PrimaryConnections®
Linking science with literacy

Science is primary

A review of Primary**Connections**
Stage 3 2006–2008

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Curtin University of Technology

APRIL 2009

Australian Government

Department of Education, Employment and Workplace Relations

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Acknowledgement

Disclaimer

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Executive summary

Background to the study

Primary**Connections** is an initiative of the Australian Academy of Science (AAS) that links the teaching of science with the teaching of literacy in the primary years of schooling. It is an innovative approach to teaching and learning which aims to improve the quality and quantity of science teaching and learning in primary schools, through enhancing teachers' confidence and competence. This is achieved by developing teachers' pedagogical content knowledge in teaching science and literacy through an innovative program of professional learning supported by rich curriculum resources (Peers, 2006).

This report provides a review of Primary**Connections**: Linking science with literacy Stage 3 (2006-2008). The purpose of this review is to assess the progress and impact of the Project and to make recommendations for Stage 4. Primary**Connections** Stage 3 was funded by the Department of Education, Employment and Workplace Relations (DEEWR) and led to the publication of 19 curriculum units and the training of 383 professional learning facilitators, approximately 900 school based curriculum leaders and 120 university science educators involved in primary science education. There were five objectives for Stage 3. They were:

1. improved student learning outcomes in science
2. improved student learning outcomes in the literacies of science
3. enhanced teacher self-efficacy and confidence in teaching science and literacy
4. increased teaching time for science
5. an enhanced profile for the teaching of science in Australian primary schools

> 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 used to reason with and develop science understandings, and to represent science data in the conventional forms used to communicate science information.

Research method

A qualitative research method was used in this study. Data sources included an analysis of Academy publications related to Primary**Connections**, a written survey of a sample of trial school teachers and principals from Stage 3 (n=52), structured telephone interviews with 10 Australian Academy of Science staff, 12 pre-service science educators and 16 reference group members (n=38), and informal discussions with Primary**Connections** project staff. The use of multiple data sources enabled triangulation of the findings and contributed to the credibility and trustworthiness of the results.

Key research findings

There is strong evidence that Primary**Connections** Stage 3 achieved its stated objectives. Multiple instances of anecdotal and indirect evidence coupled with Primary**Connections** research provide strong evidence that Primary**Connections** has had a positive impact on student learning outcomes in science and the literacies of science. There were multiple sources of evidence from direct observations of teachers and pre-service teachers by stakeholders (i.e., pre-service science educators, Academy staff and reference group members) and statements from trial school principals that self-efficacy and confidence has increased. There is also evidence from Primary**Connections** research and the trial school teachers and principals that in some schools, the time spent on science increased because of the introduction of Primary**Connections**. There is also evidence that the profile of science in schools and in the community has increased .

The most important factors contributing to the success of Primary**Connections** Stage 3 were relatively inexpensive and high quality curriculum resources that were combined with a high quality professional learning program that was flexible enough to be used with both pre-service and in-service teachers regardless of science background, teaching experience and school culture.

For example:

- the combination of the PL (professional learning) and the curriculum resources. That is the winner. We've got PL first and foremost supported by quality curriculum resources. We know from the research that it works. The support of teachers with good pedagogical resources with which to teach ensures good outcomes (Academy Staff).
- it is a good starting point for beginning teachers to give them confidence and for those teachers who don't have a lot of experience teaching science (Pre-service Science Educator).
- it is also the fact that PC did not require a strictly lock step program. We can take aspects of the program and we can tailor it to suit a context. That is part of the strength of the program (Reference Group).

The curriculum materials were also mapped against state and territory curricula to ensure that they aligned as much as possible. A substantial amount of national funding enabled the development and implementation of the professional learning program and curriculum resources. In addition, the leadership and dedication from the Primary**Connections** staff at the Australian Academy of Science was considered to be exceptional and ensured that the initial impetus from Stages 1 and 2 was maintained. The success of Stage 3 was also facilitated by active support (both human and financial) from the states and territories. The support of school principals and teachers was also considered to be essential for whole school implementation of Primary**Connections**.

Although Primary**Connections** did achieve its stated objectives, there were several factors that caused achievement to vary across schools. The amount of support (human and financial) from states and territories was variable and this impacted on access to professional learning for teachers. In some schools, science was perceived to be competing with literacy and numeracy for importance and time. School based factors such as teacher confidence

and background in teaching science, level of principal support and availability of equipment affected uptake. A small proportion of stakeholders perceived that the curriculum resources should be more flexible in their design, expand the area of literacy and promote a broader view of science.

During Stage 4 it is essential that Professional Learning Facilitator (PLF) training continue and it is recommended that preference be given to non-classroom based teachers. Professional learning needs to be readily available for pre-service teachers and in-service teachers. There is a need for more units and for existing units to be revised. In particular, new units will need to take account of developments in the national curriculum. The Primary**Connections** website should be updated to include material to extend experienced users and provide case studies of successful implementation. An important challenge during Stage 4 is complacency. It is important to maintain the momentum of the project by continuing to produce and revise existing units and continue access to professional learning by pre-service teachers and in-service teachers. In addition, the Primary**Connections** staff need to continue to lobby state and territory stakeholders to maintain and build science as a priority in primary schools.

Recommendations

Based on the research findings in this study, seven recommendations are made for Stage 4 and are listed below. It is recommended:

1. That whole school implementation of Primary**Connections** be facilitated by providing additional curriculum support to schools.
2. That the Primary**Connections** team works with jurisdictions to train local, state based master facilitators.
3. That the Primary**Connections** team continues to monitor and evaluate the progress of Primary**Connections** during Stage 4.
4. That the reference group consider strengthening the relationship between Primary**Connections** and early childhood education.
5. That the reference group consider strengthening the relationship between Primary**Connections** and indigenous education.
6. That Primary**Connections** endeavours to align itself with the national science curriculum.
7. That Primary**Connections** supports state and territory stakeholders to accept responsibility for Primary**Connections** activities in state and territory jurisdictions.

Primary**Connections** (PC) is an initiative of the Australian Academy of Science (AAS) that links the teaching of science with the teaching of literacy in the primary years of schooling.

Background to the study

It is an innovative approach to teaching and learning which aims to improve the quality and quantity of science teaching and learning in primary schools, through enhancing teachers' confidence and competence. This is achieved by developing teachers' pedagogical content knowledge in teaching science and literacy through an innovative program of professional learning supported by rich curriculum resources (Peers, 2006).

The Australian Government through its Department of Education, Employment and Workplace Relations (DEEWR), provided $1.8 million in funding for Stage 2 of the Project (July 2004 – October 2005) and funding of $3 million for Stage 3 (May 2006 – December 2008). Additionally, $948 032 in four supplementary funding agreements was provided to train curriculum leaders and pre-service science educators, to conduct extra recall days for professional learning facilitators, and to provide Primary**Connections** curriculum resources for tertiary resource centres. It also funded the pilot of the Indigenous Perspective and the incorporation of indigenous perspectives in all Stage 3 curriculum units where possible. Up to a further $4 million has been committed (2008 – 2010) to continue development and implementation of the Primary**Connections** project.

Primary**Connections** combines two components: curriculum resources and a professional learning program. The curriculum resources comprise units based on the four conceptual strands of the *National Statement on Science* (1994). They are: Earth and Beyond; Energy and Change; Life and Living; and Natural and Processed Materials. The units are divided into four stages of learning (early stage 1, stage 1, stage 2 and stage 3) which are linked to years of schooling and to the national scientific literacy progress map (MCEETYA, 2005). At the time of writing (March, 2009) nineteen units have been trialled, revised and published.

The professional learning program involves training PLFs so that they can provide professional learning workshops in Primary**Connections** to primary teachers throughout Australia, and to pre-service primary teachers. The PLFs are equipped to explain and model the teaching approaches that underpin the curriculum resources.

Overview of Primary**Connections Stage 1**

To date, the Primary**Connections** project has been implemented in three stages. Stage 1, funded by the AAS, sought and gained the support and involvement of education jurisdictions and sectors and conceptualised the project. A conceptual model was developed in partnership with a reference group comprising representatives from states and territories and major groups involved in science and literacy education. The underpinning frameworks were:

- professional learning approach
- inquiry and investigative approach
- linking science with literacy
- 5Es teaching and learning model
- embedded assessment

Overview of Primary**Connections Stage 2**

Stage 2 was funded by the Australian Government Department of Education, Science and Training (DEST) and involved developing eight curriculum units and a professional learning program that was trialled with 106 teachers in 56 schools across Australia (Hackling & Prain, 2005). The schools were drawn from all Australian education jurisdictions and sectors and comprised 45 government schools, seven Catholic schools and four independent schools.

In January 2005, the 106 trial teachers participated in a five day professional learning workshop to introduce them to science and literacy teaching strategies, the Primary**Connections** teaching and learning model, and the curriculum resources. The teachers subsequently taught a Primary**Connections** unit in term 1 and term 3, 2005. In term 2, each teacher taught a unit he/she had prepared using a Primary**Connections** planning template. The trial teachers participated in follow-up one day professional learning workshops halfway through term 1 and at the end of term 1 and term 2, 2005. Four of the trial schools had a whole school implementation of Primary**Connections** involving all teachers. These teachers participated in a one day professional learning workshop.

Stage 2 was evaluated through teacher and student questionnaires, teacher interviews and focus group discussions, classroom observations and analysis of student work samples. In brief, the key research findings were:

- implementation of the teaching and learning model through the curriculum units led to improved learning in science and literacy and changes in teachers' practice
- teachers' confidence in teaching science increased so that more time was spent teaching science and they moved from a focus on activities to a focus on learning outcomes using an inquiry based approach
- compared to other science programs, students' enjoyment of science improved and their quality of learning increased
- at the school level there was an increase in science teaching time and improvement in the status of science in the curriculum.

The research findings led to seven recommendations which informed the development and implementation of Stage 3 of the Primary**Connections** project. The recommendations were that:

1. the Australian government and state and territory departments of education need to provide support to continue the Primary**Connections** project.
2. the Primary**Connections** project needs to train PLFs from each state and territory and develop curriculum units.
3. implementation of Primary**Connections** in Stage 3 should:
   - be whole school and team-oriented
   - be based on a combination of professional learning and quality curriculum resources
   - include professional learning workshops presented by a trained facilitator and, where possible, a trial teacher, and
   - maintain and coordinate a team of facilitators within jurisdictions.
4. curriculum resources and professional learning resources should be made available in hardcopy and DVD/CD-ROM format with web support.
5. an initial teacher education package should be developed and one day professional learning workshops for pre-service science teacher educators should be conducted.
6. curriculum units with indigenous contexts should be developed.
7. Stage 3 needs to strengthen curriculum links with other national science education initiatives. For example, the Science Education Assessment Resources (SEAR) (http://cms.curriculum.edu.au/sear/) and learning objects from the Le@rning Federation (www.thelearningfederation.edu.au)

Overview of Primary**Connections Stage 3**

A document titled Primary Connection *Stage 3 Project Brief: 2006-2008* (Peers, 2006) was developed to guide the implementation of Stage 3. The recommendations from Stage 2 (above) informed the structure of Stage 3. Five success indicators or objectives were stated. They were:

1. improved student learning outcomes in science
2. improved student learning outcomes in the literacies of science
3. enhanced teacher self-efficacy and confidence in teaching science and literacy
4. increased teaching time for science
4. an enhanced profile for the teaching of science in Australian primary schools

Stage 3 of the project was funded by DEEWR and led to the development of further curriculum units, training of additional PLFs and provision of workshops for pre-service science educators. There were eight components that were intended to inform activities in Stage 3. They were:

1. Professional learning
2. Curriculum resources and unit development
3. First year of schooling
4. Indigenous perspectives
5. Pre-service teacher education
6. A web presence
7. Research and evaluation
8. Promotion of Primary**Connections**

Review of Primary**Connections Stage 3**

A requirement of the funding of Stage 3 was that a review be carried out by an independent expert as agreed to by DEEWR. This report provides a review of Primary**Connections**: Linking science with literacy Stage 3. The purpose of this review is to assess the progress and impact of the Project and to make recommendations for Stage 4.

Specifically the objectives of the review are:

- to review and provide advice on the Project progress against the objectives/success indicators in the Project, namely:

    - improved student learning outcomes in science
    - improved student learning outcomes in the literacies of science
    - enhanced teacher self-efficacy and confidence in teaching science and literacy
    - increased teaching time for science
    - an enhanced profile for the teaching of science in Australian primary schools

  To review and provide advice on:

    - the factors that facilitated the meeting of the stated objectives/success indicators
    - the barriers that inhibited the meeting of the stated objectives/success indicators
    - the national uptake of Primary**Connections**, including complementary investments and commitments (in terms of priorities, support and staffing) made by jurisdictions to promote effective uptake of Primary**Connections**
    - Primary**Connections**' planned future development and directions

- to provide advice and make recommendations concerning the most effective approaches to conclude, through Stage 4, work to underpin the implementation of Primary**Connections** in schools throughout Australia as a means of supporting the implementation from 2011 of the national science curriculum, including:

    - issues to be resolved and challenges to be addressed
    - work required to maximise the longer term take-up, sustainability and impact on student learning of Primary**Connections**, taking account of the requirement to align the Project with the national partnership arrangements for quality teaching.

Research method

A qualitative research method was used in this study. Several data collection methods were employed. Data sources included an analysis of Academy publications (including 18 research reports), a written survey of state and territory science curriculum officers and a sample of trial teachers and principals, structured telephone interviews with Academy of Science staff, pre-service science educators and reference group members and informal discussions with Primary**Connections** Project staff. Each of these data sources are elaborated on below. The use of multiple data sources enabled triangulation of the findings and contributed to the credibility and trustworthiness of the results.

