



## **An overview of *Primary Connections* Stage 3 research outcomes 2006 – 2008**

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## **Disclaimers**

The views expressed in this report do not necessarily represent the views of the Australian Academy of Science or the views of the Australian Government Department of Education, Employment and Workplace Relations. The author accepts responsibility for the views expressed and all errors and omissions in this report.

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## Executive summary

It is essential that young people's interest in science is captured and maintained through schooling so that they become scientifically literate and more students continue with their studies of science at university level in order to address the strong need for science, technology, engineering and mathematics skills. The purpose of science in primary schools is to provide opportunities for students to know science as a body of knowledge, as a way to know the world and as a human endeavour, and to develop students' scientific literacy (MCEETYA, 2006).

The Australian Academy of Science recognised the need to support primary teachers to teach science in ways that engage students. The Academy gained the support of all states and territories and the Australian government to develop a teacher professional learning program supported with curriculum resources designed to improve science teaching in primary schools.

The main activities of Stage 3 (2006 – 2008) included:

- the development of professional learning resources and the training of professional learning facilitators, curriculum leaders and tertiary pre-service teacher science educators (teacher educators)
- the development, trial, revision and publication of curriculum resources, and
- the provision of ongoing support to trial teachers.

Research studies in Stage 3 (2006 – 2008) focused on:

- evaluating the professional learning provided for teacher educators, professional learning facilitators and curriculum leaders
- monitoring the activities of professional learning facilitators and the implementation of *Primary Connections* in trial schools, and
- a major study of the impact of *Primary Connections* on students' learning.

This report provides an overview of 17 research studies conducted during Stage 3 of the *Primary Connections* program, summarises the research findings and identifies implications for further action. The research and evaluation studies undertaken for Stage 3 have established that *Primary Connections* has had positive impacts on schools, teachers and students.

Principals of trial schools have reported that the program has enhanced the status of science in their schools, improved teachers' confidence with teaching science and has enhanced students' attitudes towards science. Where *Primary Connections* has been implemented on a whole-of-school basis this has led to a more collegial approach to professional learning and science and literacy teaching, and an increased amount of science has been taught.

The program has had positive impacts on teachers' confidence with science and literacy teaching, enhanced teachers' beliefs in their self-efficacy, the amount of time devoted to science teaching and their teaching practice, and consequently has increased students' opportunities for learning science. *Primary Connections*

has had a substantial positive impact on students' development of conceptual understandings, science processes, literacies of science and attitudes towards science - the key components of scientific literacy.

The training of professional learning facilitators, curriculum leaders and teacher educators has given Australia a substantially increased capacity to provide high quality science professional learning for primary school teachers. The high quality professional learning and innovative curriculum resources of *Primary Connections* have the potential to make a significant contribution to developing the scientifically literate community needed by Australia.

## Introduction

This report provides an overview of the following research studies conducted during Stage 3 (2006 - 2008) of the *Primary Connections* project:

1. Case study teachers' experience of Primary**Connections** (2006)<sup>1</sup>
2. Professional Learning Facilitators workshop: January 2006<sup>1</sup>
3. Trial school principals' expectations of the programme and perceptions of its impact: July 2006<sup>1</sup>
4. Professional Learning Facilitators: Confidence, self-efficacy, activities as at end of term 1, 2006<sup>1</sup>
5. Professional Learning Facilitator Focus Group: October 2006<sup>2</sup>
6. Professional Learning Facilitators: Confidence, self-efficacy, activities as at end of term 3, 2006<sup>1</sup>
7. Trial teachers' activities and perceptions at the end of term 1, 2006<sup>1</sup>
8. Professional Learning Facilitators workshop: January 2007<sup>1</sup>
9. University science educators' workshop: February 2007<sup>1</sup>
10. University science educators' workshop: July 2007<sup>1</sup>
11. NSW Professional Learning Facilitators workshop: July 2007<sup>1</sup>
12. WA Professional Learning Facilitators workshop: September 2007<sup>1</sup>
13. NSW and QLD Curriculum Leader workshops: June, July and September 2007<sup>3</sup>
14. QLD, NSW and TAS Curriculum Leader Workshops: October 2007 - February 2008<sup>1</sup>
15. Impact of Primary**Connections** on students' science processes, literacies of science and attitudes towards science: August 2008<sup>1,4</sup>
16. Trial teachers' perceptions of the implementation of Primary**Connections** at their schools in Term 1/2 of 2008: August 2008<sup>1</sup>
17. Professional Learning Facilitators: Activities as at end of Term 1/2, 2008: August 2008<sup>1</sup>

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The report comprises three sections: an introduction that provides background and sets the context for the research studies; a summary of the research studies and findings, the conclusions and implications.

## Background and context

The national review of school science education conducted by Goodrum, Hackling and Rennie (2001) indicated that the teaching of science in Australian primary schools was very patchy. Research indicates that science is allocated less than 3% of curriculum time in Australian primary schools (Angus, Olney & Ainley, 2007) and Australian primary science achievement levels are significantly lower than Singapore, Taiwan, Hong Kong, Japan, Russia, Latvia, England and the USA (Thomson, Wernert, Underwood & Nicholas, 2008). Further concerns are raised by the national assessments of Year 6 students' science literacy (MCEETYA, 2005; 2008) conducted in 2003 and 2006 which indicate that more than 40% of students in the sample failed to achieve the proficient standard.

