	Wednesday Jan 19 The Shine Dome	Thursday Jan 20 The Shine Dome	Friday Jan 21 The Shine Dome
Engage	***Explore***	***Explain***	***Elaborate***	***Elaborate* and *Evaluate***
Session 1 The Hall, University House 9.30 Coffee 10.00-11.15 Letters of consent, initial data collection Mark Hackling	9.00-10.30 Exploring the curriculum units in stage-based groups. Facilitators: Early stage 1 Vaughan Prain Stage 1 Russell Tytler Stage 2 Mark Hackling Stage 3 Denis Goodrum	9.00-9.45 Using technologies effectively Vaughan Prain 9.45-10.30 Effective pedagogies surrounding the learning objects Lea Chapuis	9.00-10.30 Improving assessment practice Mark Hackling	9.00-10.00 Component mapping Russell Tytler
11.15 Walk to the Shine Dome	**Morning tea 10.30-11.00**	**Morning tea 10.30-11.00**	**Morning tea 10.30-11.00**	**Morning tea 10.00-10.30**
Session 2 The Shine Dome 11.30 Welcome Jim Peacock, John McKenzie, Trish Mercer 11.45-12.45 What is good science teaching like? Introduction to pedagogical principles. Pairwise interviews. Russell Tytler	11.00-12.30 Trying out the activities, making observations, discussing findings and developing explanations.	11.00-1.00 The 5Es model, cooperative learning strategies, effective questioning techniques. Denis Goodrum	11.00-1.00 Unit planner and template, overall design of units Unit planning using the template Mark Hackling and Vaughan Prain Facilitators: Russell Tytler, Denis Goodrum (Teachers to bring their own curriculum resources to develop a unit during this session)	10.30-12.30 Working with others, managing change through audit and action planning processes; building school commitment for whole-school implementation. State-based groups. Russell Tytler Facilitators: Mark Hackling, Vaughan Prain, Denis Goodrum, Ina Kuehlich
Lunch 12.45-1.45	**Lunch 12.30-1.30** **Tour of CSIRO Discovery**	**Lunch 1.00-2.00**	**Lunch 1.00-2.00**	**Lunch 12.30-1.30**
Session 3 1.45-3.15 Exploring literacy practices Vaughan Prain	1.30-3.15 Overview of concepts and conceptual development in the units.	2.00-4.00 Open investigations and inquiry. Break-out groups. Mark Hackling Facilitators: Vaughan Prain, Russell Tytler, Denis Goodrum	2.00-2.45 Reflection, journaling and discussion in stage-based groups. Facilitators: Mark Hackling, Vaughan Prain, Russell Tytler, Denis Goodrum	1.30-2.00 Reflection, journaling and discussion in stage-based groups. Facilitators: MH, VP, RT, DG 2.00-2.30 Evaluation of workshop 2.30-3.30 Celebration, closure and drinks
Afternoon tea 3.15-3.45	**Afternoon tea 3.15-3.45**	**Afternoon tea 4.00-4.30**		
Session 4 3.45-4.30 Reflection, journaling and discussion in stage-based groups. Facilitators: Mark Hackling, Vaughan Prain, Russell Tytler, Marian Heard	3.45-4.15 Reporting back to whole group. How pedagogical principles are demonstrated in the units. Russell Tytler 4.15-5.00 Reflection, journaling and discussion in stage-based groups. Facilitators: Mark Hackling, Vaughan Prain, Russell Tytler, Denis Goodrum	4.30-5.00 Reflection, journaling and discussion in stage-based groups. Facilitators: Mark Hackling, Vaughan Prain, Russell Tytler, Denis Goodrum	Free afternoon	4.00 Buses depart for airport
6.30 BBQ, Fellows Garden, University House	Free evening	6.30 Dinner and tour of galleries, Questacon	7.00 Dinner, The Deck, Regatta Point	

Appendix 6 | End of term 1 teacher questionnaire

We request your name and school details for follow-up purposes only. Your responses will contribute to our overall picture of primary science teaching. Only the researchers will see your name.

Please answer this questionnaire honestly and frankly. Respond in the way that it is, rather than portraying things as you would like them to be seen.