Data sources and analysis

Australian Academy of Science publications

A number of publications produced by the Australian Academy of Science were reviewed as part of this research. Three important reports were reviewed. The first report was Primary**Connections** *Stage 2 Trial: Research Report.* (Hackling & Prain, 2005). Their report summarised the implementation and evaluation of Stage 2 and provided contextual information that acted as a rationale for the development and implementation of Stage 3 (see page 8). The second report was Making a Difference: Primary**Connections** *Stage 3 Project Brief: 2006-2008* (Peers, 2006). This report draws on the research findings from Stage 1 and Stage 2 and provides a plan for the implementation and evaluation of Stage 3 (see page 9).

The third report was *Small Study – Big Success Story:* Primary**Connections** *Incorporating Indigenous Perspectives Pilot Study Report* (Bull, 2008). This report describes the outcomes of the teaching of the curriculum unit, *Plants in Action*, in seven schools that had a higher than average proportion of indigenous students. The Plants in action unit had been revised to incorporate indigenous perspectives. The pilot study showed evidence for both indigenous and non-indigenous students of:

- increased student engagement and participation in literacy learning;
- improved student self-esteem, confidence and attitude to learning;
- increased student participation and contribution;
- increased experiences of success by students;
- increased student attendance;
- improved student relationships with learning (enthusiasm and commitment to learning);
- improved teacher attitudes to teaching science and literacy incorporating indigenous perspectives; and
- improved relationships and development of partnerships with parent and communities. (Bull, 2008, p.18)

Between February 2006 and December 2008 a total of 18 interim research and evaluation reports were prepared by a range of authors and published on the Australian Academy of Science website (www.science.org.au/primaryconnections/research.htm). All of the reports were read and the key findings were summarised. The summaries were examined for evidence of the extent to which the objectives for Stage 3 were achieved.

The foci of the research reports are diverse. They cover:

- evaluation of whole school implementation (Research report 1);
- evaluation of pre-service science educator workshops (Research reports 9, 10);
- evaluation of PLF workshops and activities (Research reports 2, 4, 5, 6, 8, 11, 12, 17);
- evaluation of curriculum leader workshops (Research reports 13, 14);
- follow up of trial teachers' activities and perceptions of Primary**Connections** (Research report 7, 16);
- trial school principals' perceptions of Primary**Connections** (Research report 3); and
- student data on the outcomes of Primary**Connections** (Research report 15)

Interviews with stakeholders – data sources

In consultation with the Managing Director of Primary**Connections**, three key groups of stakeholders were identified. They were 'reference group members' (RG), 'pre-service science educators' (PSE), and 'AAS staff'(AS). The reference group members comprised state and territory curriculum officers in science and literacy, and representatives of science education and literacy organisations. This group met regularly to provide advice on the implementation of the Project and also promoted Primary**Connections** within their jurisdictions and organisations. The pre-service science educators included lecturers and professors in science education and were selected from the academics who had attended pre-service science educator workshops conducted by Primary**Connections** in 2007. AAS staff included full-time and contract staff who were paid by the Academy for their services (e.g., Primary**Connections** staff, writers and research consultants). Note that these three groups are not discrete. Some Academy staff and some reference group members were also academics. Some academics had trained as PLFs and had acted in an advisory role to AAS staff.

A purposive sampling method was used to select a sample of stakeholders who were located in all states and territories, and represented a diverse range of organisations. A purposive sampling method is used in qualitative research to select individuals in order to best understand a phenomenon, in this case, Primary**Connections**. The final sample comprised 38 stakeholders and was selected in consultation with AAS staff. There were 10 AAS staff, 12 pre-service science educators and 16 reference group members. An information letter, consent form and interview protocol were developed and ethics approval was obtained from Curtin University of Technology. The purpose of the interview was to determine stakeholders' views about the extent to which Stage 3 of the Project met its initial objectives and to seek advice about the future of the Project. (See Appendix 1 for a copy of the interview questions.)

All 38 stakeholders were emailed by the Academy informing them that a review was to be conducted and that they would be approached to participate. Each stakeholder was then contacted by telephone and invited to participate. A mutually convenient time for the interview was organised. One pre-service science educator and one reference group member were not available. The stakeholders were emailed the interview protocol, information sheet and consent form prior to the interview. All except one interview was conducted by telephone. All interviews were audiotaped.

Interviews with stakeholders – data analysis

All interviews were fully transcribed. Initially, the transcripts were divided into the three stakeholder groups of 'reference group members' (n=16), 'pre-service science educators' (n=12), and 'AAS staff' (n=10). At the first level of analysis all 38 transcripts were searched for statements related to the following aspects:

1. Quality of curriculum resources
2. Quality of professional learning program
3. Views about, and evidence of achievements of, objectives for Stage 3
4. Factors that facilitated or inhibited achievement of objectives
5. Resources needed for Stage 4
6. Challenges for Stage 4
7. Alignment of Primary**Connections** with other national initiatives
8. Other issues

These aspects related directly to the terms of reference and the interview questions. For each interview transcript, sections of text related to each aspect, (e.g., quality of curriculum resources) were cut and pasted into a separate document. This text was then analysed for distinct categories that are called themes in this report (e.g., curriculum resources are flexible). The themes were coded (i.e., numbered) and the entire text related to each aspect was then coded for the themes. There was considerable overlap between the three different stakeholder groups. Thus, the same coding scheme was used for all three groups. The themes and associated quotes were ranked by listing them in order of frequency cited from most frequent to least frequent. Exemplar quotes that illustrated the full range of responses for each theme were selected.

Survey of state and territory science curriculum officers

In consultation with the Australian Academy of Science, nine state and territory curriculum officers who had been involved in the implementation of Primary**Connections** Stage 3 were identified. A survey, information letter and consent form were developed and ethics approval was obtained from Curtin University of Technology. (See Appendix 2) The purpose of the survey was to determine science curriculum officers' views about the extent to which the project met its initial objectives and to seek advice about the future of the Project in their state or territory. Only four out of nine surveys were returned. This sample was too small for the results to be meaningful and the surveys were not analysed. All state and territory curriculum officers were interviewed which provided responses to all of the questions in the survey.

Survey of trial school teachers and principals

A sample of trial school teachers and principals were surveyed about the implementation of Primary**Connections** Stage 3 in their schools. In order for data to be obtained from all 45 government schools, ethics approval would need to be obtained from Curtin University of Technology and each of the eight state and territory education departments. In order for data to be collected within the time frame of the contract, a sample of 19 principals and 33 teachers from 19 schools were invited to participate. The 19 schools comprised 11 non-government (Catholic and independent) schools located throughout Australia and 8 Western Australian government schools.

A survey, information letter and consent form were developed and ethics approval was obtained from Curtin University of Technology. (See Appendix 3) Ethics approval was also obtained from the Western Australian Department of Education and Training. The purpose of the survey was to determine trial teachers' and principals' views about the extent to which the project met its initial objectives and to seek advice about the future of the Project in their school. The responses to each question were categorised, coded and summarised as frequency counts. A total of 18 surveys were returned which comprised 12 from trial teachers and six from trial school principals The response rate was 35%. Note that this sample is not representative of all trial teachers and principals because they were predominantly from Western Australia. Thus, the survey data cannot be generalised beyond the sample schools. The comments from trial teachers and principals were combined and a summary is presented at the end of the results section.

Results

The results are presented according to the eight aspects stated in the method on page 13 of this report. They are:

1. Quality of curriculum resources
2. Quality of professional learning program
3. Views about, and evidence of achievements of objectives for Stage 3
4. Factors that facilitated or inhibited achievement of objectives
5. Resources needed for Stage 4
6. Challenges for Stage 4
7. Alignment of Primary**Connections** with other national initiatives
8. Other issues

For each aspect (e.g., quality of curriculum resources) a summary table is presented. The summary table lists the themes in decreasing order of frequency. Thus, the themes cited by stakeholders most often appear higher in the table than those cited less frequently. For example, in table 2 on page 18, the theme, 'flexible and readily adapted for different contexts' (number 5) was cited by more stakeholders than 'fits state and territory curriculum' (number 10). After each summary table, exemplar quotes from the stakeholder groups are presented to illustrate and elaborate on each theme and to provide an overview of the range of responses. Note that some stakeholders used terms that may identify themselves or others. In those situations the terms were replaced with the letters, XX. Some stakeholders also used abbreviations that may be unfamiliar to a lay audience. Where necessary, the extended terms are added to the quotes.

Quality of curriculum resources

By the end of Stage 3 a total of 19 curriculum units were developed, trialled and published. Table 1 summarises the titles and conceptual area of the units within early Stage 1, Stage 1, Stage 2 and Stage 3. The contexts of the units are spread across all conceptual areas of science and all years of primary schooling. Each of the curriculum units has a similar layout. There is ring bound booklet with a glossy hard cover. The booklet includes information about the Primary**Connections** teaching and learning model, a one page unit plan of about eight lessons, detailed lesson plans with resource sheets, and appendices describing the teaching strategies (e.g., word wall, co-operative learning). All unit booklets contain a CD of science background that was considered appropriate for primary teachers.

Stage	Conceptual area	Title of unit
Early Stage 1	Earth and Beyond	Weather in my world
Early Stage 1	Energy and Change	On the move
Early Stage 1	Life and Living	Staying alive
Early Stage 1	Natural and Processed Materials	What is it made of?
Stage 1	Earth and Beyond	Water works
Stage 1	Energy and Change	Push-pull
Stage 1	Energy and Change	Sounds sensational
Stage 1	Life and Living	Schoolyard safari
Stage 1	Natural and Processed Materials	Spot the difference
Stage 2	Earth and Beyond	Spinning in space
Stage 2	Energy and Change	Light fantastic
Stage 2	Energy and Change	Smooth moves
Stage 2	Life and Living	Plants in action: Incorporating Indigenous perspectives
Stage 2	Natural and Processed Materials	Change detectives
Stage 2	Natural and Processed Materials	Material World
Stage 3	Earth and Beyond	Earthquake explorers
Stage 3	Energy and Change	It's electrifying
Stage 3	Life and Living	Marvellous micro-organisms
Stage 3	Natural and Processed Materials	Package it better

Table 1. Stage, Conceptual Area and Title of Units

The high quality of the resources was acknowledged independently of the Academy when Primary**Connections** won the 2006 Australian Publishers Association Award for Excellence in Educational Publishing in the Primary Teaching and Learning category. The award recognised the high standard of the first four published curriculum units and the *Questioning Minds* DVD. Unit sales also provide evidence of the quality and demand for the curriculum resources. Graph 1 shows a steady increase in sales from February 2006 to December 2008. By January 2009, approximately 127,000 unit booklets had been distributed with WA and Qld receiving almost half. It is estimated that 46% of Australian primary schools have at least one curriculum unit.

Total Unit Distribution by Period

Total unit distribution to 31 March 2009

146,024
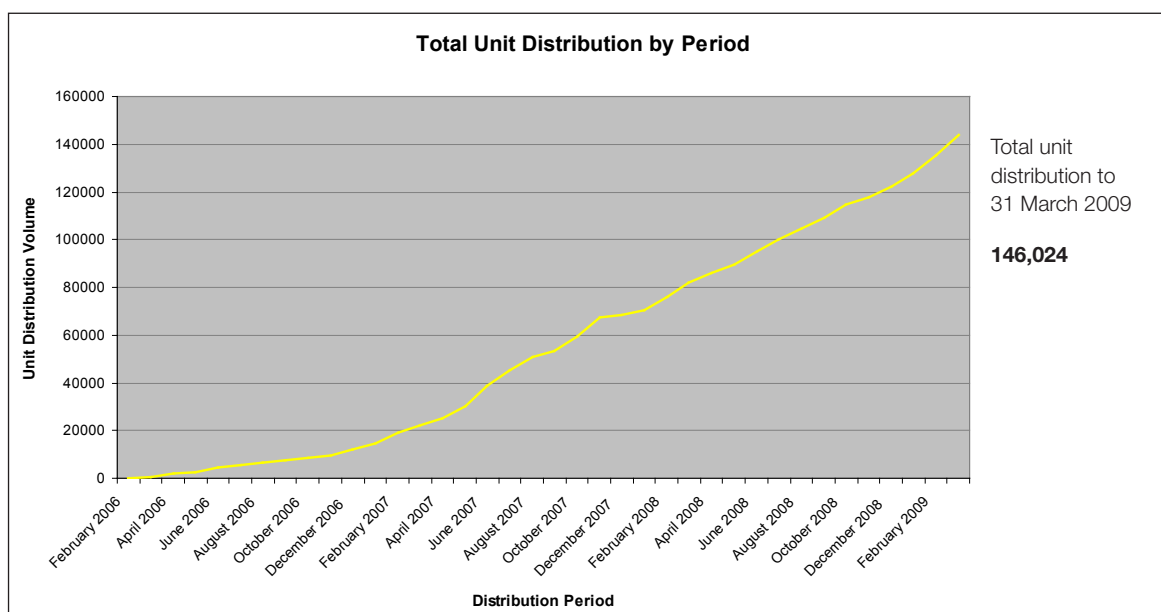
Graph 1 Distribution of curriculum units from February 2006 to March 2009

Overall, stakeholders expressed very positive comments about the quality of the curriculum resources. However, some suggestions for improvement were made. The main themes are listed in Table 2.

Themes
1. Excellent
2. Quality is maintained by extensive research, trialling and evaluation
3. Resources are appropriate for all teachers regardless of background
4. High quality resource with the science content clear, accurate and detailed
5. Flexible and readily adapted for different contexts
6. Professional development component is essential to success of curriculum resources
7. Combining of science and literacy essential
8. Inexpensive
9. Resources and equipment readily available
10. Fits state and territory curriculum
11. Inflexible and prescriptive
12. Need to broaden view of science
13. Need to strengthen link between science content and literacy

Table 2. Quality of Curriculum Resources – Themes
Themes are presented in decreasing order of frequency

1. Excellent

2. Quality is maintained by extensive research, trialling and evaluation.

The constant review process keeps the quality high and ensures Primary**Connections** (PC) remains at the forefront (Pre-service science educators (PSE)).