It is essential that young people's interest in science is captured and maintained through schooling so that they become scientifically literate and more students continue with their studies of science at university level in order to address the strong need for science, technology, engineering and mathematics skills.

The *Primary Connections* Stage 3 project brief argued that:

*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. A community with an understanding of the nature of science and scientific inquiry will be better equipped to participate in an increasingly scientific and technological world (Peers, 2006, p.1).*

Tytler, Osborne, Williams, Tytler and Cripps Clark's literature review (2008) found:

*... considerable evidence that, for the majority of students, their life aspirations are formed before the age of 14, with the implication that engaging students in STEM pathways becomes increasingly difficult after the early secondary school years. Interventions and resources aimed at encouraging student engagement in STEM thus need to be prioritized to engage and capture the imagination of students in the upper primary and early secondary school years (p. viii).*

## **Purpose of primary science education**

The purpose of science in primary schools is to provide opportunities for students to know science as a body of knowledge, as a way to know the world and as a human endeavour, and to develop students' scientific literacy (MCEETYA, 2006). The definition of scientific literacy adopted by the statements of learning for science (MCEETYA, 2006) is derived from Goodrum, Hackling and Rennie's (2001) Australian review of science education which states that:

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, & Rennie, 2001, p. 7).

Scientific literacy (Bybee, 1997; OECD PISA, 2006; Roberts, 2007; Ryder, 2001) requires citizens to be interested in and engaged with scientific matters and have the knowledge and skills that can be applied in real-world contexts to investigate, represent and communicate findings and solve everyday problems. Scientific literacy, therefore, requires positive attitudes towards and interest in scientific matters, competence with science processes and literacies of science, and broad conceptual understandings which can be applied in real world contexts (Figure 1).

Processes of science are required for formulating questions, planning investigations, and for collecting and interpreting data from investigations. Literacies of science are the particular practices, processes and products that are used to represent and communicate understanding of science concepts, processes and

skills. These include factual texts, data tables, labeled diagrams, graphs, models, drawings and embodied forms such as gesture and role play. Literacies of science are required to interpret science texts, to reason with science ideas, make and evaluate claims and to construct texts that represent and communicate findings from science investigations (Mortimer & Scott, 2003; Norris & Phillips, 2003).

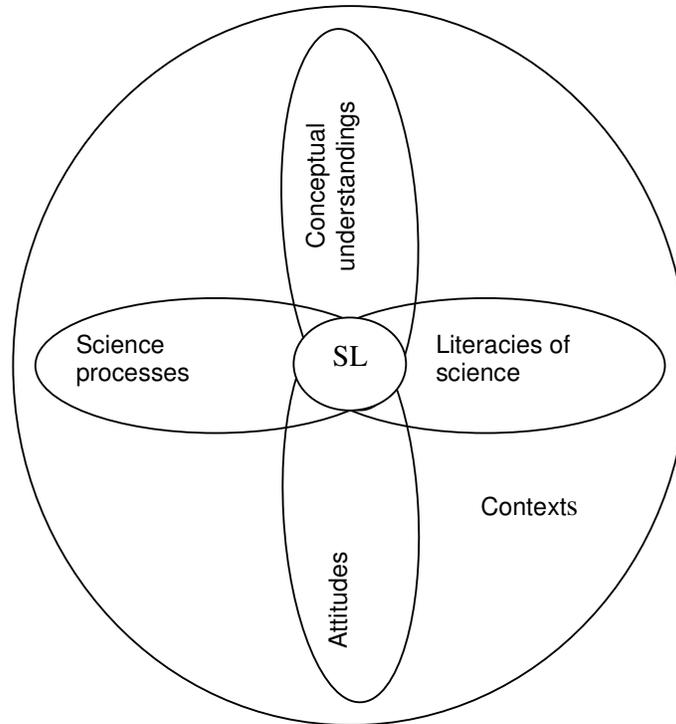


Figure 1: Scientific literacy (Hackling & Prain, 2008)

### **Primary Connections**

The Australian Academy of Science recognised the need to support primary teachers to teach science in ways that engage students. The Academy gained the support of all states and territories and the Australian government to develop a teacher professional learning program supported with curriculum resources designed to improve science teaching in primary schools. This became known as *Primary Connections: Linking science with literacy*.

The aim of the *Primary Connections* project is to:

*... improve the quality and quantity of science teaching and learning in Australian primary schools through enhancing teachers' confidence and competence. This is achieved by developing teachers' pedagogical content knowledge in science and literacy through an innovative programme of professional learning supported with rich curriculum resources (Peers, 2006, p. 2).*

The program employs highly innovative approaches to professional learning and the curriculum resources are based on a sophisticated teaching and learning model. Significant innovations in the PC approach are that it is inquiry oriented and hands-on, so students have an authentic experience of science; science and literacy teaching and learning are integrated and there is explicit teaching of the literacies of science; and assessment is used to both support and evaluate learning.