ID number

For office use only

Teacher background

Teacher name: ____

State/Territory: ____

Name of school: ____

About your science teaching

Which science topic did you teach this Term? ____

Did you teach from the *Primary Connections* unit? Yes / No

What year level is this class? ____

What time of day did you mainly teach science this Term? am / pm / am and pm

Tick one box to indicate how much science you have taught this Term.

Amount of science taught	Tick
I taught science on a regular basis and averaged 60 minutes or more per week this Term	
I taught science on a regular basis and averaged between 30 and 60 minutes per week this Term	
I taught science intermittently and averaged less than 30 minutes per week this term	
I rarely taught science this Term	

Now that you are using *Primary Connections*, please indicate the degree to which you agree or disagree with each statement below by ticking the appropriate box to the right of each statement:

SA = Strongly Agree; A = Agree; UN = Uncertain;
D = Disagree; SD = Strongly Disagree

Item	Statement	SA	A	UN	D	SD
1	I am continually finding better ways to teach science					
2	Even when I try very hard, I don't teach science as well as I do most subjects					
3	I know the steps necessary to teach science concepts effectively					
4	I am not very effective in monitoring science experiments					
5	I generally teach science ineffectively					
6	I find it difficult to explain to students why science experiments work					
7	I am typically able to answer students' science questions					
8	Given a choice, I would not ask the Principal to evaluate my science teaching					
9	When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better					
10	When teaching science, I usually welcome student questions					

Please rate your confidence with the following aspects of science teaching when using *Primary Connections.*

VC = Very confident; C = Confident;
LC = Limited confidence; NC = No confidence

Item	Aspect	VC	C	OK	LC	NC
1	Engaging students' interest in science					
2	Managing hands-on group activities in science					
3	Managing discussions and interpretation of science observations					
4	Explaining science concepts					
5	Teaching science processes					
6	Developing literacy skills needed for learning science					
7	Assessing children's learning in science					
8	Using computers and ICTs in science					
9	Using a constructivist model to plan science units of work					

Indicate how frequently you used the following strategies in your science teaching this Term.

All = In all science lessons; Most = In most science lessons
Some = In some science lessons
Few = In few science lessons; Never = Never in science

Item	Statement	All	Most	Some	Few	Never
1	Students did hands-on activities					
2	Students followed the procedure I planned for the investigation					
3	Students worked out their own question and procedure for the investigation					
4	I demonstrated the experiment for the children					
5	Students used computers in their science lessons					
6	We used a digital camera in science lessons					
7	Students developed PowerPoint presentations for science					
8	We developed literacy skills needed for learning science in science lessons					
9	Students developed posters in science					
10	I used diagnostic assessments of students' science misconceptions					
11	I developed cooperative group skills					
12	We went on science excursions					
13	Children do activities outdoors					
14	We had members of the community talk to the class about science					

Which (if any) aspects of science teaching with *Primary Connections* this Term have been different from your previous science teaching?

____

____

____

____

Which (if any) aspects of the program are you finding particularly beneficial?

____

____

____

____

What (if any) improvements to your teaching practice have been made as a result of participating in the *Primary Connections* program?

____

____

____

____

Which (if any) aspects of the program are causing you concern or difficulty?

____

____

____

____

Feedback on the *Primary Connections* professional learning program

How helpful was the mid-term professional learning workshop in supporting you with teaching *Primary Connections?* Tick one box.

Very little help	Little help	OK	Helpful	Very helpful

Do you have any additional professional development needs at this stage?

____

____

____

Feedback on the *Primary Connections* curriculum units

How effective are the *Primary Connections* curriculum units in supporting teaching and learning? Tick one box

Very ineffective	Ineffective	OK	Effective	Very effective

Why?

____

____

____

Has the *Primary Connections* unit been compatible with your state/territory's curriculum framework?

Yes / No

Explain

____

____

____

What (if any) changes would you like made to the *Primary Connections* curriculum units?

____

____

____

____

Have you adapted the materials or the approach for your class? Explain.

____

____

____

____

Did you/how did you integrate the literacy focuses of your *Primary Connections* unit with your literacy programming?