A lot of lead time and refinement went into each of those resources – there was about a nine month refinement and succession of feedback from a whole range of people, so that it could actually be relatively durable and have a fair chance of successful learning opportunities for kids. There was a lot of intense scrutiny and labour that went into the pedagogy of the unit, the clarity of the guidance for the teachers thus maximising the likelihood of positive outcomes for participants in classrooms (Academy of Science Staff (AS)).

The quality is certainly there in the effectiveness – that's a thing that people comment on, how effective and good they are. And that is no accident, they are very strongly trialled and critiqued before they are released (Reference group (RG)).

3. Resources are appropriate for all teachers regardless of background

It is a good starting point for beginning teachers to give them confidence and for those teachers who don't have a lot of experience teaching science (PSE).

They have been developed with sensitivity to the real-world classroom needs of teachers (AS).

Some people will take the resources and follow them word for word and that's there and that goes back to increasing teachers' confidence in teaching science. I turn the page and it tells me what to say, it tells me what I have to find and it's fantastic in that way. And we're having people say I don't think I can teach science but I can using these (RG).

4. High quality resource with the science content clear, accurate and detailed

The background CD is a good resource for teachers, the design is good. It's very good high quality material, detailed and easy to follow (PSE).

It does help the teachers think through and understand scientific principles that are there and it does provide that basic understanding of processes. (PSE)

The teacher background [CD] is a very strong component that teachers feel very comfortable with and it's great to have that included (RG).

5. Flexible and readily adapted for different contexts

The research of the Professional Learning Facilitators (PLFs) show that most of them modify the resources to meet the local context and that is a measure of success, not an inadequacy of the resources (AS).

That's what is great about these resources – people can use them in different ways (RG).

6. Professional development component is essential to success of curriculum resources

Units need to be reviewed and upgraded but don't do that at the expense of the Professional Development (PD) (PSE).

Very user friendly and accessible for teachers, especially in that it offers some differentiated professional learning which I think is essential in this day and age (RG).

7. Combining of science and literacy essential

The allying of literacy education and science education throughout with PC was a masterstroke. This was a very practical way of getting science into the crowded curriculum (AS).

8. Inexpensive

I think this is a really, really important thing because I teach in low SES areas and my pre-service teachers come from these areas (PSE).

9. Resources and equipment readily available

Resources are easy to get, you don't need highly specialised equipment. You might need sugar and a spoon! Practical everyday things (RG).

10. Fits state and territory curriculum

It lines up with the curriculum of each state – no difficulty in teachers saying how am I going to use it with my curriculum here because it actually fits right in (RG).

11. Inflexible and prescriptive

The 5Es is a very blunt model to plan quality units around. The 5Es is difficult to apply consistently to different units. Often you can have a unit with a lot of concepts promoted, but you ended up exploring one part of the concepts and examining another further on. I think, intellectually, it's a little messy (PSE).

I heard a few criticisms from some teachers saying it is too restrictive and that there are not enough details in them (AS).

The downside has been the perception of some people that it's prescriptive. I think that that idea for teachers who have been doing a bit of science, there has been an initial concern that they've been constrained by it. But on the other side I've heard teachers say that they have felt liberated and they've been more creative because the program is already planned and it allows them opportunities to think about how to extend the work and link it to other pieces of work (RG).

12. Need to broaden view of science

PC has a very conservative view of science. It doesn't really get strongly into the social aspects of science. It doesn't talk about values. It doesn't talk about what science means to them or people who work with science. It's mainly got a conceptual focus and the investigating focus is OK but it tends to be a bit restrictive (PSE).

The units are very topic-centric, whereas, there needs to be some consideration about opening up the process to be more pedagogy-centric. One of our concerns is that if what we get at the end of this project is 20-odd units of work that teachers can pick up and deliver that in a recipe style then what we've got is 20 units of work that get delivered without really enabling anything broader. If we can shift the emphasis towards building quality teachers who understand what it is to teach quality science, then we actually open up a much broader opportunity (RG).

13. Need to strengthen link between science content and literacy

I think the link between science and the content could be made stronger. Many teachers didn't really see the need for the links. They were going through the motions without really understanding what it was about (PSE).

Being a literacy specialist, I think we could have done more to improve the way that literacy was connected or the way that literacy was presented because in the end the scientists had the last say (RG).

Quality of professional learning

An important component of Stage 3 of the Project was the training of PLFs who would return to their education environment and provide professional learning to enable teachers to use the curriculum resources effectively. In January 2006 a group of 89 PLFs participated in a three day workshop in Canberra conducted by the Australian Academy of Science. Written surveys administered before and after the PLF workshop in 2006 indicated that the participants were well qualified and experienced in primary teaching and professional learning (Research report 2). After the workshop, the PLFs had a high level of confidence and self-efficacy about using Primary**Connections**. Suggestions for improvement of future workshops included more activities, modelling of practice (e.g., 5Es), and improved organisation of the resource folder.

During 2006, these PLFs attended further one day workshops at the end of term 1 and end of term 3. At the end of term 1 PLF workshop 28 of the 72 PLFs (39%) who attended had facilitated or planned to facilitate a workshop. Two thirds of the PLFs had not taught Primary**Connections** although most PLFs had shown Primary**Connections** to their colleagues and answered questions (Research report 4). At the end of term 3 PLF workshop, 40 out of 60 (67%) PLFs had facilitated a workshop, most commonly an *Introduction to* Primary**Connections** workshop for teachers (Research report 6). Factors enabling the effectiveness of the PLF role were the facilitators' current role and their communication networks, support from line managers and time made available for preparation and facilitation. Factors limiting the effectiveness of the PLF role were time to facilitate the program, schools finding time for workshops and lack of demand from teachers.

In late 2006, focus group discussions were held with 12 of these PLFs to obtain feedback about the Canberra 2006 PLF workshop. Suggestions for improvement included more hands-on and interactive sessions, time for reflection and consolidation, time for networking, modelling of the 5Es and collaborative approaches, and self assessment (Research report 5). These findings resulted in changes to the professional learning model for the PLF workshop held in Canberra in January 2007. Ninety five per cent of the 118 PLFs who attended this workshop had some professional learning experience in science or literacy education. This workshop resulted in a greater increase in mean self-efficacy and confidence and was rated more positively than the 2006 workshop (Research report 8).

In June 2007 it was resolved that the Australian Academy of Science would conduct PLF training workshops collaboratively with jurisdictions within the jurisdictions. PLF workshops were conducted in states and territories in 2007 (Research reports 11, 12). A total of 383 PLFs were trained. About 120 tertiary pre-service science educators were also trained as facilitators in January 2007 (Research reports 9, 10).

In addition, two day workshops for state and territory curriculum leaders (approximately 900) were held between June 2007 and February 2008 (Research reports 13, 14). Curriculum leaders were principals, deputy principals, science coordinators or teachers who would take a leadership role in implementing Primary**Connections** in their schools. After these workshops, both PLFs and curriculum leaders rated a high level of self-efficacy and confidence in their capacity to conduct professional learning using Primary**Connections** materials.

At the end of term 1, 2008 130 of the 383 (34%) PLFs responded to a survey about their PLF activities during 2007 and 2008 (Research report 17). A high proportion (89%) of the respondents were active in their PLF role. Until the end of term 1, 2008, the 130 PLFs conducted 2360 activities, an average of 18 each. It was found that non-classroom based PLFs engaged in more activities than classroom based PLFs. It was perceived that demand for workshops had remained high. This was thought to be a result of an increased awareness of PC and science becoming a priority in some states. As in the earlier evaluation of PLF activities (Research report 6) time availability was the most important factor limiting the number of workshops able to be offered to teachers.

Overall, stakeholders expressed very positive comments about the quality of the professional learning. However, some suggestions for improvement were made. The main themes are listed in Table 3.

Themes
1.   Excellent
2.   Sound pedagogical practice in professional learning
3.   Flexible for different contexts
4.   Professional learning is appropriate for teachers regardless of background
5.   High quality organisation and presentation of professional learning
6.   Combination of professional learning and curriculum resources leads to success
7.   Need to broaden view of science
8.   Lack of funding for professional learning with teachers

Table 3. Evidence of quality of professional learning - Themes
Themes are presented in decreasing order of frequency

1. Excellent

2. Sound pedagogical practice in professional learning

It got the teachers engaged, it got them doing things. It wasn't a stand-up delivery program. It was very much an interactive approach. Its approach was modelling its own belief structure and systems – so it practised what it preached. It got people to do it rather than to just get up there and tell us about it (PSE).

Teachers found it very useful to share ideas and hear different issues from people who have gone through it (RG).

It's excellent. It is varied and it's got pedagogical and content issues covered and it's got a literacy and representational focus, so that's good (PSE).

The information is succinct and accessible. It gives you the terminology that you need and there is easily understandable information about it (RG).

3. Flexible for different contexts

I think it is important that you have a person overseeing the PLFs to let them know that you don't have to follow it exactly and can modify it according to your audience (RG).

Really adaptable to our current situation, obviously we incorporate XX perspectives into them (RG).

It is also the fact that PC did not require a strictly lock step program. We can take aspects of the program and we can tailor it to suit a context. That is part of the strength of the program (RG).

4. Professional learning is appropriate for teachers regardless of background

The teachers were really charged, they were very excited and they went away enthusiastic (PSE).

PL has been valued – it seems that the facilitators that we have trained have valued the PL and some have even said it's the best that they have ever done (AS).

From the point of view of a PLF, I find that the actual units of work that have been prepared and the PLF notes with the modules are a very useful tool in starting schools on their journey (RG).

We don't use a deficit model. They [teachers] are highly trained, they are highly capable. They just may not have had an effective way of teaching science. It is true that many of them may not have science in their background, but it does not prevent them from teaching this important subject. The constant approach that we are dealing with professionals in the field is paramount (AS).

5. High quality organisation and presentation of professional learning

The people that I engaged with in Canberra. The whole thing was top-notch. This is big dollars flying people interstate, then following up across a large country and plugging into the networks. Accommodating people who are time poor and all the contingencies in getting release from schools and relief teachers. I've been more than impressed (PSE).

I think a strength of that [PL] have been the people they've had doing it – XX and YY are both excellent deliverers of PL (RG).

The workshops that I've seen are very professional, very well organised and cover a lot of areas (RG).

6. Combination of professional learning and curriculum resources leads to success

We can say that PL is a learning program first and foremost and I think in some way PL needs to be available for all teachers. A teacher can pick up the units and teach it quite well but they just don't have a thorough understanding of the underpinning principles that they get from PL (AS).

7. Need to broaden view of science

They could have done more on what is the big question we're answering. I don't think that was in teachers' minds. To go for the approach with a big question I know is a big ask, but it is still a way to start understanding the concepts in more depth (PSE).

The PL program should head more towards a generic view of what quality science education looks like. Things like good questioning technique. I know they are picked up in elements but there is a real opportunity to explore those things in much greater depth (RG).

8. Lack of funding for professional learning with teachers

It is restricted by the fact that departmentally there's no focus on science. I feel like I'm sitting here licensed to drive my car, but no-one's given me the keys to the car (RG).

There is no funding to access to be able to provide PD [as a PLF] (RG).

Evidence of improved student learning outcomes in science

Research report 15 described the findings from an evaluation of student processes of science (e.g., reasoning skills) and the literacies of science (e.g., graphing) in two groups of years 3-7 students (n=1476). 1113 (75%) students were from 18 Western Australian schools and the remaining 354 (25%) were from eight Queensland schools. One group of students (n=905) were from classrooms where at least two units of Primary**Connections** units were taught and the other group of students (n=562) were from classrooms where Primary**Connections** had not been taught. It was found that students from the Primary**Connections** classes performed significantly better than students from non-Primary**Connections** classes. The schools were matched for socioeconomic index.

Overall, stakeholders expressed similar comments about improved student learning outcomes in science. The main themes are listed in Table 4.

Themes
1. Anecdotal positive feedback from teachers and principals
2. Evidence from PC research
3. Direct observations of teachers (anecdotal)
4. Non PC research
5. Pre-service teachers use the PC curriculum materials (indirect)
6. No firm evidence

Table 4. Evidence of improved student learning outcomes in science - Themes
Themes are presented in decreasing order of frequency

1. Anecdotal positive feedback from teachers and principals

Anecdotal evidence from talking with my pre-service teachers and their experiences of using the materials in the classroom and inservice teachers that I work with (PSE).

It's quite clear in the schools that took up PC, there has been quite good outcomes in terms of science learning (PSE).

Certainly anecdotally all the teachers that I speak to tell me that the students are performing really well and they love PC and the teachers are happy with their progress (AS).

No formal data on that because it's not a formal role - everything is incidental. And because there is no budget within my team to follow things through, I have no hard evidence other than feedback from teachers saying that the kids just really love doing this and it's just so easy to run with it (RG).

2. Evidence from PC research

Certainly, the evidence I'd base it on is the work I saw at those workshops and also having read the report by Mark and Vaughan (PSE).

The first independent review - the specialists who did that were just staggered at the difference, the increase in the comprehension ability of the students and I don't think that there's been any indication that that has lessened over time. It has been quite remarkable how this hands-on approach has brought science to the children in a way that they understand and get excited about (AS).

Also they have the feedback from the teachers and the principals involved indicating that they have seen some growth in students' science learning outcomes (PSE).

3. Direct observations of teachers (anecdotal)

I could actually see the difference, particularly between a group of students who hadn't had any science much at all and then after a term of PC what a difference it made (AS).

Only anecdotally, the kids that I have worked with, so as a teacher, and I have seen them do the science. I think it has increased their science and literacy knowledge, but not on a broad school basis (RG).

4. Non PC research

Yes, across the board because they actually do a second unit of science and technology education where they go out into schools and run teaching clinics. They use the PC material as a basis for what they have delivered for the last 2 years. They have gone to the same schools and have asked their students to collect evidence of students gaining outcomes pre and post of the unit that they teach. Therefore they have some data on a unit basis that has been quite strong (PSE).