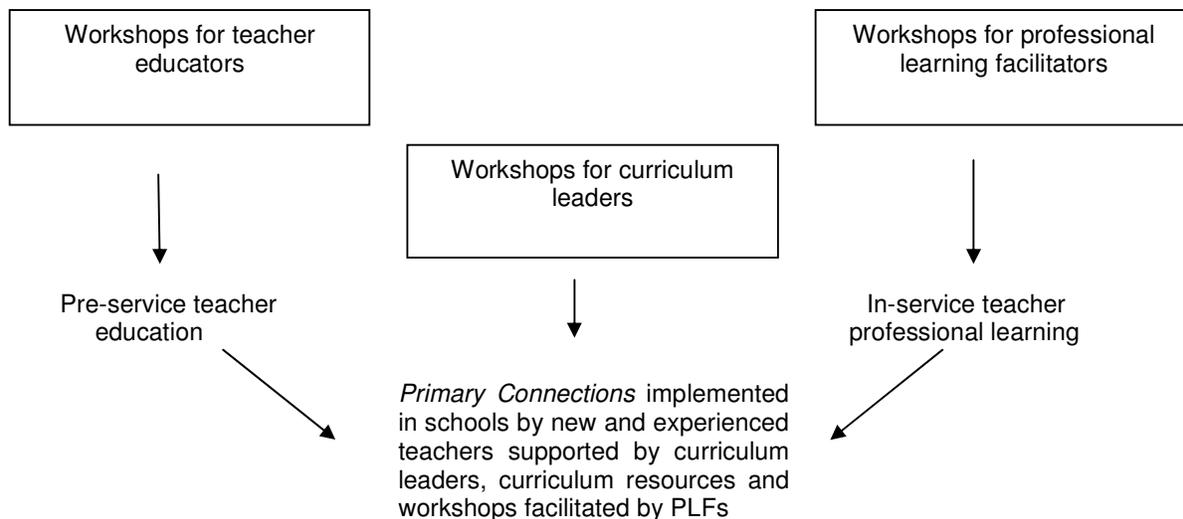


Figure 2: *Primary Connections* Stage 3 professional learning initiatives

Innovations in the professional learning model include coordinated initiatives in pre- and in-service teacher education, the training of professional learning facilitators and the training of curriculum leaders (Figure 2).

Professional learning workshops provided by the Academy of Science for teacher educators have facilitated the adoption of *Primary Connections* in pre-service teacher education courses at all Australian faculties of education thus ensuring that new teachers entering the profession are familiar with the *Primary Connections* approach to science teaching and learning. Complementing this pre-service initiative, the professional learning facilitators trained by the Academy of Science deliver professional learning workshops in schools across Australia for in-service teachers. Academy trained curriculum leaders provide leadership, coordination and professional learning within their schools to support the implementation of *Primary Connections* so that science and literacy teaching and learning are enhanced.

Stage 3 of *Primary Connections* builds on the foundations established through earlier stages of the project. Stage 1 developed a conceptual model for the project and gained the support of all key stakeholders. Stage 2 developed the professional learning model, developed the teaching and learning model upon which curriculum resource development was based, and evaluated the impact of the program on trial teachers and their students (Hackling & Prain, 2005).

The main activities of Stage 3 (2006-2008) included:

- the development of professional learning resources and the training of professional learning facilitators, curriculum leaders and teacher educators
- the development, trial, revision and publication of curriculum resources, and
- the provision of ongoing support to trial teachers.

## Research studies and findings

Research studies in Stage 3 focused on:

- evaluating the professional learning provided for professional learning facilitators, curriculum leaders and teacher educators
- monitoring the activities of professional learning facilitators and the implementation of *Primary Connections* in trial schools, and
- a major study of the impact of *Primary Connections* on students' learning.

The focus of each of these research studies and the main findings from them are summarised in the following sections of this report drawing on the evidence previously published in 17 Stage 3 Interim Research and Evaluation Reports and other research papers. All reports are available on the *Primary Connections* website [www.science.org.au/primaryconnections](http://www.science.org.au/primaryconnections).

### Workshops for teacher educators

*Primary Connections* is unique in Australian teacher education in that it has taken a highly strategic and innovative approach to teacher professional learning, combining initiatives with both in-service and pre-service teacher professional learning. An ideal scenario would see new teachers developing innovative and effective science teaching and learning practices in their pre-service education, going into schools and being mentored by experienced teachers who have the same understandings of the principles of effective science and literacy teaching and learning. Two-day workshops were therefore conducted by the Academy of Science in February and July of 2007 to inform teacher educators about *Primary Connections* and to support them to implement elements of *Primary Connections* in pre-service teacher education programs. Thus, pre-service teachers could be introduced to the same principles of effective science and literacy teaching and learning that were being presented to in-service teachers at *Primary Connections* workshops for schools. Complementing this initiative, DEST (now DEEWR) introduced an awards scheme for pre-service education students that rewarded them for high achievement in their pre-service science education units that included elements of *Primary Connections*. The *Primary Pre-service Teacher Awards for Excellence in Science Education* provided an incentive for teacher educators to participate in the professional learning workshops and for universities to include elements of *Primary Connections* in their science education courses. The awards also provided an incentive for teacher education students to strive for excellence in science education studies. Award winners received \$2000 and a set of *Primary Connections* resources.

#### Purpose

The purpose of the evaluation of the teacher educators workshops (Research reports 9 and 10) was to elicit information about:

- educators' beliefs about teacher professional learning
- experiences of the workshop
- feedback on the workshop and the *Primary Connections* professional learning resources, and
- any further support needs.