____

____

____

____

____

How effective is the integration of science and literacy in *Primary Connections* for supporting **learning in science**? Tick one box

Very ineffective	Ineffective	OK	Effective	Very effective

Why? ____

____

How effective is the integration of science and literacy in *Primary Connections* for supporting **learning of literacy**? Tick one box

Very ineffective	Ineffective	OK	Effective	Very effective

Why? ____

____

____

Describe any links you made to other learning areas?

____

____

____

____

Cooperative learning model

Have you used the cooperative learning group roles? **Yes / No**

Have the group roles helped you manage group work **Yes / No / NA**

What suggestions (if any) do you have for improving the group roles?

____

____

Assessment resources

Have the assessment tasks in the Engage, Explain and Evaluate lessons been easy to use? **Yes / No**

Have they provided useful evidence about students' learning? **Yes / No**

How have you been recording information about students' learning and achievement in science and literacy?

____

____

____

____

What suggestions (if any) do you have for improving the assessment tasks and resources?

____

____

____

How Tos

Have you used any of the How Tos? **Yes / No**

What additional How Tos would you like written?

____

____

____

Feedback on the *Primary Connections* unit planning template

Has the template been a useful resource to support your planning units of work?

Yes / No

Explain

____

____

____

____

Has developing your own unit using the template helped you better understand the *Primary Connections* teaching-learning model?

Yes / No

Explain

____

____

____

Do you have any suggestions for improving the template resources?

____

____

____

Feedback on the *Primary Connections* electronic resources

Have you used any of the resources on the Science Background CD-ROM? **Yes / No**

Have you used any of the resources on the Resource CD-ROM? **Yes / No**

Comments – what have you used/ease of access/usefulness etc

____

____

____

Have you logged in to the *Primary Connections* web page? **Yes / No**

Comment – ease of access/usefulness etc

____

____

____

Students' reaction to the program

How have your students responded to the **activities** and the **learning approach**?

Activities (Tick one box)

Very negatively	Negatively	OK	Positively	Very positively

Learning approach (Tick one box)

Very negatively	Negatively	OK	Positively	Very positively

Amount and quality of learning

How does the amount and quality of **science learning** using *Primary Connections* compare with last term?

Amount of science learning

Worse than last term	Same as last term	Better than last term

Quality of science learning

Worse than last term	Same as last term	Better than last term

Has *Primary Connections* made a contribution to students' **literacy learning**?

Worse than last term	Same as last term	Better than last term

How has *Primary Connections* contributed to literacy learning?

____

____

____

Science in your school

How important was science in your school this Term? If the most important subject is ranked 1, and the second most important subject is ranked 2, what rank was science this Term?

I think science was ranked number _____.

Was there a science coordinator at your school this Term? **Yes / No**

If you had a coordinator, did the coordinator have time release from teaching to do the coordination?
Yes / No / Not applicable

How do you rate the budget for science equipment and consumables at your school this Term? Tick one box.

No budget	Inadequate	Satisfactory	Good	Very good

How well equipped is your school for teaching science this Term? Tick one box.

Poor	Adequate	Well equipped

Has your school developed improved strategies for organising science resources this term? **Yes / No**

Will science achievement be reported as a separate subject to parents at your school this year? **Yes / No**

Format of resources

In what format would you prefer to be supplied with *Primary Connections* resources?
Tick boxes as appropriate

Resource	**Hard copy i.e. book or folder**	**CD-ROM**	**On-line**
Curriculum units			
Background information about the structure and philosophy of the program			
Resource worksheets			
Assessment resources			
Science Background CD			

Overall summation

How highly do you rate your involvement in the *Primary Connections* program as a professional learning experience? **Tick one box**.

Better than any other professional learning program I have experienced	
As good as the best professional learning programs I have experienced	
OK	
I have experienced better professional learning programs	
It is one of the least useful professional learning programs I have experienced	

Which aspects of the program have been useful?