5. Pre-service teachers use the PC curriculum materials (indirect)

We have good evidence that they have used the PC materials to enhance their understanding and their learning of science (PSE).

6. No firm evidence

I was in XX and a lot of schools don't do any science. To say it improved when you were doing none isn't really saying that it's improving it's just says that you're doing it. In the schools who were doing things before, it's hard to say if it improved – I'm not saying it didn't improve but there wasn't measurement before to compare with after (PSE).

Part of the problem for XX, we've got a fairly scattered take-up of PC because it's not something that we have basically directed teachers or said to teachers that this is what you must do or should do. Really we haven't got a lot of evidence at this stage and I think it is still probably too early to know. If we look at our NAPSL [National Assessment Plan Science and Literacy] data, you know XX does reasonably well. If I look at the 2006 data, comparatively to YY, we out perform YY significantly and YY had a big uptake of PC. Maybe it's still early days (RG).

Qualitatively, teachers who have accessed the resource have indicated their positive support of PC and they like it and they say it's good material. I'm very mindful of the fact that the reality in all of these things is in terms of getting that measurement of impact, there are so many factors that impact on student performance that actually isolating the impact of any one resource like this is very difficult to do (RG).

Their academic achievement, we are yet to see this because we haven't had the facility to collect data from a range of schools. The National Assessment Plan Science and Literacy (NAPSL) test for 2009. To be able to get those results and compare it with the 2006 results, we should be able to see the impact for what we've been in doing in 2007 and 2008. But that won't come through for another couple of years, so unfortunately that's a bit of wait and see (RG).

Evidence of improved literacies of science

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 used to reason with and develop science understandings, and to represent science data in the conventional forms used to communicate science information.

Overall, stakeholders expressed similar comments about improved literacies of science. The main themes are listed in Table 5.

Themes
1.   Direct observation of teachers (anecdotal)
2.   Must improve because science and literacy are linked
3.   Evidence from PC research
4.   Linking science and literacy with pre-service teachers (indirect)
5.   No definite evidence

Table 5. Evidence of improved literacies of science - Themes
Themes are presented in decreasing order of frequency

1. Direct observation of teachers (anecdotal)

The last lesson at each school was used like an expo where the students explain what they have done through various means like blogs, acting as reporters or making brochures (PSE).

The teachers and the students, even after only two terms of PC were right on target with understanding what it was all about and the benefits of developing literacy in a science context (AS).

We certainly have found that by combining it with the XX literacy team that they have improved; showed more engagement of students in learning literacy, which if you unpack it we haven't got specific details that it's been purely due to PC. It's more a general feeling and as I said anecdotal information from teachers reporting on and reflecting on their classes (RG).

Really just anecdotally, the kids are really just a lot more eager to write because they've got something to write about. You never get that, 'I don't know what to write about', because it simply just follows on (RG).

2. Must improve because science and literacy are linked

We realised that if we tried to introduce science as a regular part of the curriculum it would be difficult because the teachers are under such pressure anyway. So we decided to introduce this through the literacy program because every school spends so much time on literacy every day. So we prepared our units so that they were effectively units for the literacy program, so it brought in science in that way and it also of course increased the vocabulary and increased the understanding of concepts at the same time (AS).

The whole program was conceptualised as the relationship between literacy and science. In science, you've got to learn a particular set of literacies. So it was really the core focus of what is the point of diagrams, tables, graphs, flow charts and all the rest of it in terms of clarifying and sorting explanations and data (AS).

Once again, the units encourage use of the literacies of science and the different ways in which literacy is used to record their information and to show evidence that they are fair, the tests that the children are devising and their using tables and all sorts of different ways to record this information. I think the fact that they're using more, they are learning more about the literacies of science (RG).

3. Evidence from PC research

This is the area where there was the greatest overall difference between PC and non-PC students (AS).

Report number 15 [Academy publication] shows highly significant differences between PC classes and comparison classes, and very strong effect sizes (AS).

4. Linking science and literacy with pre-service teachers (indirect)

With my pre service teachers, it has certainly raised an awareness within their minds to begin to think through those processes and connect it more with their current literacy programs (PSE).

5. No definite evidence

I've got no evidence. They were doing things, but there's no comparative data (PSE).

However, because we don't have an evaluation tool that we can actually use on this, we don't actually have the data that can tell us that the literacies of science have improved (RG).

Evidence of enhanced teacher self-efficacy and confidence

Overall, stakeholders expressed similar comments about enhanced teacher self-efficacy and confidence. The main themes are listed in Table 6.

Themes
1.   Anecdotal positive feedback from teachers and principals
2.   Direct observation of teachers
3.   Evidence from PC research
4.   Evidence from non PC research
5.   Observed changes in pre service teachers
6.   PC makes teaching science easier, thus must increase self-efficacy (indirect)

Table 6. Evidence of enhanced teacher self-efficacy and confidence - Themes
Themes are presented in decreasing order of frequency

1. Anecdotal positive feedback from teachers and principals

Teachers are saying that they have never taught science before and now they have a tool with which to teach it. For those who have avoided teaching science they have a detailed tool to use, so they are happier to do it (PSE).

One of the teachers from XX wrote to me and said that she'd been teaching in primary schools for 12 years and she and her colleagues did everything they could to never teach science. And she said, 'But you should see me now!' And I think that's the best thing I can say to you, she came to one of our PL courses and it just completely changed her confidence and her abilities to work with the children and to introduce them to the discovery mode of learning and to appreciate science (AS).

There are teachers that have come up to me at a number of PDs [professional development] and say, 'I used to hate science but I like science now. I never used to teach it, I teach it now' (RG).

We are getting extremely favourable comments about teachers' confidence in teaching science and literacy (RG).

2. Direct observations of teachers

There is an increased capacity of teachers through increased confidence and competence. It is observable when I am out doing workshops. There is excitement and transformation even in a couple of days. They are thinking differently. I can see the transformation of pedagogical philosophy and that practice at the classroom level (AS).

In a couple of schools I have observed that following a couple of years of using PC, there is a translation of the pedagogical philosophy into planning their own units, which is just terrific. That is where I hoped it would go (RG).

3. Evidence from PC research

They developed scales that were reliable and they monitored teachers' self-efficacy and confidence through a whole range of routes and people. The report showed a significant growth in confidence (AS).

4. Non PC research

The [pre-service] teachers start off warily and he reassures them. After the second unit, he gives them the Bandura self-efficacy scale to complete. They have seen big changes in [preservice] teachers' feelings about their ability to teach science, but also along with their confidence. They are quite confident with PC as a touchstone (PSE).

I've noticed that the teacher feedback at the end of the day, and it's a fairly open-ended questionnaire that we give them, reflect that teachers feel much more confident now and that they'll have a go at it and that they tend to include science and tend to teach it through the literacy aspects (RG).

5. Observed changes in pre-service teachers

I can definitely see that PC provided a good starting platform for the pre-service teachers and the in-service teachers that I worked with to at least feel that they had something to work with (PSE).

At the beginning, the pre-service teachers don't see themselves as teachers of science at all. Very rare. But by the end of the unit, there is a complete change. They are all saying I know I am good at this and I can do it. Evidence of change in belief, change in practice and change in capacity to do it (PSE).

6. PC makes teaching science easier, thus must increase self-efficacy (indirect)

PC provides structure and simplifies the teaching of science so they are more able to handle science concepts. It builds confidence. Literacy is something they identify easily with and it works with the children (PSE).

Yes, this went hand-in-hand with all of these teachers talking about how confident they were and I think a lot of it had to do with the first trial unit we put together (AS).

Yes, definitely. I think that teachers have found it really helpful because it is a very thorough program. You've got quality activities and that you've got those PD workshops where people feel part of the movement (PSE).

Evidence of increased teaching time for science

Overall stakeholders expressed similar comments about teaching time for science. The main themes are listed in table 7.

Themes
1. Science is taught at different times of day
2. Combining science and literacy leads to more science time
3. Better and more resources means more time (indirect)
4. Little change in teaching time
5. Anecdotal positive feedback from teachers and principals

Table 7 Evidence of increased teaching time for science - Themes
Themes are presented in decreasing order of frequency

1. Science is taught at different times of day

Yes, because teachers can see the combined value of teaching science and literacy together. Sometimes you might see science in the morning, when usually it would be allocated to the afternoon (PSE).

That actually has occurred because in XX, we have a 2 hour literacy block and teachers have tried to stop feeling guilty for doing their PC work in their 2 hour literacy block. So instead of having science on Friday afternoon, it comes into a morning session and they can get several sessions each week (RG).

That it's not always Thursday afternoon or Friday afternoon when everybody is at their lowest energy ebb and they've had it for the week. But it's actually being done at different times of the day, and it becomes the whole life of the classroom as it becomes the classroom theme and they integrate everything else into it. The other thing is that I'm finding that teachers are feeling that they can let go of other areas, like letting go of literacy blocks and integrating learning areas more and more (RG).

2. Combining science and literacy leads to more science time

The reality is that it has to. You are taking literacy in a traditional sense and putting it in the context of science (PSE).

On my personal observations – yes, now that teachers actually know that literacy is linked to science teaching. I think they are fitting in science to other places instead of just a dedicated science time (RG).

It does come through with people saying I've being doing this, I've been making science the focus of my classroom (RG).

3. Better and more resources means more time (indirect)

Increased confidence and available resources leads to more time spent on science (PSE).

For Stage 3, we have things such as the increase in unit sales, the evidence as the PLFs come back to the workshop. Because we have released units in both December and January we have had a continuous increase with figures at 128,000. You'd have to think that that is some sort of evidence of continued engagement and teacher's teaching it (AS).

I can tell you that to actually do PC requires increased teaching time over and above the average of 41 minutes per week (AS).

4. Little change in teaching time

I think it would be wrong to say that it has increased time for teaching science because that is really an administrative position to how much time is allocated (PSE).

I don't think we could honestly say that there's been any impact of PC on the change to teaching time, but again the problem here is that there are a huge number of competing factors in the school and I think the bigger issue is then, in terms of science, is that because we don't have mandatory time (RG).

I think that in the schools that have taken up PC – definitely. The question is how widespread it is and it's not as widespread as one might have hoped is my understanding. The answer is yes, but only in some schools (PSE).

5. Anecdotal positive feedback from teachers and principals

I've had the feedback from schools that they're spending more time in science and science is more accessible (AS).

Evidence of improved profile of science in Australian schools

Overall, stakeholders expressed similar comments about the profile of science in Australian schools. The main themes are listed in Table 8.

Themes
1. Impact of PC has been variable
2. Many teachers are aware of, and interested in PC
3. Increased community awareness of science
4. Evidence from PC research
5. Teachers are more confident with teaching science
6. No impact on profile of science

Table 8. Evidence of improved profile of science in Australian schools - Themes
Themes are presented in decreasing order of frequency

1. Impact of PC has been variable

I think at the policy level – yes. I think having a project like PC that has the AAS behind it and DEST funding, it gives primary science a focus which is valuable. But in terms of on the ground, who knows? There may be some schools who have never heard of it and those that have (PSE).

For states that are embracing PC, I would say that's absolutely, definitely happening. In states that aren't or haven't bought in at this stage, not necessarily so (RG).

But in XX, I'd have to say that probably it's still a small percentage of schools (RG).

So you've got varying profiles and uptakes of teaching science in schools. It's always different if a leader in the school has a mind set for science than those who don't, or if they have identified science in their school development plan as an area they'd like to develop (RG).

2. Many teachers are aware of, and interested in PC

People are talking about, people are moving the PC books, I get heaps of emails about where to get the resources or when the new ones are coming – there is a huge tick on that one (PSE).

There is an enhanced profile and they are hearing about it. There is definitely an increase in uptake across different states and territories now (AS).

3. Increased community awareness of science

Members of the community outside of the immediate school community are aware of PC and when I talk to them about work I'm doing in primary science, they usually say is this connected to PC. So that profile is in schools and outside of schools (RG).

When this particular school started doing science journals, the parents became very interested and thought that it was quite prestigious that their kids were doing science and that they had science journals. So the parents got interested as well (RG).

4. Evidence from PC research

This comes through quite strongly through the survey of the principals and their comments about the impact of PC on those trial schools. They said science is more visible in the school; more science is being taught; more teachers are teaching science in their schools and the kids are having a very positive response to that (AS).

5. Teachers are more confident with teaching science

With the re-engagement of teachers instead of blaming them, teachers have come to realise teaching science is not a specialised area. They now have the confidence and resources to use PC as a safe touchstone and this a has really enhanced the profile for teaching science (PSE).

6. No impact on profile of science

I think a lot of principals see this as the latest run for the last two or three years, and they're waiting for the next one. So while it did raise it for a while, I think there's issues about the continuity in the fact that most principals don't see it as a long-term thing, but something that they can get benefit out of rather than helping the kids. It's more for school PR than student learning (PSE).

I don't think it has done anything in terms of raising its profile due to other agendas that have come in [literacy and numeracy] and made itself more demanding and put science down the list (PSE).

No, not on a huge scale because it hasn't been taken up by XX. The XX has no dedicated primary science person. It is really frustrating to know that there is this great resource out there and there no emphasis on science in schools coming down from above that then gets fed to principals. I think at the moment, I've just sat through meetings about literacy and numeracy test results and that's what principals are having hammered into them by their bosses (RG).

Factors that facilitated achievement of objectives

Overall, stakeholders expressed similar comments about the factors that facilitated the meeting of Stage 3 objectives. The main themes are listed in Table 9.