## Method

A questionnaire based survey method was adopted to gather information from the teacher educators at the end of the workshops. The sample comprised 62 teacher educators who attended the February workshop and 52 who attended the July 2007 workshop. The sample included teacher educators from all Australian universities that offer teacher education programs.

## Findings

The teacher educators who completed the workshops had high levels of confidence and self-efficacy for facilitating *Primary Connections* professional learning. A large majority of the participants achieved key aims of the workshop related to:

- understanding the theoretical underpinnings of *Primary Connections*; understanding the teaching and learning model and the professional learning model
- understanding the pedagogical approaches of *Primary Connections*
- awareness of opportunities for using *Primary Connections* to exemplify aspects of primary science teaching in pre-service science education units, and
- familiarity with the curriculum and professional learning resources.

A large majority believed they had been very well or well prepared for facilitating workshops in both pre- and in-service contexts. Participants gave *Primary Connections* and its resources strong endorsement and gave the workshops a very positive evaluation (Research reports 9 and 10).

## Implications

Given the teacher educators' high levels of confidence and self-efficacy for facilitation, understanding of the theoretical and pedagogical aspects of *Primary Connections*, and familiarity with *Primary Connections* and its resources, one would expect them to be effective facilitators of professional learning for pre-service teachers. Given the participation in the workshops of science educators from all Australian universities that have a pre-service teacher education program and the provision of science education awards for student teachers in 2007 by DEST (now DEEWR), there is likely to be a high level of uptake of *Primary Connections* into teacher education programs at Australian universities. However, this level of commitment may decline without the incentive of the awards scheme.

## Training of professional learning facilitators

Previous studies in Australia (Goodrum, Hackling & Trotter, 2003) and overseas (Tinoca, 2004) have shown that the combination of professional learning supported with exemplary curriculum resources is an effective approach to supporting science teachers' professional learning. *Primary Connections* has trained a cadre of professional learning facilitators (PLFs) who are available Australia-wide to conduct workshops supported with innovative professional learning and curriculum resources.

Three-day professional learning workshops developed and implemented by the Australian Academy of Science were used to train PLFs in Canberra during January 2006 and 2007. Follow-up one-day workshops were used to extend the professional learning of these PLFs, build a networking group, gain feedback on

their roles and to update them on new resources. Further three-day training workshops were conducted in Queensland, New South Wales, South Australia and Western Australia in collaboration with the jurisdictions and these were tailored to fit the local professional learning structures and curriculum requirements. A total of 383 PLFs were trained in Stage 3.

### **Purpose**

Eight studies were conducted to evaluate the effectiveness of the workshops for PLFs (Resource reports 2, 4, 5, 6, 8, 11, 12, 17).

Evaluations of three-day PLF workshops, one-day follow-up workshops with these PLFs, professional learning activities of PLFs and teachers' perceptions of the workshops facilitated by PLFs were conducted.

The purposes of these studies were to:

- provide formative evaluations of the workshops so that research findings could be used to enhance the workshops to maximise their effectiveness
- gather evidence about the impact of the workshops on the PLFs' confidence and self-efficacy as facilitators, and
- evaluate teachers' perceptions of the workshops facilitated by the PLFs.

### **Method**

Pre- and post-workshop questionnaires were used to evaluate the impact of workshops on the PLFs' confidence and self-efficacy and to elicit from them information about factors that enable or constrain their activities as facilitators of professional learning. When trained PLFs presented workshops in schools, workshop evaluation forms were completed by the teachers to gain their feedback on the workshops.

### **Findings**

The initial three-day professional learning workshops significantly increased PLFs' confidence and self-efficacy for facilitating *Primary Connections* workshops for teachers (Research reports 2, 8, 11 and 12). The PLFs gave very positive evaluations of their training with a large majority indicating they were very well or well prepared for their role and a large majority rated the professional learning resources as excellent or good. Surveys of facilitators conducted at follow-up one-day workshops showed that experience of facilitating led to further growth in PLFs' confidence and self-efficacy for facilitation (Research reports 4 and 6).

Key factors enabling PLFs' effectiveness were:

- the flexibility afforded by their professional role which made it possible to conduct workshops, particularly for those based in central or district offices
- the high quality of the program and its resources and schools' interest in the program
- support from their line manager, and
- their experience as a teacher of *Primary Connections* (Research reports 6 and 17).

Key factors limiting PLFs' effectiveness were finding time within their overall workload for conducting workshops, particularly for classroom-based PLFs, and schools finding time in their professional learning

programs for the workshops. Only two of the 178 PLFs' responses related to a lack of confidence, knowledge or skills of presenting workshops (Research reports 6 and 17) which provides further corroboration of the quality of training provided in the workshops.

PLF training workshops conducted collaboratively between the Academy of Science and jurisdictions, in jurisdictions, were very successful and helped link the training to the local context (Research reports 11 and 12).