Tick boxes as appropriate

Aspect of the program	**Very useful**	**Useful**	**Not useful**
The summer school in January			
The follow-up one-day workshops			
The supplied curriculum units			
The How Tos			
The assessment resources			
The resource sheets			
Science Background CD			
The template and writing my own unit			
The web site			
The networking with colleagues within and across schools and states			

Thank you for responding to this questionnaire – your feedback will be very useful

Appendix 7 | Summary of teacher feedback on *Plants in Action* unit

Plants in Action

Stage 2, Life and Living

Trialled in term 1, 2005

Number of annotated units returned from teachers = 19

Number of teachers who taught this unit = 30

GENERAL COMMENTS

- The curriculum resource unit was seen as an excellent resource that was comprehensive, and also flexible enough to be adapted to suit individual contexts.
- The literacy links were considered in high regard.
- The time taken to complete the unit was a concern, caused by too many activities within lessons and lessons within the unit. It was noted that Term 1 has many activities which need to be included, and this has implications for classroom programming.

STRENGTHS	WEAKNESSES
• An excellent teaching resource. Everything needed was there and I could adapt as I saw fit. • The literacy aspects were excellent. Relevant to activities right across the curriculum. Science became the lynch pin of teaching program. • This unit is an excellent resource. It engages children and allows for diverse learning styles. The cooperative teaching/learning strategies allow children to take charge of their learning. • Unit was enjoyed by children. Highlights – bean seed germination, recording growth, Garden Buddies. • Science took over our classroom, which was great, but I wasn't prepared for it to go into every facet of work. • I followed this program very closely and was impressed with the detail and organisation. There was very little that didn't work for the students. The explanations were very helpful and necessary. Given that this program is for the 'masses' there is plenty in it to get science into the classrooms at last.	• An excellent unit but far too long, especially for Term 1. • Presentation of unit fantastic, but repeats itself too often. • Unit too long. Chose not to do SOSE but still worked on unit into Term 2. Feel there could be fewer activities in each lesson. • Suggested time for sessions way out, especially if explicit teaching is to occur with literature component. • Didn't start until week 3 after whole school program, although this allowed teacher to know students better. • Too much content for one term. Felt I glossed over a lot of the content.

SPECIFIC STRATEGIES and FOCUSES

Unit Overview

STRENGTHS	WEAKNESSES
• Excellent. I could teach from this.	

Unit Outcomes

STRENGTHS	WEAKNESSES
• Good to see outcomes presented so clearly.	

Background information

- Considered an important resource.

STRENGTHS	WEAKNESSES
• Fantastic having the background info, it is very important to have this. • Photocopied and laminated illustrations to use as reference material.	• Suggest a pronunciation chart for scientific terms.

Assessment

STRENGTHS	WEAKNESSES
• Good explanation of Formative assessment.	

5Es Model

STRENGTHS	WEAKNESSES
• Good explanation of 5Es strategy throughout the unit.	• The contents page should show the 5Es.

Equipment

- Considered a necessary resource.
- Replication of equipment list within lesson, and then in a complete unit list at the end of the unit, was unnecessary.

STRENGTHS	WEAKNESSES
• Very necessary.	• Don't need to list before a lesson and at the end of unit.

How Tos

STRENGTHS	WEAKNESSES
• An excellent idea for this program.	

Cooperative learning

- Cooperative learning had a positive impact on classroom management and was enjoyed by students.
- Suggestions about ways to modify the cooperative learning approaching were also included.

STRENGTHS	WEAKNESSES
• Great for classroom management. • Kids enjoyed teams and the idea of allocated job.	• Children did not like staying in one team for a whole unit. • Badges are daggy. Would not use any sort of badge. • Add another team member – *scribe*-responsible for group writing, and which would means less groups.

LINKING SCIENCE WITH LITERACY – Literacy focuses

Science journal

- The science journal provided a purpose and context for writing, and teachers could adapt it to suit their individual situations.

STRENGTHS	WEAKNESSES
• Daily observation of bean in journal very successful. Writing improved from 1 day to the next. Learnt how to make real scientific observations using real scientific language. Daily basis made task more relevant. • Great idea. Kids loved it. • Developed planned focus questions for science journal writing. Drew final choice in journal as a mind map.	• Science Journals involved a large amount of time. Lesson 2 took two hours. • I put more emphasis on the talking/listening than the writing. • Did not model journal entry. Ran out of time. Revised the essential requirements of a journal entry. • I didn’t get into the Science Journal bit but would have loved to have mastered it.