Themes
1. High ighHighquality of curriculum resources
2. High quality of professional learning
3. Training of PLFs around Australia
4. National support and leadership from AAS
5. Support from state and territory jurisdictions
6. Involving pre-service science educators and pre-service teachers
7. PC is underpinned by research
8. Linking science and literacy
9. Appropriate for all teachers regardless of background
10. Inexpensive curriculum resources and equipment
11. Alignment of PC with state and territory curricula
12. Timely

Table 9. Factors that facilitated achievement of objectives - Themes

Themes are presented in decreasing order of frequency

1. High quality of curriculum resources

It's fairly easy to use, it's very friendly and it's got a consistent pattern through it with the 5Es model (PSE).

It does not require the teacher to make judgments about where they can put this activity or that activity because it is an integrated package (PSE).

The teacher background information in the curriculum units is run past a Fellow for approval. It means that it's not just something that someone's said oh, that sounds like a good idea (AS).

Quality of the units - the way that they're structured, the way that the appendices help teachers to understand the connections like, for example, the word wall and science journals and the cooperative learning aspects (RG).

2. High quality of professional learning

The follow-up with the workshops - having those available both during vacation times and after-school and during professional workshop days (AS).

I think the other thing that was great in working with schools and in improving the science and literacy were the meetings that we had for the PLFs and the trial teachers. So from the point of view of not only skilling up your approaches, but having those conversations, being in touch with people, sharing ideas, materials – that was really terrific. There was that real richness that comes out of that opportunity to work professionally alongside the other PLFs (RG).

The fact that we've got a 'package' that we've got PL, curriculum resources, a website and indigenous perspectives. A principal or a system can go – oh, they've thought of everything (AS).

3. Training of PLFs around Australia

Having PLFs around the country (PSE).

Our state co-ordinators and facilitators, the ones who are available and are active, make a huge difference (AS).

The PLF training has provided probably the very best opportunity for people to come together for an extended period of time to actually talk about teaching science in a primary context. That sustained opportunity to engage with colleagues, to engage with experts in the field and actually work through materials and have that opportunity to discuss, to look at it in terms of their own context, and then be able to go away and trial the materials (RG).

4. National support and leadership from AAS

The leadership in the project in that key people have been so committed to this project (PSE).

The extraordinary professionalism and organization of the AAS. Without the funding, nothing would have happened (AS).

The prominence of the AAS was unifying given the adversarial climate amongst the states, territories and the Commonwealth. AAS was seen as an honest broker with great expertise in science (AS).

The perception that here is a resource that has come out of a reputable organisation, that has as its core business a focus on science (RG).

5. Support from state and territory jurisdictions

I think that it has buy in from all of the states and territories via the national reference group. By signing up to that they're endorsing the product and saying that they are committed to it and seeing it through (AS).

Having the reference group made up of key stakeholders in curriculum development in literacy and science from each state was crucial - a collaborative pathway for getting all of the states to at least see the potential and to feel that they had some significant say in the shape of it (AS).

We've got a state-wide commitment in government schools to the implementation of PC - a huge focus on teacher PD realising that we need this to have effective science education. The funding that has been allocated to this project over the 3 years is at least $2.4 million and this funding has been devolved to regions. The funding is based on the number of teachers in the region and most importantly the geographical location (RG).

6. Involving pre-service science educators and pre-service teachers

It was very clever providing those awards to universities. I know that XX has given out a number of awards and PC is part of our undergraduate course and all our educators have been trained in it, so all of that has given it a much higher profile (PSE).

Involving pre-service teacher educators. It gave an opportunity to work with people prior to going out into classrooms and opening their minds (PSE).

The uptake of PC in every faculty of education in Australia resulting in the broad familiarisation of staff with the resources and the support program has been very powerful (AS).

7. PC is underpinned by research

People feel confident in the providers of that training, because it's informed by research (PSE).

The strong conceptual basis underpinned with the research (AS).

It was trialled. Teachers very much like the fact that every single lesson, every single part of those books have been trialled extensively by classroom teachers and feedback put in. And it shows in the materials that have been developed (RG).

8. Linking science and literacy

It enhances the confidence that the teacher has because usually they have a better understand(ing) of literacy development than they do of the science content. So it makes it easier for them to incorporate that kind of lesson into their teaching (PSE).

Links science and literacy, that was a great premise to base it on (RG).

The integration aspect - if you tell people that they're supposed to be teaching a lot of science in a primary setting, they would think it's impossible. A fair amount would be to teach 120 minutes a week, but they don't have a spare 120 minutes anywhere. So the integration is a powerful tool for teaching science in a context both for literacy and numeracy (RG).

9. Appropriate for all teachers regardless of background

It is especially good for the science-shy student [pre-service teacher] that having a program that is put together in this integrated kind of package is much easier for the student to develop some confidence in the teaching of science (PSE).

I think the beauty of PC is the ability to go above and beyond what is presented on the page. It allows them to cater for individual needs, so it allows them to bring on board kids with particular learning needs or disabilities. This is an ongoing issue in primary schools, in that they have to cater for such a wide variety of needs and abilities (RG).

10. Inexpensive curriculum resources and equipment

The resources are pretty cheap and useable (PSE).

I think the cost of the resources is definitely in our favour. Through the funding from DEEWR, we are able to offer the resources at a cost of $13.75, which when you compare it to the predecessor Primary Investigations is much cheaper (AS).

11. Alignment of PC with state and territory curricula

PC fits extremely well based on our work mapping the documents and the work of AAS. We cross-checked every published PC unit in extreme detail to the XX as a two-way process – PC unit to XX curriculum document and vice versa – lesson by lesson (RG).

We did an audit of all the curricula across the country to ensure that the units aligned with what was going on in each state (AS).

12. Timely

It is a timely initiative given the evident gap in quality of the teaching and learning of science in primary schools. This addresses the gap (AS).

It benefited from the added momentum through the broad agreement that National Curriculum is important and ought to be supported and the current Government to develop and implement national curriculum I think in time will see further impetus (AS)

Factors that inhibited achievement of objectives

Overall, stakeholders expressed similar comments about the factors that inhibited the meeting of objectives. The main themes are listed in Table 10.

Themes
1. Availability of professional learning for teachers
2. Availability of units
3. Availability of school science resources
4. State and jurisdiction support
5. Availability of funding in states and territories
6. PC does not match state curricula
7. Dominance of literacy and numeracy
8. School culture
9. Availability of non-classroom based PLFs
10. Teachers' awareness, confidence and willingness to use PC
11. Achieving sustainability is difficult
12. PC is too prescriptive
13. Low priority of science

Table 10. Factors that inhibited achievement of objectives – Themes
Themes are presented in decreasing order of frequency

1. Availability of professional learning for teachers

Although we have our science education strategy, training in PC is not mandatory. Currently, we've got a 64% coverage of teachers who have been to a PC training program of one or more days duration (RG).

There is an enormous cost involved in effective professional teacher learning programs, if you're trying to do something on a massive scale and that can affect the take-up (AS).

2. Availability of units

It was very difficult going to have whole school PD, but saying wait there's no books ready for you to use if you want to do natural and processed materials. So that sort of frustrated a lot of schools who were ready, well and truly ready to do it. It wasn't really until now when we've got a core sample of books that are ready. That frustration has been a concern (RG).

The time it has taken to get enough units out. People are waiting and wanting – if more could be created faster that would be exciting (RG).

Time factor for the people working on the project - sometimes it seems like an incredibly long time from trial to publication of the curriculum unit. I've heard teachers say, 'When are they going to get some units out?'. And I know that there's quite a number been published so far, but it has actually taken a long time (AS).

3. Availability of school science resources

Schools are finding it difficult to co-ordinate that [science resources]. We've tried to minimise that as much as possible by providing one of our regional technicians time for primary, so that they can set up and have ready equipment crates developed at cost for primary teachers to purchase so that they don't have to go out and shop for the material themselves (RG).

Lack of management of resources for hands on activities. PC needs to be supported in this way on an on-going basis (PSE).

4. State and jurisdiction support

Commitment in terms of each of the jurisdictions. In terms of XX, the science profile hasn't been as strong as it has been in the past, which is not to say that it's dropped off but it has changed the profile of science and the direction that PC may have gone. PC has been a very good vehicle for the direction of other science focuses in XX, but somewhat inhibited by the skills and capacities of those PLF (RG).

Mainly systemic and that differs between states and territories and their different priorities, their operational methods (AS).

There is an issue between the roles and responsibilities of the Commonwealth Government versus the State Governments. PL seems to be a state responsibility even though we have trained facilitators with our funding, the Commonwealth funding. It's then the facilitators' responsibility to go back to their states and deliver the PL at their government's cost (AS).

5. Availability of funding from states and territories

There is a lack of a state based consultancy network or at least one person working closely with us who could have been the point of call for teachers in XX to contact and speak to about PC. They could have supported networks through providing administrative support and enable networks to be generated and to be ongoing and productive. But we didn't have that and we couldn't build that into our already stretched schedule (RG).

There is a lack of money for teacher relief - the profile of science in the states and territories is so low that teachers can usually get money for literacy and numeracy things, but for science they have to dip into either their own resources or some other residual money somewhere or try and argue with someone (AS).

We need to invest more funding to pay for teachers to come in because we've got teachers who are just a great distance away from major towns. Particularly with the new indigenous perspectives that have been incorporated into the resource, it really needs to get out to our remote communities too (RG).

6. PC does not match state curricula

PC doesn't map directly to our syllabus, which is science and technology. There were some issues that we had to try and resolve, such that PC only really addresses half of our syllabus (RG).

Dealing with a national program that is being put out to states that have their own curriculum packages. The AAS has done as well as they could in getting states to at least agree that PC is consistent with their own curricula (PSE).

The competition in one jurisdictions between its own science and technology curriculum, and a program that deals with science alone (AS).

There are challenges with all the local versions of assessment in each different state, whether it's outcome based or other, we've got quite diverse things running. I think that the fact that the assessment was left relatively open-ended, so it could be like as though that's a defect but in fact as soon as you prescribe assessment you probably wipe-out half the country in terms that it doesn't match their calibrated version of progress (AS).

7. Dominance of literacy and numeracy

There is a general predominance of literacy and numeracy in primary schools and we are competing in the marketplace. And especially politically, there's a message come out about 50% of all time should be spend in literacy and numeracy (RG).

The focus on literacy and numeracy. There is so much of an emphasis nationally (RG).

8. School culture

Support of principals. There needs to be a leadership mind set change, in that some principals think you shouldn't be teaching science in literacy blocks (RG).

The cultural positions within primary schools - teachers are not as tuned to science as many of us would like. Therefore, it hasn't had the uptake that we would have hoped (AS).

Principal support - from workshops that I've done, if the principal's involved and comes to the workshops then it seems to flow right through the school. But if the principal's not really involved or don't seem too keen on the project, then it certainly flows again through the school as to how much science is done (AS).

9. Availability of non-classroom based PLFs

Another factor that we take up with the AAS from time to time is that many of our PLFs are class-based classroom teachers and they are fantastic people to have on board because they are real people doing real stuff with real kids. However, sometimes those people aren't able to be released to run PC programs and if they are released, they sometimes end up with a greater workload in preparing for a day away and chasing it up when they get back. A lot of our PLFs are in senior teacher roles, so they are already doing extra jobs as well (RG).

Hanging on to your facilitators if they move into other roles (RG).

10. Teachers' awareness, confidence and willingness to use PC

I think teachers finding out about the workshops. In some ways, it's not quite like preaching to the converted but you've got to at least be aware or have some level of confidence that yes you want to go into that science space (RG).

There is a difficulty of really getting the message right down to the classroom teacher (AS).

There is a fearfulness of science by a lot of the primary teachers who don't understand what the teaching of science is about (PSE).

11. Achieving sustainability is difficult

I think PC has got to work at the other end of really changing the view of what science is and really giving out the fundamental core of getting teachers to explore their beliefs and views about what science is. You've got to change the teacher if you really want to make a change to science (PSE).

How do you sustain anything? You get that initial ground swell of excitement and passion, but then something else will come along, so how do you keep that going? You need to forward plan – where to from here? You need to gather some case studies about what people are doing and how they are adapting it will inform that idea of sustainability (PSE).

Sustainability - the thing about PC is that you don't want it to be a flavour, you want it to be an on-going sustainable thing happening in schools (RG).

You can't get significant quality change in a short period of time. We have to stay in there with the teachers and a lot of funding and a lot of initiatives are politically driven and will stop, which leaves the teachers high and dry. So we have worked at building up that sense of sustainability (AS).

12. PC is too prescriptive

Sometimes the fact that it goes Lesson 1, 2, 3, … that it is quite formal in its presentation, so some people are not sure about doing it in the lock step (RG).

Unfortunately, I've asked students [pre-service teachers] to write units of work and they almost copy what is in PC, so it hasn't enhanced it as I want them to think up their own and use PC as a model (PSE).

13. Low priority of science

There is a need for ongoing advocacy at all levels from the Prime Minister down to school principals advocating for the importance of school science (AS).

Science is still an optional extra and ought to be a top priority in schools (PSE).

Resources needed for Stage 4

Overall, stakeholders expressed similar comments about the resources needed for Stage 4. The main themes are listed in Table 11.

Themes
1.   Maintain PLF training and ongoing support
2.   Maintain pre-service teacher and teacher professional learning
3.   Facilitate state based master facilitators
4.   Produce more units and revisions
5.   Web based support
6.   Maintain funding (Commonwealth and state)
7.   Encourage jurisdictions to promote PC
8.   Ongoing research program
9.   Science equipment kits and storage in schools
10. School science coordinators
11. Link PC to national curriculum
12. Broaden view of science

Table 11. Resources needed for Stage 4 - Themes
Themes are presented in decreasing order of frequency

1. Maintain PLF training and ongoing support

We would like ongoing support from the AAS for our current PLFs (RG).

We need to have the PLF days each year to re-energise, to look at new ways of doing things, to build upon it and to bring in the new documents and new units that are being produced (RG).

2. Maintain pre-service teacher and teacher professional learning

If you could transform time for teachers into time to trial, teach and share that would be fantastic (RG).