PLFs reported that they had conducted 2360 *Primary Connections* workshops in 2007 and the first term of 2008 which represents a high level of engagement with primary schools in Australia. Most PLFs thought that the demand for workshops was either increasing or remaining the same. PLFs based in schools were far less active in facilitating workshops than those not based in schools (Research report 17) and this is related to the difficulty of classroom teachers leaving their classes and schools to facilitate professional learning at other schools. Teachers gave consistently positive evaluations of the quality and relevance of the *Primary Connections* workshops facilitated by PLFs and how much they learned from the workshops (Hackling & Prain, 2007), indicating that the PLFs were well trained and resourced for facilitating professional learning.

### **Implications**

The training of PLFs by the Academy of Science has been highly professional and very effective. The PLFs have conducted an extraordinary number of *Primary Connections* workshops and these have been well received by teachers. Time and flexibility within the professional role of PLFs and support of a line manager have been the most important factors influencing their workshop facilitation activity. Consequently, PLFs not based in schools have been more active than those based in schools. There will be a need for training of additional PLFs to top up the pool of active facilitators as some are lost through career and life changes, and to meet the ongoing demand for *Primary Connections* workshops over the next five years.

### **Training of curriculum leaders**

Research indicates that strong leadership within schools, effective coordination of science teaching, and ongoing professional learning are required for effective implementation of innovative science programs (Bronfenbrenner, 1989; Lewthwaite, 2006; Peers, Diezmann & Watters, 2003). Successful implementation of *Primary Connections* and the development of effective science teaching and learning in a school are likely to be enhanced when supported by a trained science curriculum area leader who can coordinate the science program in the school. The Academy of Science developed and implemented two-day professional learning workshops for curriculum leaders (CLs). The workshops familiarised teachers with the *Primary Connections* teaching and learning model and curriculum resources, and addressed issues associated with planning for whole-school implementation of *Primary Connections* and supporting the professional learning of their colleagues. Curriculum leader workshops have been conducted in all states and territories except the ACT and approximately 900 CLs were trained in Stage 3. Research was therefore conducted to evaluate the training provided to *Primary Connections* curriculum leaders.

## **Purpose**

Research reports 13 and 14 describe the evaluation of the curriculum leader workshops. These studies were conducted to evaluate the impact of the workshops, the curriculum leaders' confidence with science teaching, self-efficacy as a curriculum leader and confidence with facilitating professional learning.

## **Method**

Pre- and post-workshop questionnaires were completed by teachers who attended the curriculum leader workshops conducted in Queensland, Tasmania and New South Wales.

## **Findings**

The workshops had large, positive and statistically significant impacts on the participants' confidence with science teaching, their self-efficacy as a curriculum leader and their confidence in facilitating professional learning workshops. The CLs were particularly confident with facilitating professional learning related to an introduction to *Primary Connections*, conducting investigations and developing literacies of science. Evaluations of the workshops were extremely positive with a large majority of participants indicating that they had been very well or well prepared for the role of curriculum leader. CLs indicated that time available for preparation and for supporting their colleagues was the factor most likely to limit their effectiveness (Research reports 13 and 14).

## **Implications**

Given the teachers' high confidence in teaching science and for facilitating professional learning and their high self-efficacy in their roles, one would expect that they would be effective curriculum leaders if they were provided with sufficient time in their workload to lead and coordinate the teaching of science in their schools. There would be value in a follow-up survey of curriculum leaders to elicit from them information about their roles, the factors influencing their effectiveness in these roles and their needs for further support.

## **Implementation of *Primary Connections* at trial schools**

106 teachers in fifty-six schools were recruited in 2005 to trial *Primary Connections* curriculum resources. Most schools nominated two teachers to participate in the trial, one being an experienced teacher of science and one being inexperienced. Two of the trial schools opted for a whole-of-school implementation of *Primary Connections* and became subjects of case studies. Trial teachers at these schools taught draft curriculum units and provided the Academy with detailed feedback on the units which has been invaluable in the revision and improvement of the units before they were published. Trial school principals, trial teachers and other teachers at the two case study schools have been involved with the project from 2005 and are therefore in a unique position to provide useful insights into the implementation of *Primary Connections* in schools, the factors that influence its implementation and the impact of the program on science teaching and learning.

## Purpose

The purposes of the studies of trial teachers and schools (Research reports 1, 3, 7 and 16) were to:

- investigate the level of commitment to *Primary Connections* at trial schools
- identify factors enabling and constraining its implementation, and
- investigate the impact of the program on the teaching of science at these schools.

## Method

Trial teachers were surveyed in 2006, 2007 and 2008 and teachers and principals at case study schools were surveyed in 2008 to gain insights into the implementation of *Primary Connections* in trial schools.

## Findings

The majority of the trial teachers taught science in most of the school terms in which they were teaching and most of the topics taught were drawn from the *Primary Connections* program. There was an increase from 2006 to 2008 in the proportion of *Primary Connections* science units being taught which may reflect the increasing availability of units as they were published progressively. The trial teachers indicated that almost all would teach two or more *Primary Connections* units per year when more units became available. They indicated that most teachers at their schools were teaching whole *Primary Connections* units with little modification, however, some teachers were modifying units and others were developing their own science units based on the *Primary Connections* teaching and learning model (Research report 16).

Almost half of the trial schools had moved to whole-of-school implementation and in more than half of trial schools *Primary Connections* had replaced the previous science program, whilst in other schools *Primary Connections* had supplemented the existing science program.