KWLH chart

STRENGTHS	WEAKNESSES
• Students really into this which surprised the teacher. • KWLH chart is great. • They knew a lot. Kids used sticky notes to add to chart.	• Change 'What we know' to 'What we think we know'. • Need specific focus for this unit (how grow and change) to be more obvious. • Went off track – what we know, what we want to know.

Word Wall

STRENGTHS	WEAKNESSES
• Worked very well. Children really engaged.	• Word Wall good to begin with, but wish there was more time to keep it going.

INVESTIGATION SKILLS

Investigation Planner

STRENGTHS	WEAKNESSES
• Useful	• Too complex; designed a simpler form.

Writing investigation questions

STRENGTHS	WEAKNESSES
Spent time on this.	

LESSON BY LESSON REVIEW

Lesson 1 Mystery Bag

- Good level of engagement, discussion and introduction to cooperative groups.
- Took a long time.

STRENGTHS	WEAKNESSES
• Lots of good discussion from 'uses of plants'. • Brainstormed as a whole class; worked well. • Teacher adapted lesson to suit the stage the students were at. • Excellent cooperative group activity. • This worked out really well. Turned it into a game. Time stopped teacher from making individual bags.	• The journal entry was not as good as expected. Too much information for students to include in their recount. • Students had trouble working out products derived from plants. Needed teacher help. • Response to the 'plant-use' brainstorm was limited. • Excellent cooperative group activity but took too long. Journal writing takes so long in year 3. • I felt there was too much writing in lesson. I modified and did whole class.

Garden Buddies

- Good for engaging students and building links with their families and community.

STRENGTHS	WEAKNESSES
• Garden Buddies took ages to set up but very worthwhile. • Biggest success. Well supported by families. Books looked great. Shared pages daily. • Inspired kids from the start. Loved idea of camera. Used project money. Would have to budget for this. • The kids loved it and were so excited. • Garden Buddies worked really well.	• If home buddies have been done before, students get bored. • To get the extra resources takes a lot of time, as does the initial set up of program. • Class Roster – way too hard. Not all notes returned. Didn't do the information share.

Lesson 2 What goes where?

STRENGTHS	WEAKNESSES
• Lots of good discussion generated from partner discussion about plant life-cycle. • Students very engaged – had good prior understanding. • Most were quite aware of cycle and parts. Good to see an example of KWLH chart.	• Hard to keep students on track re KWLH chart, second column. • Lesson went for longer than anticipated. • Lesson went into three lessons. • Illustrations were confusing. • Discussion took up time.

Lesson 3 What's inside a seed?

- ➢ The hands on component of the lesson was very engaging.
- ➢ Challenges in the unpredictability of the seeds, and implications from the students' existing science and literacy skills.

STRENGTHS	WEAKNESSES
• Lesson very successful. Much language and discussion from 'Living, Not Living, Not Sure' activity. • Resource sheets with this lesson were excellent. • Fantastic background information. • The best activity. Hands on just great. • Time the only problem but I wouldn't change anything. • Step 4 created great discussion.	• Children had no previous experience of science. There was some pre-teaching needed for my slow learners. • I needed more than double the time. • I had to do several lessons on the structure of the procedural text before using it with the experiments. • No time for predictions. • Lots of embryos fell or broke off.

Lesson 4 Baby Bean's germination

- ➢ The hands on component of the lesson was very engaging.
- ➢ Challenges in the unpredictability of the seeds, and implications from the students' existing science and literacy skills.

STRENGTHS	WEAKNESSES
• Excellent activity. Works well and is quick. Chn loved watching the seed grow almost in front of their eyes. • Each person had a cup and seed of their own to encourage responsible watering. • Demonstrated scientific drawing criteria. • Using the cups and pegs was perfect from an organisational point of view. • Linked with measurement in Maths. • Arranging seeds easier if each child has own cup.	• Fungal problems water problems with seed growing. • Kids had trouble reading the procedural text. Kept asking teacher what to do. • Teacher did steps one at a time with the whole class to overcome the difficulty children had doing this. • Hard to keep moist over a hot weekend. • Read a book instead of procedural text. • Need a resource sheet here.