Continual mentoring - helping teachers to think through what they are doing and their beliefs systems about the teaching and learning of science. Without touching base with teachers you in-serviced, you just handover the materials and go away and leave them. I think it will just curl up and die in 12 months (PSE) .

Continue that development with pre-service educators because it is a massive influence. It is not just about opening [the students' {pre-service teachers'}] minds. Each of those students [pre-service teachers] then goes out and has a big opportunity to influence what is happening in schools in their practice (PSE).

3. Facilitate state based master facilitators

We would like state-based 'master trainers' (but call them whatever you like) because at the moment if we train people in XX, we cannot call them PLFs even though we've done the course but they are not allowed to be called PLFs as they are not AAS accredited (RG).

There needs to be dedicated state based officers to manage science as a KLA and certainly PC needs to sit within that (AS).

So the approach through Stage 4 will sort of be a staged one where the emphasis will lie in developing a cadre of trained trainers and PLFs so they can go into their systems and further devolve the PL to other teachers (AS).

4. Produce more units and revisions

We need more units. If they don't want to write too many more, then maybe reviewing them and putting out a second edition with more photos of how the unit has been happening in classrooms (RG).

I think there needs to be a steady addition of new materials because if it just sits at a certain number, and it doesn't matter what that number is, it starts to become stale (RG).

The materials would need maintenance by the AAS, in terms of ongoing updates. However there will probably come a time when there will be no more changes to the resources (AS).

It would be good if there was a broader range of units. Originally, we thought that once teachers saw the design they could design their own units. That was probably a bit optimistic (AS).

5. Web based support

The further development of some of the web materials would be a good direction to head in. I do think that teachers are using the web more and more as learning resources (RG).

A more focused website – at the moment, there is sort of more generalist kind of stuff, but I think getting stuff up there like examples, case studies, what people are doing in their neck of the woods and development of PC as a model for their own school-based stuff. I'd love to see how people are developing assessment and evaluation tools against PC (PSE).

There needs to be links to excellent websites that have some really good science content for teachers and others for students (PSE).

The website needs to be more creative and innovative - putting up different and interesting resources for teachers, not just a copy of what's already in the units. Something that takes some of the more interested teachers to a higher level of teaching (AS).

6. Maintain funding (Commonwealth and state)

Unless we can get some sort of localised support through a network facilitator, it's going to be very hard for us to promote it broader than we can at the moment. So the reality is that there is no extra money to be spent on this. And it would be such a shame to see a resource that's had the money spent on it, not actually be taken up to the level that it could be just because of a lack of a bit of local or state facilitation (RG).

A budget – if it's not Commonwealth then our department of education needs to provide locally for continual PL communities to participate in (RG).

Continuing fairly hefty investment by the jurisdictions in the teacher PL approach associated with PC to make it happen (AS).

7. Encourage jurisdictions to promote PC

I think that there has to be some commitment to overseeing and co-ordinate the needs of the PLFs and look after how things are happening with the implementation of the resource books, and how it connects to current policies that are happening within individual states (RG).

I would like to think that there is some work taken on by each of the jurisdictions to ensure that the linkages are made for PC and the state standards or outcomes (RG).

More facilitators or people in the states/territories who would be able to train teachers in PC. To date most of the training that has been occurring for facilitators has been conducted by AAS, and we can't continue to be the only place who can deliver that PL. Because there is such a high turnover and attrition rate that's all we would do (AS).

Science will need to be backed by the politics (of the day) and made a priority in the states and territories to ensure the focus remains (AS).

8. Ongoing research program

More testing - it is only when that happens that people sit up and think oh, we have to do something about this (RG).

Research. I would like to see that we get offered opportunities for research and some funding for opportunities for use to report on what we are doing and finding (PSE).

I think it's important to have other research conversations and I know particularly in the facilitator's guide for PD, there is a section there on academic research and I think that needs to be promoted a bit more. I think performing research in certain areas, like some snapshots would be great (PSE).

9. Science equipment kits and storage in schools

Basic science equipment, like microscopes and books about science (RG).

As simple as storage space. PC has all these simple resources, but you've got to take the time and have the space to store all the things (RG).

One of the things that we should do is start to develop some kits that people can purchase. I know that PC has been designed so that the materials are cheap to buy and readily available type of stuff, but you've still got an over packed curriculum in the primary area and teachers find it difficult to get out there and collect all the things and put it together (RG).

Have activity kits ready for purchase by schools (Have teachers trained, books available, and kits ready for purchase) (PSE).

10. School science coordinators

Introducing science coordinators - what would work well is to have some emphasis or resourcing put into a science coordinator type position in each school, where a person had some student-free time, some coordinator type time to implement the program (RG).

Have a science co-ordinator in the school. You need someone dedicated to organise that and to make sure that everything is ready to go and any consumables are replaced (PSE).

11. Link PC to national curriculum

Make links with the national science curriculum documents (RG).

Looking very carefully at the national curriculum agenda and what's going to happen there (RG).

A lot will depend on what shape the national curriculum takes and whether PC is seen as an off-the-rack supplement or whether we are going to be looking at different sorts of focus (AS).

12. Broaden view of science

And PC, as good as it is, should really just be the beginning and not the end. It should provide a platform for further discussion and reflection around the profession about how things could be improved (AS).

Plenty of people who would like science to shift off canonical concepts and to more socially based and a different agenda to the one it's had for the last 40 years. It will need conceptualisation about how a national resource like PC can mesh (AS).

Challenges for Stage 4

Overall, stakeholders expressed similar comments about challenges for Stage 4. The main themes are listed in Table 12.

Themes
1. Complacency
2. Teachers' awareness, confidence and willingness to use PC
3. Maintain access to professional learning for pre-service teachers and teachers
4. Maintain PLF training
5. Insufficient units and revisions
6. Support for teachers to use PC in schools
7. Maintaining the profile of science in states
8. Dominance of literacy and numeracy
9. National curriculum
10. Insufficient funding

Table 12. Challenges for Stage 4 - Themes
Themes are presented in decreasing order of frequency

1. Complacency

Complacency. PC's success doesn't mean we don't need to continually invest in this area (AS).

Internally, making sure that our own competency and enthusiasm and energy is able to be sustained for the rest of the project (AS).

Complacency. 'The problem is solved and we don't need to do anything more'. Science education is not a static discipline, in that it is ongoing and it needs to be updated (PSE).

It is hard to maintain any one project over a long period of time. The history of education generally is that people move on (PSE).

2. Teachers' awareness, confidence and willingness to use PC

My big beef is getting every teacher to be a teacher of science, not just the science DOTT [duties other than teaching] provider or the science specialist. PC doesn't function that well in that environment because there are missed opportunities and the links to the literacy are superficial. So if it's going to be, every class teacher has to have ownership of it (RG).

I wonder about all the teachers that we don't know about who don't teach science. I'm concerned how we are going to really influence all of those teachers to look at this as (a) important and (b) that they can do it (AS).

Keeping the primary teachers interested in teaching a subject that requires more resourcing, more content knowledge, more planning than other subject in the primary school curriculum (AS)

Helping teachers to see science as do-able. To teach science well you need to have good pedagogy, but you also need an awareness of knowing what makes science, science and often they don't have that (PSE).

3. Maintain access to professional learning for pre-service teachers and teachers

The other concern I would have would be the continuity of funding and in particular the funding for teacher PL, in order to make this a long-term success. The vast majority of teachers particularly in a primary school setting have very low levels of confidence in their own knowledge and their own preparedness to teach it. I think to make it successful it is going to need a national scale, major initiative in terms of PL (RG).

Keep that pre-service science education going to make sure that is working. To see if the teachers that have been trained in their educational institutions and they still don't teach it when they come out then you have to see what is the matter (AS).

4. Maintain PLF training

The right people, the right expertise. Dedicated roles that continue to enable that (AS).

Continuation of the PD for different areas – PLFs, tertiary educators, curriculum officers and to sometimes bring those different areas together for a bit of a forum and all hear how it is going for someone who has an entirely different role to me and what they're doing about it (PSE).

The challenge is in maintaining enough of a structure to keep training people (PSE).

5. Insufficient units and revisions

To find the resources for the sustainability, but then I think it's to maintain the freshness. You've got to be prepared to change the material. Otherwise, it becomes stale (AS).

Boredom with the current units. People will get bored when there is only one unit for each year for each strand. There needs to be a long-term implementation of new units, so there's new things coming through, maybe once every 3 years or 4 years (AS).

6. Support for teachers to use PC in schools

If we want PC to be useful, it's got to be incorporated and embedded into school plans for sustainability. To work with schools on their whole school planning of science. When I started in my position, I had 50 schools and only 2 had a plan for science – they all had literacy plans, they all had numeracy plans. Now we are starting to get a slow turn around where each of the schools that I work with has a whole school plan for science (RG).

Support - in the school that I've worked with, there is a science co-ordinator there who is a passionate PC person and who has motivated the others and with my support as well has kept the ball rolling. But I think things need to be supported by the school (RG).

Communication and support - if it's not in your face, you don't have the emails, you don't have this constant hey, this is what's new in PC, that communication then it will be like every other resource and starts to sit on a shelf maybe (PSE).

7. Maintaining the profile of science in states

Get it as a system priority and once you've got science as a system priority, it's getting it as a school priority, which takes a bit of energy as you're competing with literacy and numeracy as the big drivers. And I think it's not a competition, but a complementary relationship (RG).

It requires continual advocacy – we've got to penetrate a wider population and work further with the schools that are implementing programs and go into the next phase of the PL (AS).

To get the states on board and behind it because I don't think that's happened even though there's been in principle support, but I don't think there's been a huge push (PSE).

8. Dominance of literacy and numeracy

I think the biggest challenge talking to teachers around our schools is the emphasis on literacy and numeracy at the moment and I think that's a national thing. It's not just in our context. Teachers and schools are being pushed to get their literacy and numeracy results up and world-wide when this has happened there is a danger that they'll just focus on that, that they'll just focus on teaching to the test. I think it would be advantageous to the books if they could sell the literacy aspect more, even though they are linking science and literacy they are seen very much as a science product (RG).

Competition with literacy and numeracy (PSE).

9. National curriculum

 I think that there will be a period between now and September where the PC team may need to have a bit of a think about what is on the agenda for units for the future and maybe hold back a bit. There would be a good opportunity then to actually look at some of that pedagogy and practice stuff and some of that much more strongly. And maybe one of the things that need to be looked at is putting aside some money to review units to bring them in line with the national curriculum as it starts to come out (RG).

I'm concerned that now the NCB (expand)are not going to not exist but become ACARA (expand)and they may do something similar to the UK and put out tests and the secondary flavour may influence what they're like. So that may well shift the success that we have had in focusing on quality teaching and learning (AS).

10. Insufficient funding

Money - when they stop funding, it becomes something that just sits on the shelf because something else will be being pushed (RG).

Funding - Governments love to draw a line after a certain amount of time. It will be interesting see what they are going to do with the extra XX million that they've given them for Stage 4 (RG).

Alignment with national curriculum

Overall stakeholders expressed similar comments about how Primary**Connections** can be aligned with the national curriculum. The main themes are listed in Table 13.

Themes
1.   Maintain and build partnerships with National Curriculum Board
2.   PC already aligns with state and territory curricula
3.   PC already aligns with likely national curriculum
4.   Map PC to national curriculum to see if it aligns
5.   PC may need to be modified
6.   Market and promote PC to stakeholders
7.   PC needs to align with National Assessment Program Scientific Literacy (NAPSL)
8.   Need more units

Table 13. Alignment of Primary**Connections with the national curriculum**
Themes are presented in decreasing order of frequency

1. Maintain and build partnerships with National Curriculum Board

The AAS has officially provided feedback on the framing paper and XX continues to be part of their advice group, and now the project with their partnership with DEEWR has been asked to provide briefs to the National Curriculum Board on the entire project and the resources. And I'm pretty sure we'll be asking for a NCB rep to come on board with the reference group as part of PC (AS).

Forming a relationship or establishing more of a relationship with the NCB and keeping them regularly updated with the progress of the project (PSE).

So seriously making sure the curriculum writers at the national level are really taking on board what has been done in PC, its success and including that from the very beginning of school (AS).

2. PC already aligns with state and territory curricula

I think PC is situated in a good place to be aligned with the National Science Curriculum. It is in a place where it's tried to cover various syllabi across Australia. So, it's ahead of the game in that respect. There will need to be time or facilities put aside for the review of that in light of National Curriculum if and when it comes into fruition (PSE).

At the AAS, they went through all the states' and territories' curriculum documents and they match up. So there's no problem with a national science curriculum that still allows the states to take some initiatives and uses PC as a really good model because there's not a great deal of difference between states and territories anyway (AS).

These units are readily placed in any science curriculum that is developed. There are slightly different versions in all the states, so they're enhancing the value and they will be in the national curriculum. When you're learning how to learn, it fits with any curriculum (PSE).

3. PC already aligns with likely national curriculum

PC does recognise questions that can be investigated scientifically that is certainly one of the criteria that the National Curriculum is working towards (PSE).

Looking at the framing paper, it's really clear that the national curriculum is headed in the direction of being inclusive – science for the people, not just the future scientists. It's very clear that the direction of the national curriculum will be one strongly based on inquiry and investigations, which is totally consistent with PC. And it will largely be about the doing of science, not just the knowing of science (RG).

National Curriculum will develop, presumably, a broad framework that describes the learning opportunities and skills that students at the primary level ought to acquire throughout the nation. PC will give teachers a means by which that can be achieved (PSE).

4. Map PC to national curriculum to see if it aligns

What needs to happen is that the PC program needs to be mapped onto the national curriculum in such as way that it shows that these particular objectives are actually achieved within the program (PSE).

If you look at the philosophy that is underlined in the science framing paper, it matches very closely with the philosophy and the 5 learning principles of PC. PC can probably be seen as a vehicle for implementation so we can acknowledge no matter how many resources there are in PC, they are exemplary resources (RG).