Surveys of trial teachers conducted in 2006, 2007 and 2008 indicate an increasing commitment by trial schools to the implementation of *Primary Connections* and the most common reasons for this relate to:

- the move to whole-of-school implementation
- *Primary Connections* units matching the school's curriculum scope and sequence chart
- science being a focus of the school
- success from trial teaching, and
- provision of professional learning to staff.

Data from the 2006 survey indicated that the difficulty of working out how to integrate *Primary Connections* with an existing program was a barrier to implementation (Research report 7). Data from the 2008 survey indicate that factors inhibiting the implementation of *Primary Connections* include:

- resistance from non-trial teachers
- time
- new units arriving later than anticipated, and
- new staff at the school requiring professional learning support to implement the program (Research report 16).

Teachers at case study schools that had taken a whole-of-school approach to the implementation of *Primary Connections* reported that it had led to a more collegial approach to professional learning and to science and literacy teaching, and an increased amount of science taught in the schools (Research report 1). Principals of trial schools reported that *Primary Connections* had enhanced the status of science in their schools, improved teachers' confidence in teaching science and had enhanced students' attitudes towards science. They indicated that the lack of time for planning and professional development is the main constraint on implementation (Research report 3).

Data from the 2006, 2007 and 2008 surveys of trial teachers suggest that aspects of coordination have improved progressively over the last three years in trial schools. Linking the science curriculum to the assessment and reporting framework of the school, keeping staff informed about developments with the program and collegial planning for integrating the teaching of science, literacy and other learning areas were well coordinated (Research report 16).

### **Implications**

The 2006, 2007 and 2008 survey data from trial schools paint a picture of a progressively increased commitment to *Primary Connections* and increasing amounts of science being taught, and taught using *Primary Connections* units. An increased proportion of trial schools have moved to whole-school adoption while some, as yet, have not reached this level of implementation. More than half of the schools are replacing an existing program with *Primary Connections* and other are supplementing an existing program with *Primary Connections* units. There would be value in communicating information about *Primary Connections*, its alignment to the developing national curriculum and the availability of units and professional learning to executive directors of curriculum in education systems and to primary schools throughout Australia as these factors are likely to influence decisions to adopt the program.

### **Impact of *Primary Connections* on students' learning**

Previous research (Hackling & Prain, 2005; Hackling, Peers & Prain, 2007) conducted on *Primary Connections* Stage 2 has demonstrated that it improves teachers' confidence with a range of science and literacy teaching strategies and their self-efficacy beliefs for teaching science. Teachers supported through their participation in *Primary Connections* professional learning workshops and curriculum resources report that their pedagogy has improved and that they spend more time teaching science, which increases the opportunity for more student learning. Small scale case studies have shown that *Primary Connections* promotes students' development of conceptual understandings (Hackling & Prain, 2005; Hackling, Peers & Prain, 2007).

There is international consensus that the main purpose of primary science education is the development of scientific literacy. Scientific literacy requires that students develop conceptual understandings, literacies of science, science processes and a positive disposition to science so that they can engage with scientific matters in real world contexts (Bybee, 1997; Goodrum et al., 2001; OECD PISA, 2006; Roberts, 2007). Given that previous studies have demonstrated *Primary Connections*' impact on students' development of conceptual understandings, there was a need for further research to evaluate the impact of *Primary*

*Connections* on students' development of the literacies of science, science processes and their attitudes towards school science.

Literacies of science are required to interpret and construct science texts, to make and evaluate claims (Mortimer & Scott, 2003; Norris & Phillips, 2003) and to represent and communicate findings from science investigations (MCEETYA, 2006). The literacies of science evaluated in this study were students' use of tools and conventional forms to reason about and represent scientific data such as labelled diagrams, data tables and graphs. Processes of science are integral to conducting investigations and scientific literacy (Hackling, 2007f). Processes of collecting data by observation and measurement, reasoning with data and variables such as formulating investigable questions, identifying relationships between variables, and planning investigations that are fair tests were included in the evaluation. An interest in science is a component of scientific literacy (Goodrum et al., 2001; OECD PISA, 2006) and a positive disposition to school science is critical if the scientific literacy of Australian citizens is to be enhanced and enrolments in post-compulsory secondary science and university enrolments in the enabling sciences is to increase. Students' responses to school science such as their enjoyment, interest and curiosity were therefore included in the evaluation.

### **Purpose**

The purpose of this major study (Research report 15) was to conduct a summative evaluation of the impact of *Primary Connections* on students':

- development of literacies of science
- science processes, and
- attitudes towards school science.

### **Method**

To evaluate scientific literacy learning in *Primary Connections*, contextualised assessment tasks were developed which allowed students to demonstrate how effectively they could apply literacies of science and science processes to authentic science tasks in real world contexts. All assessment tasks were set in contexts independent of the content of *Primary Connections* curriculum units so that skills developed within the context of the units had to be applied to the particular contexts of the assessment tasks. Students completed age-appropriate versions of the test. Students also responded to a seven item attitude scale.