Lesson 5 Patterns in our plants

- The opportunity to reflect on and represent learning in the context of sharing with others was well received.
- Some of the literacy representation options (especially the summary) were too difficult for this Stage.

STRENGTHS	WEAKNESSES
• The representation options were great but needed more time, other lessons, to prepare the students. Teacher chose the graphs and PowerPoint. • Sharing the representations with another class was a Wow! Children had experience of sharing.(6) • Representations were excellent exercises for the children. • Children enjoyed the scientific words. • Modelled summaries. Chn share orally and then write. Lesson took a long time. • *Living, Not Living, Not Sure* a fantastic activity.	• Far too much for one lesson. • Session too long for formal presentations. Had oral discussion summarising points. Teaching time taken up by carnivals etc. • Need 3-4 sessions plus explicit teaching how to write a summary. It was difficult. • Difficult to assess individual if all work is in a group. • None of my students had ever heard of a summary.

Lesson 6 Investigating conditions for growth

STRENGTHS	WEAKNESSES
• I managed to do this lesson much better than lesson 4. Discussion more important. Leave involved recording to Stage 3. 'Plant Expert' was keen to talk and question rather than look at books. • Used Investigation Planner with sticky notes. Got some good ideas. Students in groups. • This lesson worked really well. It was the first major investigation this group has done. • The investigation planner made it easy to set up.	• I feel this session could be optional or interchanged with lesson 4. • Question writing proved difficult. Students wanted their plans to live. • Time became a factor and lesson not finished. • Forgot to start the lesson with step 1 and went straight to variables. It really made them miss the point about variables.

Lesson 7 Reporting on conditions for growth

STRENGTHS	WEAKNESSES
• This lesson was outstanding. • Presentations were more oral. Too early in the year for multimedia presentations. Posters were popular. • A terrific activity. Literacy time was spent on this for 2 weeks – 40 minutes per day.	• We didn't do this very well. The children haven't had much science in earlier grades. They'll get better. • Children had difficulty identifying variables even after using planning chart – I think this may have confused them. Need to do many many investigations before children will be able to work through this process with confidence and understanding.

Lesson 8 Botanical artists at work

➢ A very engaging task.

STRENGTHS	WEAKNESSES
• Students particularly enjoyed doing this activity. • The children did an amazing job on their drawings. • Children really liked this lesson. One student discovered he was very good at this. • Very good activity. Children vocal and enthusiastic. • Looking at flower parts was excellent. • Think, Pair, Share worked very well. • Children found this very interesting.	• All children used the same flowers. • Time was the only problem.

Lesson 9 Flowers, fruits and seeds

STRENGTHS	WEAKNESSES
• *Rosy Dock* – lively discussion on introduced plants and animals. • Observed seeds in fruit and made fruit salad. • We tried to get 100 types of seeds. • We had them in snap-lock bags all over our science table. • What seed is this chart? Was great. • 'Private Life' video – excellent.	• Drawings on the whole not very good. Observation skills need practise. • Not done.

Lesson 10 Plant life-cycle production

STRENGTHS	WEAKNESSES
• Interactive crossword a great resource. • The life-cycle jumble was a good evaluation tool. The KWLH chart was a great evaluation. • Had to carry this session into Term 2. Students surprised teacher with the amount of information they had retained. All understood what the cycle represented. Used key words from the Word Wall for write up in books. • A Fantastic CD. • Step 10: Student reflection – very good.	• Had to teach notetaking for Step 9. • Not done. • Had great ideas for drama production but ran out of time. • This seems a rather simplistic activity to repeat – plant life-cycle- unless most students struggled with it initially.

Resource sheets

STRENGTHS	WEAKNESSES
RS 8/9: Excellent table for recording. RS 15: Excellent language extension activity. Great for dictionary skills. RS12: Great. RS13: Students particularly enjoyed doing this activity.	RS11: This planer was too complex for my group. I designed a simpler form for our investigations. RS6: Plant life cycle – hard to fit squares into a circle. RS6: Seed and flower picture needs to be clearer. RS12: Add common name.

PrimaryConnections

Linking science with literacy