It's not going to go away, so mapping the resources into how it could support the implementation of the national curriculum could be a very good idea (RG).

5. PC may need to be modified

If it is going to be too prescriptive, it may not match with the PC modules. So PC may decide to modify them to fit with the National Curriculum (PSE).

The draft framing paper had a lot of elements in there that aren't picked up as strongly in PC as they might be and I was talking about the human aspects, in terms of the careers or the people that are in engaged in science or the social aspects, I think that could be strengthened to align (PSE).

They need to bring in 'science as a human endeavour' (RG).

6. Market and promote PC to stakeholders

PC is very worthwhile, but I think it will need to be sold to politicians who are supporting the national curriculum in such a way to show that the learning outcomes are achieved through PC (PSE).

I would like PC to make some comment and to say in the news how it feels about the national curriculum or how it does align. Having that connection to where does PC fit with that type of policy and research development (RG).

7. PC needs to align with National Assessment Program Scientific Literacy (NAPSL)

The national curriculum won't please everyone. There needs to be a strong alignment between PC and the national curriculum because there will be a strong alignment between national curriculum and NAPSL. The most critical element is NAPSL. If there is constructive alignment between national curriculum and NAPSL and the PC resource and approach then it's a very good rich model (AS).

If we are going to go to National Curriculum and there's going to be national testing then I think teachers are going to go back to teaching children what they need to know for that test (PSE).

8. Need more units

It touches on what I said before about there not being a unit to cover every year and strand, and I think that's what the National Curriculum looks at (AS).

If they [PC] want to align with that they need to go ahead and make sure that there's a unit for each year level and each strand as well (AS).

Other issues

The stakeholders were asked if they had any further comments. The main themes are listed in Table 14.

Themes
1.   Involvement with PC has been rewarding
2.   PC has had a huge impact
3.   Early childhood education
4.   Indigenous education
5.   Need ongoing support for sustainability
6.   Broaden view of science
7.   Improve literacies of science
8.   Funding opportunities

Table 14. Other issues raised by stakeholders
Themes are presented in decreasing order of frequency

1. Involvement with PC has been rewarding

I feel quite privileged to be involved with the project over such a long time – it's been fantastic (RG).

I really like the way it's been approached in the development of it in a professional way - backed with support from the academic world, and it's backed by all jurisdictions, but also groups like XX and YY and ZZ, all the professional bodies have been stakeholders in it as well (RG).

The PC experience has been the most professionally rewarding experience of my professional life, which extends over quite a long time. It's been a very rich, personal experience and I have grown enormously through it. I think most people who have been involved in the project will have the same comment to make (AS).

I think what has happened has just been wonderful. Without being patronising, I just think that so much hard work has gone into it and it really has had in many respects bi-partisan support (PSE).

2. PC has had a huge impact

I think that the education system at primary level in Australia had an emphasis on literacy and numeracy. And I think PC has sort of opened up and demonstrated the need to have an emphasis on science in our lives, that's what it's about. It's the science course rather than the literacy and numeracy courses that emphasises self-learning and an approach to never be afraid of the unknown (AS).

3. Early childhood education

I know that there was talk about an early childhood speciality. I know that there has certainly been concerns from teachers about the K-PP [Kindergarden to pre-primary] and we have suggested that they could modify the early Stage 1 books that are aimed at Year 1 to suit students in the non-reading and non-writing area. But I think that there would be more satisfaction if they actually were able to have some books that were perhaps not as formal in their approach as the 5Es, but more concentrating on lots of play and lots of exploring (RG).

4. Indigenous education

Indigenous perspective - I'm just concerned about how that is taking place as I think that could be a real issue of concern – how do you teach indigenous children science and what is an indigenous perspective to science? (PSE).

5. Need ongoing support for sustainability

And it has had some very strong support. I think we've just got to keep going and the PD is essential. I think that the subsidisation by the Federal government should continue. To access the books and CDs, that is all low cost… the high cost is the labour and that's where the money has to go. We don't need artefacts, we need people engaging in the artefacts and showing them how to use them (PSE).

Unless they get this ongoing support then it will end. To me that is essential. In schools it will collapse like other things. Teachers are willing, but if they don't get what they need and it's not seen as important, it gets dropped when other schemes come in with more money and a bigger push (AS).

Again, the big challenge is sustainability and priorities. Often within curriculum development, it's a moving feast! (PSE).

6. Broaden view of science

The 5Es a model is a bit limiting (PSE).

PC is only one model of a way to teach science (RG).

Broadening of the view of science, whether they include more on those social aspects of science (PSE).

Continuing the range of topics - I know we've got lots of volumes, but there are still topics around and I think some more things that take on board the more multi-disciplinary into the environment space. I think we could keep adding to it from that point of view. Climate change and all the rest of it. We've got to get kids thinking about them, but thinking about them in positive ways and understanding the science behind it (RG).

7. Improve literacies of science

We need a more sophisticated model of the literacies of science. I have been involved with XX looking at the literacies of science and the role of representations. The work that we've

been doing could be much better represented in PC (PSE).

A lot of them think that literacy will solve all issues, but literacy out of context will not solve anything. It's the context that's missing from most of the teaching. But some of them put it in context, but don't check which literacy outcomes they are covering (PSE).

8. Funding opportunities

We need information about opportunities for grants that we can apply for. All that sort of stuff that would build the practice and extend it. It would be great to have funding opportunities, research opportunities, grants and things that would enable us to develop further projects (PSE).

Trial school teachers' and principals' perspectives

This section of the results summarises the survey data from trial school principals (n=6) and trial school teachers (n=12). Forty per cent of the 18 trial teachers or principals mentioned the high quality of the curriculum resources as a positive factor in the success of the Stage 3 objectives. One principal who also teaches science using the Primary**Connections** resources wrote that they have, "clear and precise lesson plans, good support documentation and are easy to follow". The trial teachers (5/12) were also positive about the benefits of the professional learning program especially in regards to the support provided by the Primary**Connections** network. One teacher wrote that, "The constant support and network available, both personally, with resources and through ICT is appreciated".

In the survey the trial teachers and principals were asked to answer the following question 'To what extent has Primary**Connections** Stage 3 achieved the following objectives in your school?', on a scale of 1 to 5, where 1 = not at all, 3 = somewhat and 5 = to a large extent. Means and standard deviations were calculated separately for the teachers and principals.

Teachers (n=12)		Principals (n=6)	
Mean	Standard Deviation	Mean	Standard Deviation
3.77	0.72	4.20	0.76

Thus, both principals and teachers consider that the objectives have been achieved to a reasonable extent. The respondents were then asked to provide evidence that the five objectives had been achieved in their school. All of the principals (6/6) and most trial teachers (8/12) mentioned staff comments and direct observations as evidence. Many respondents (15/18) included evidence such as an improvement in state wide science testing, improved student grades and an increase in the number of science competition winners. In relation to student outcomes in the literacies of science both principals and teachers cited improved student work samples and student grades as evidence.

Trial teacher comments and teacher observations were the most common forms of evidence provided by both the principals (5/6) and trial teachers (5/12) about teachers' self-efficacy and confidence. Words used repeatedly to describe the teachers included "excited", "confident" and "enthusiastic". One principal described evidence collected through, "school self assessment processes and staff surveys". Half (6/12) trial teachers noted an improvement in staff attitudes towards teaching science. For example, "Teachers [are] more willing to teach science. Teachers express greater confidence" and "Many teachers needed help years ago but over the years are working collaboratively with minimal guidance."

There is evidence from most principals (5/6) and several teachers (4/12) that teaching time for science has increased in their schools. One principal stated that "It was a challenge for teachers to devote more time to teaching science". "Again a battle – but teachers know that giving time means they reap the benefits across a range of subjects". A few (3/12) trial teachers noted that since Primary**Connections** can be integrated with literacy, there is more science taught because it is integrated with other subjects.

Respondents included a variety of responses as evidence of an enhanced profile of science. For example, principals perceived that teachers were more aware of science because "Staff are requesting more PD based on Primary**Connections**". Several principals were increasing the profile of science (and Primary**Connections**) in their local community through newsletter articles. One school principal included a list of evidence highlighting how they shared Primary**Connections** with the wider community. "Evidence of student achievement is shared with the community in the School Report and DET [Department of Education and Training] through Director of Schools". A few trial teachers (3/12) wrote that their school was being used as a model for other primary schools. "Other schools are visiting to observe staff teach and use Primary**Connections**".

From the trial teachers' (7/12) perspective the most important factor that enabled the success of Stage 3 was the personal commitment from the trial teachers and PLFs. Support provided by the Primary**Connections** team (6/18) as well as support from the school principal (8/18) was also important. The quality of the resources and ease of use were also important factors. Several principals (3/6) mentioned that having a trained facilitator in the school was an enabling factor. One principal indicated that the literacy basis of Primary**Connections** is important as it "allows teachers to use science to teach literacy."

Two of the six of the principals stated that the generally negative attitude to science by teachers as well as an overcrowded curriculum (2/6) inhibited teachers from using Primary**Connections**. Primary**Connections** becomes yet "another new program to implement". Several (5/12) of the teachers agreed with the principals that an overcrowded curriculum was an inhibiting factor. One principal was also concerned about the lack of scientific knowledge in the younger/new teachers. She commented that there is a "lack of scientific knowledge amongst younger teachers (content in pre-service teaching courses does not seem adequate)". An important factor for many (8/12) teachers was the lack of teacher release/time for collaboration, organisation and collection of resources. "It (Primary**Connections**) takes more time (class time and preparation time) than other simpler science programs." Lack of money for science within the school budget was another concern (3/12).

To be successful in Stage 4, half of the principals (3/6) stated that ongoing support from the Primary**Connections** team needed to continue: "Professional development – keep it up for new teachers AND to keep trained teachers refreshed and motivated". One principal suggested that, "Generating greater choices of units that fit themes/plans/units of work at individual schools/areas" would be useful. Teachers also suggested promotion of Primary**Connections** through a magazine or website (3/12), equipment kits for units (3/12), and new units (4/12).

When asked about the challenges for Stage 4, a frequent response from teachers (8/12) was the need for more support and funding of science. We need the "finances to adequately provide opportunities for collaboration, professional learning and resources." Many (7/12) teachers agreed that extra time is important because "We no longer have time to organise and prepare". An already crowded curriculum (5/18) with demands on numeracy and literacy was also a concern. There is "Greater emphasis on other learning areas. 50% of our time is used for Maths/English, 90 minutes for LOTE [languages], two hours for PE (physical education) – these are mandated".

Discussion

The discussion of the results is presented according to the eight aspects for this review which are stated in the terms of reference and which were used to frame the interview questions and questionnaires. They are:

1. Quality of curriculum resources
2. Quality of professional learning program
3. Views about, and evidence of achievements of objectives for Stage 3
4. Factors that facilitated or inhibited achievement of objectives
5. Resources needed for Stage 4
6. Challenges for Stage 4
7. Alignment of Primary**Connections** with other national initiatives
8. Other issues

The results indicated that the curriculum resources were considered to be of a high quality, relatively inexpensive, easy to use in the classroom, and flexible enough to meet the needs of teachers regardless of science background, teaching experience and school environment. It is important that Primary**Connections** maintains the high quality in the production of further units while ensuring that they remain relatively inexpensive.

Some stakeholders perceived that the curriculum resources were inflexible in their design, limited in the area of literacy and that they promoted a narrow view of science. Several stakeholders suggested a move away from a prescriptive 5Es model to approaches that may promote a broader view of science. A Stage 3 unit on social issues in science (e.g., sustainable development, gene technology, diet and obesity, health, food production, pollution, climate change) with a focus on argumentation and decision-making may help develop a broader view of science amongst teachers and students.

Overall, stakeholders agreed that the development and implementation of an effective professional learning program contributed to the success of Primary**Connections** in achieving its objectives in Stage 3. The professional learning program was flexible enough to cater for a range of audiences and modelled good pedagogical practice. Again, there was a perception by some stakeholders that the view of science could be broadened in the professional learning program. Some stakeholders perceived that lack of funding and availability of professional learning for teachers was an issue during Stage 3. It was noted that some PLFs who were based in classrooms experienced difficulties in finding the time to conduct teacher professional learning except within their own schools.

During Stage 3, there was a considerable amount of research conducted that demonstrated the success of PLF workshops in raising confidence and self-efficacy, and preparing PLFs to conduct professional learning with teachers. However, there was little research conducted about the impact of the professional learning in schools on non-trial school teachers and their students.

The results of Research report 15 indicated that students in classes that taught Primary**Connections** scored higher in a test of literacies of science and processes of science than students in non-Primary**Connections** classes. Two intended outcomes of using Primary**Connections** are improvements in these areas. While these findings show that one group of students performed better than another, it cannot be stated with certainty how much of the difference was due to Primary**Connections**. The schools in both groups were matched for socio-economic index which was taken as an indirect measure of literacy.

In future research, it is important to determine what and how much science is taught to the comparison students. In addition, contextual information about the science background and experience of the teachers in both groups, relevant factors related to school culture (e.g., whole school science plans), presence of related curriculum programs (e.g., mathematics) and students' previous experiences in science is needed. The most essential data would be to know what the students' scores for literacies of science and processes of science are before Primary**Connections** is introduced.

Apart from Research report 15, the evidence for improved student learning outcomes and literacies of science is anecdotal (i.e., individuals' observations) or indirect (e.g., more science must mean higher achievement). Some stakeholders observed that students' academic achievement improved after the introduction of Primary**Connections**. Evidence of improvement included single class pre and post tests, increasing scores in state wide testing and success in science competitions. There is indirect evidence of improved student learning outcomes because of increased teaching time in science, increased pre-service teacher and teacher engagement with science as well as observations of student enthusiasm. These multiple instances of anecdotal and indirect evidence coupled with the Primary**Connections** research provide strong evidence that Primary**Connections** has had a positive impact on student learning outcomes in science.