A total of 1467 students in Years 3-7 were recruited from 26 government schools in Western Australia and Queensland to participate in the testing program which was conducted in Term 4 of 2007. Students were recruited from classes which had studied science using *Primary Connections* and from comparison classes which had studied science using other programs. *Primary Connections* classes and comparison classes were matched on the socioeconomic index levels of the schools to take account of the effects of social disadvantage on student achievement (Rothman & McMillan, 2003). Most of the *Primary Connections* classes had completed two units during the year and were taught by teachers who had completed at least two days of *Primary Connections* professional learning, however, there was no assumption of fidelity of implementation of the *Primary Connections* teaching and learning model. The comparison classes were taught by teachers who volunteered to participate in the evaluation and had taught science using other programs. Given that these teachers volunteered to take part in the study, it was expected that many were

confident teachers of science. When tested, students in these comparison classes reported that they enjoyed school science, suggesting their experience of school science had been a positive one. These classes formed a legitimate group against which the performance of *Primary Connections* classes could be compared.

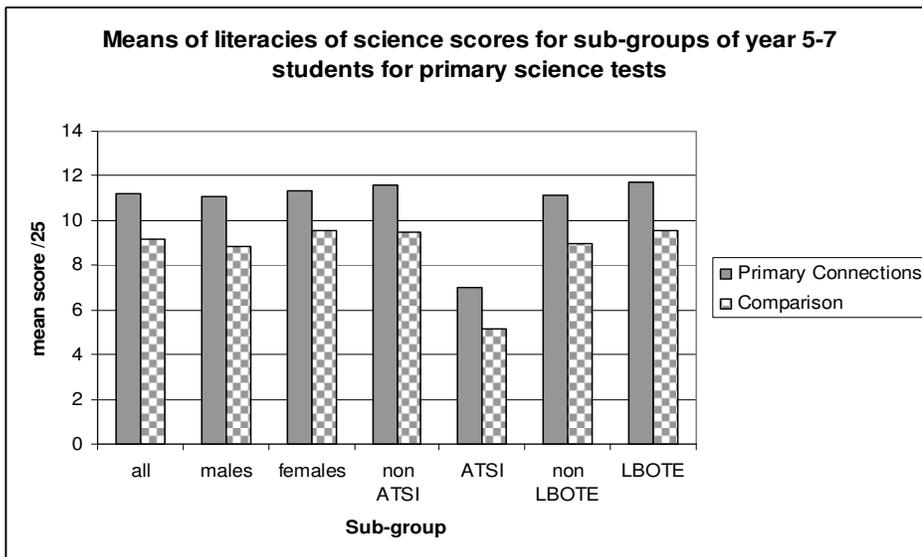
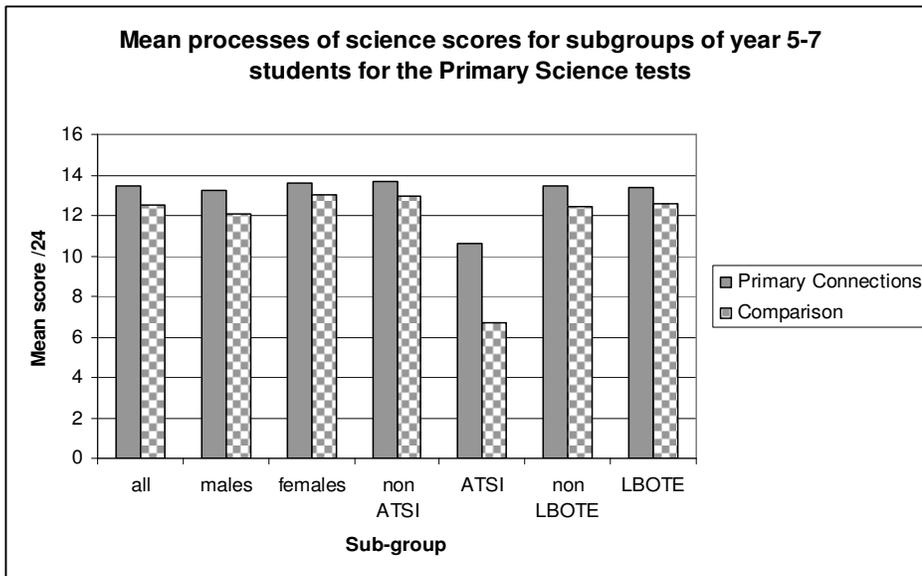
## **Findings**

Data were aggregated by task for science literacies and for science processes for Year 3 students, Year 4 students and Years 5-7 students. For all year groups and on all assessment tasks, students from *Primary Connections* classes achieved significantly higher mean scores on the literacies of science and the processes of science than students from comparison classes. Effect size (Cohen, 1988) values for literacies and processes of science indicate that *Primary Connections* had a substantial impact on students' achievement of literacies and processes of science. These statistical analyses show that the differences between groups were real and not the result of chance factors and were substantial. Effect sizes were larger for the literacies of science than for the processes of science, indicating that *Primary Connections* had particularly positive impacts on students' development of the literacies of science which are necessary to represent and communicate scientific data.

The inquiry-oriented teaching and learning approach of *Primary Connections* and the inclusion of student-planned practical scientific investigations provides students with opportunities to practise and develop the process skills associated with formulating questions, planning investigations, collecting data through observation and measurement, interpreting data and drawing conclusions. The research findings indicate that these process skills have been developed more effectively in *Primary Connections* classes than in the comparison classes.

The integration of science and literacy teaching in *Primary Connections* and the explicit teaching of the skills needed to reason with and represent science data has provided students with an opportunity to practise and develop these literacies of science. The research findings indicate that these literacies of science have been developed more effectively in *Primary Connections* classes than in the comparison classes.

The aggregated data for Year 5-7 students were further analysed according to the types of students who completed the tests. These analyses revealed that for all groups; males, females, students of Aboriginal and Torres Islander descent (ATSI), students with a language background other than English (LBOTE) and for non-ATSI and non-LBOTE students; students from *Primary Connections* classes achieved significantly higher mean scores in the literacies of science and science processes than students from comparison classes.



Figures 3a and 3b: Mean literacies of science and processes of science scores for sub groups

Although based on only modest sample sizes, of particular interest are the much higher mean scores for Indigenous students studying in *Primary Connections* classes compared with Indigenous students from comparison classes. Given the focus on closing the gap between academic achievement of Indigenous and non-Indigenous students in Australia, *Primary Connections'* impact on Indigenous students' achievement is worthy of further research and development activity.

The attitude scale revealed that a majority of all sampled primary students enjoyed school science; however, for two items there was a statistically significant difference in favour of students from *Primary Connections* classes. Students in *Primary Connections* classes reported that they experienced curiosity and learned interesting things more frequently than did students in the comparison classes.

The first of these findings, that most of the sampled primary students enjoy school science whether they are in *Primary Connections* science classes or in comparison classes, provides further evidence to support the integration of science and literacy learning so that science contexts interesting to students are used to enhance their engagement in literacy learning. The second finding, that students from *Primary Connections* classes are more frequently curious in science and report more frequently that they learn interesting things in science, is significant for science learning. The science community places a high value on curiosity as it is a trait associated with inquiry, problem solving and innovation. The opportunity to learn interesting things in *Primary Connections* science lessons would be expected to enhance engagement, achievement and a positive disposition to science. As Tytler et al. (2008) have argued, capturing students' interest in science during the primary years is critical if they are to remain in STEM study pathways.

### **Implications**

Previous research demonstrated that students achieve strong conceptual growth in *Primary Connections* classes (Hackling, Peers & Prain, 2007). This study has shown that students in *Primary Connections* classes achieve higher mean scores on the literacies of science, processes of science and on some aspects of attitudes to school science. These are all important components of scientific literacy which is the main purpose of primary science education in Australian schools (Goodrum et al., 2001). Significantly, this study has shown that students from *Primary Connections* classes outperformed students from comparison classes on those aspects of achievement that the latest science education literature indicates are important for science.

## Conclusion and implications

Goodrum, Hackling and Rennie (2001) argued that a national collaborative approach to teacher professional learning was needed to improve the status and quality of science teaching and learning in Australian schools. The collaborative approach taken by DEEWR, the Academy of Science, Australian universities and education jurisdictions has enabled large cohorts of professional learning facilitators, curriculum leaders and teacher educators to be trained to facilitate the professional learning of pre- and in-service teachers, and a wide range of innovative curriculum resources to be developed, trialled and published. *Primary Connections* is based on teaching and learning and professional learning models that are both highly innovative and consistent with the contemporary science education literature and have attracted international interest.

A comprehensive program of research and evaluation has established that *Primary Connections* has had positive impacts on schools, teachers and students. Principals of trial schools have reported that the program has enhanced the status of science in their schools, improved teachers' confidence in teaching science and enhanced students' attitudes towards science. Where *Primary Connections* has been implemented on a whole-of-school basis this has led to a more collegial approach to professional learning and to science and literacy teaching, and an increased amount of science has been taught. The program has had positive impacts on teachers' confidence in teaching science and literacy, enhanced their self-efficacy beliefs, the amount of time devoted to science teaching and their teaching practice and, consequently, increased students' opportunities for learning science. *Primary Connections* has had a positive impact on students' development of conceptual understandings, science processes, literacies of science and attitudes towards science; the key components of scientific literacy.

The training in *Primary Connections* of professional learning facilitators, curriculum leaders and teacher educators, has given Australia a substantially increased capacity to provide high quality science professional learning for our primary school teachers. The high quality professional learning and innovative curriculum resources of *Primary Connections* have the potential to make a significant contribution to developing the scientifically literate community needed by Australia.

Clearly, a great deal has been achieved; however, there is a need to consider implications for further developments of the program. The ideal is that all primary school children have the opportunity of a high quality science education and this will require a more widespread implementation of the program. Preliminary research findings indicate that Indigenous students, in particular, have benefitted from teaching based on *Primary Connections* with its integration of science and literacy teaching and the explicit teaching of the literacies needed to develop and communicate science understandings. Further research and development is required to fully exploit this approach as a means of closing the gap between the science achievement of Indigenous and non-Indigenous Australians.

Finally, there is a need to consider the further professional learning needs of teachers who have completed the first wave of professional learning and to develop additional resources such as video/DVD case studies of exemplary teaching that can enhance teacher professional learning. To maintain the currency and sustainability of the program there will be a need to update and refresh both the professional learning and the

curriculum resources to maximise *Primary Connections* alignment with national curriculum initiatives. There will also need to be training of additional numbers of professional learning facilitators, curriculum leaders and teacher educators to replace those who leave teaching or move to new roles.

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