There were multiple sources of evidence from direct observations of teachers and pre-service teachers by stakeholders and statements from trial school principals that self-efficacy and confidence has increased. There is also indirect evidence from the increasing unit sales although this can be attributed partly to the increasing number of units available.

There is evidence from Primary**Connections** research and the trial school teachers and principals that in some schools, the time spent on science has increased because of the introduction of Primary**Connections**. Stakeholders have observed that teachers are teaching science integrated with literacy and teaching science at different times of the day. Stakeholders indicate that the increase is variable amongst schools because of competing curriculum areas (e.g., literacy and numeracy).

There is evidence that the profile of science in schools and in the community has increased. There is anecdotal evidence of increased local community awareness from the trial school principals and some stakeholders. Some stakeholders stated that the presence of science plans in schools has increased with the introduction of Primary**Connections**. Again, the impact has been variable and seemed to depend on the individual state, jurisdiction and school.

There were many factors identified that contributed to the success of Primary**Connections** in Stage 3. The most important factor was the combination of high quality curriculum resources with a high quality professional learning program that was flexible enough to be used with both pre-service and in-service teachers regardless of teaching background. The curriculum materials were also mapped against state and territory curricula to ensure that they aligned as much as was feasible. A substantial amount of national funding enabled the development and implementation of the professional learning program and curriculum materials. In addition, the leadership and dedication from the Primary**Connections** staff at the Australian Academy of Science was considered to be exceptional and ensured that the initial impetus from Stages 1 and 2 was maintained.

The success of Stage 3 was also facilitated by active support (both human and financial) from the states and territories. Some states and territories provided financial support for staffing and the purchase of curriculum materials while all states supported the training of PLFs. The support of school principals and teachers was also considered to be essential for whole school implementation of Primary**Connections**. The relatively low cost of the curriculum resources also contributed to the success.

There were several factors that inhibited Primary**Connections** from achieving its objectives. The amount of support (human and financial) from states and territories was variable because of state based priorities. Insufficient support impacted negatively on access to professional learning for teachers. In some schools, science was perceived to be competing with literacy and numeracy for importance (i.e., time). Other school based factors such as teachers' confidence and background in teaching science, school principal support, the need for equipment (no matter how simple) and storage space also affected uptake.

The resources needed for Stage 4 are similar to those that facilitated the success of Stage 3. It is considered essential that PLF training continue with preference given to non-classroom based teachers. Professional learning needs to be available for pre-service teachers and teachers. Some stakeholders have suggested that more units need to be produced and that existing units need to be revised. It was suggested that the Primary**Connections** website be updated to include material to extend experienced users and provide case studies of successful implementation. Some stakeholders also requested support materials such as equipment kits to assist teachers using the curriculum resources.

An important challenge identified by several stakeholders is the risk of complacency during Stage 4. They believe it is important to maintain the momentum of the project by continuing to produce and revise existing units and continue access to professional learning by pre-service teachers and teachers. In addition, the Primary**Connections** staff need to continue to lobby state and territory stakeholders to maintain and build science as a priority in schools.

The national curriculum presents both a challenge and an opportunity for Primary**Connections**. Several of the stakeholders considered that because Primary**Connections** already aligns well with all state and territory curricula that it will inevitably align with any proposed national science curriculum. A mapping exercise will be necessary when the new curriculum is released. It was suggested that Primary**Connections** ensure that members of the National Curriculum Board are aware of the scope of

Primary**Connections** through formal and informal networks. It was also suggested that future units should encompass the likely parts of a national curriculum, for example, social aspects of science.

All stakeholders were very positive about their involvement with Stage 3 of the Primary**Connections** project. Many stakeholders spoke with passion about their roles and the enthusiasm of the Primary**Connections** staff. There were several issues raised by stakeholders which need to be considered during Stage 4. They were the long term sustainability of the project, the literacies of science, and the role of Primary**Connections** in early childhood education and indigenous education.

Primary**Connections** is well placed to be sustainable in Australian primary schools. Firstly, there was a need for primary science education to change. The combination of professional learning for pre-service teachers and teachers combined with (relatively) low cost curriculum resources that improve student learning outcomes in science has been powerful. However, to ensure that all children have access to a quality primary science education, Primary**Connections** needs to be promoted in regions of Australia where there is a low uptake in schools.

Conclusion and recommendations

The purpose of this research report was, first, to evaluate the extent to which Primary**Connections** Stage 3 met its stated objectives and to identify factors that facilitated or inhibited achievement of the objectives. There is strong evidence that Primary**Connections** Stage 3 achieved its stated objectives.

Multiple instances of anecdotal and indirect evidence coupled with Primary**Connections** research provide strong evidence that Primary**Connections** has had a positive impact on student learning outcomes in science and the literacies of science. There were multiple sources of evidence from direct observations of teachers and pre-service teachers by stakeholders and statements from trial school principals that self-efficacy and confidence has increased. There is also evidence from Primary**Connections** research and the trial school teachers and principals that in some schools, the time spent on science increased because of the introduction of Primary**Connections**. There is also evidence that the profile of science in schools and in the community has increased.

The most important factors that facilitated the success of Primary**Connections** Stage 3 were relatively inexpensive and high quality curriculum resources that were combined with a high quality professional learning program that was flexible enough to be used with both pre-service and in-service teachers regardless of their science background, teaching experience and school culture. The curriculum materials were also mapped against state and territory curricula to ensure that they aligned as much as was feasible. A substantial amount of national funding enabled the development and implementation of the professional learning program and curriculum resources. In addition, the leadership and dedication from the Primary**Connections** staff at the Australian Academy of Science was considered to be exceptional and ensured that the initial impetus from Stages 1 and 2 was maintained. The success of Stage 3 was also facilitated by active support (both human and financial) from the states and territories. The support of school principals and teachers was also considered to be essential for whole school implementation of Primary**Connections**.

Based on the research findings in this study, seven recommendations are made for Stage 4. They are listed below.

1. It is recommended that whole school implementation of Primary**Connections be facilitated by providing additional curriculum support to schools.**

Nineteen curriculum units that covered all stages of primary schooling were published by the end of Stage 3. Despite this, many stakeholders (in particular trial teachers) insisted that more units were needed. It is suggested that further units be produced and where necessary existing units be revised. However, it would be prudent to wait for details of the national science curriculum to be clarified before proceeding with unit production and revisions.

Curriculum support encompasses more than the development of further units and revision of existing units. It also involves web based support, equipment kits and support for school based science coordinators. Web based support has the advantage that information can be readily updated and is accessible to all teachers. Web based support could be differentiated by including extension resources for confident and experienced teachers as well as structured support for teachers who are less experienced. The web site could provide an online professional learning program for those teachers and pre-service teachers who do not have readily available access to face to face professional learning.

The trial teachers stated that lack of time was an issue in the implementation of Primary**Connections** in schools. School science coordinators could be supported through the provision of equipment kits to assist those teachers who do not have the time to prepare science equipment. Primary**Connections** could trial the need for equipment kits by producing and marketing a trial kit for one of the more popular units. Promotional material sent to schools during Stage 4 should emphasise the important role of a science coordinator in the school.

2. It is recommended that the Primary**Connections team works with jurisdictions to train local, state based master facilitators.**

The Primary**Connections** team needs to liaise with the reference group to select individuals who are willing to train as master facilitators. These individuals would preferably have a sound understanding of science, primary teaching and pedagogy. Previous experience in professional learning and adult education would be useful. It may be possible for individuals to be seconded to these roles. Initial training would be conducted by the Primary**Connections** team in consultation with state and territory stakeholders.

The master facilitators would be based in the states and territories and work closely with state and territory science, numeracy and literacy curriculum officers to support existing PLFs, train new PLFs and target professional learning activities to those areas that the state and territory stakeholders believe are most important. These might include professional learning in regions with low uptake, schools in low SES areas or schools with poor results in state based testing of science or literacy. It is strongly suggested that PLF training during Stage 4 target non-classroom based teachers to ensure that they are available to conduct teacher professional learning without disrupting schools or adding to the workload of individual teachers.

Additional responsibilities for the master facilitators might include training curriculum leaders, facilitating whole school implementation of Primary**Connections** and liaising with stakeholders (e.g., principals, district directors). The additional responsibilities will depend on state and territory priorities.

it is recommended that the Primary**Connections** team continues to monitor and evaluate the progress of Primary**Connections** during Stage 4.

Evaluation of the progress of Primary**Connections** is essential in order to maintain the high quality of the curriculum resources and to determine the outcomes of professional learning and the use of master facilitators (see recommendation 2). Monitoring the uptake of

PrimaryConnections in states and territories will enable future professional learning activities to be targeted to areas of need.

Compelling evidence about the success of whole school implementation of PrimaryConnections will be needed to bring about change in schools, regions and sectors where there is low uptake. The reporting of successful implementation of PrimaryConnections to a range of audiences (e.g., school principals, district directors, state and territory Ministers of Education) will facilitate the promotion and uptake of PrimaryConnections.

The findings of this report indicate that there are multiple examples of successful implementation of PrimaryConnections in schools as a consequence of which student learning outcomes have improved. These success stories should be written up as brief 'cases of best practice' and be accessible through the website to a wide range of audiences including teachers, principals and pre-service teachers. Research about PrimaryConnections needs to be published in both peer reviewed research journals and also teaching journals. The Academy may consider becoming a clearing house for quality research on PrimaryConnections.

3. It is recommended that the reference group consider strengthening the relationship between PrimaryConnections and early childhood education.

Early childhood education (0-8 years) is currently a national priority. Children's learning experiences during this stage of their lives can have a profound effect on their future lives and schooling success. Early childhood education is recognised as a specialist area where a 'push down' curriculum is not appropriate. It is essential that these children have experiences in science that are appropriate to their stage of development.

The reference group should consider whether the PrimaryConnections view of science and the teaching and learning model is flexible enough to be modified to provide guided play in a stimulating environment. It was suggested that PrimaryConnections consider producing several early Stage 1 units aimed at non-readers. The PrimaryConnections team may be able to access funding to provide specific professional learning and web based support for early childhood teachers and coordinators about PrimaryConnections. It cannot be assumed that early childhood teachers will have the skills to modify the existing curriculum resources.

Discussions about the relationship should be informed by input from leaders and experts in the field of early childhood education.

4. It is recommended that the reference group consider strengthening the relationship between PrimaryConnections and indigenous education.

Indigenous education is also a national priority. Discussions about the relationship between PrimaryConnections and indigenous education should be informed by input from leaders and experts in the field of indigenous education. The findings of the report titled Small Study – Big Success Story (Bull, 2008) were based on a pilot study. This report demonstrated

that the use of Primary**Connections** incorporating indigenous perspectives resulted in positive learning outcomes for both indigenous and non-indigenous students. The Primary**Connections** team should engage in discussions with stakeholders in indigenous education about the most culturally appropriate way of introducing Primary**Connections** into schools, especially schools located in communities with a high proportion of indigenous students.

6. It is recommended that Primary**Connections** endeavours to align itself with the national science curriculum.

The development of the national curriculum presents both a challenge and an opportunity for Primary**Connections**. A national science curriculum is likely to increase the status of science in primary schools to that of literacy and numeracy. The preliminary framing paper suggests that the national science curriculum will encompass a broader view of science and a greater focus on the nature of science than the Primary**Connections** curriculum resources. Some stakeholders in this study suggested that the curriculum resources and professional learning program need to emphasise, for example, that science is a human endeavour, that scientific knowledge is subjective and tentative and that the products of science impact both positively and negatively on society. Future revision of units could incorporate these aspects.

At present, Primary**Connections** is well positioned with its national reach and existing partnerships to be the dominant curriculum resource for a national science curriculum. A national curriculum will require professional learning and quality curriculum resources to support teachers. As details of the national science curriculum emerge the curriculum resources should be mapped to ensure compatibility. Any new units or support materials developed during stage 4 should align closely with the national curriculum and address gaps in existing resources.

7. It is recommended that PrimaryConnections supports state and territory stakeholders to accept responsibility for Primary**Connections** activities in state and territory jurisdictions.

The Australian Academy of Science, with the assistance of federal government funding developed and implemented Primary**Connections** in Australian primary schools. The current level of Federal funding for Primary**Connections** is unlikely to be available in the long term. In order for Primary**Connections** to become sustainable there needs to be capacity building at a local level. There are six aspects of capacity building that are relevant to a school environment (Jenkins, 2009). They are:

1. Leadership – school principals need to be aware that Primary**Connections** can improve student learning outcomes in science without adversely affecting achievement in other curriculum areas. Trial school principals could 'showcase' their use of Primary**Connections** to local principals. The benefits of Primary**Connections** can also be promoted through newsletters aimed at deputy principals and principals.

2. Organisational development – implementation of Primary**Connections** must be at the whole school level, and have the support of teachers, the school leadership team, parents, the community and students. Science needs to be explicit in school plans.

3. Workforce development – all teachers need to be aware of and supportive of Primary**Connections**. Follow up professional learning may be necessary to maintain expertise and enthusiasm.

4. Curriculum – teachers need to be aware of, and have access to, the curriculum resources. Initial awareness should occur during pre-service education.

5. Development of partnerships – formal and informal partnerships between schools using Primary**Connections** and other support organisations (e.g., science centres and professional associations) needs to occur.

6. Allocation of resources – human and financial support may be needed in some schools to assist with whole school implementation of Primary**Connections**. Preparation time, funds for equipment and storage space are necessary for a high quality science program.

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Appendices

Appendix 1

Interview protocol for stakeholders

Thank you for agreeing to be interviewed as part of this review of Primary**Connections** Stage 3. Please note, (as described on the information sheet) that this interview will be audiotaped and transcribed. No data that has the potential to identify individuals will appear in the final report presented to the Australian Academy of Science. Pseudonyms will be used throughout.

Questions

1. Please describe your job/role.
2. How did you come to be involved with the Primary**Connections** project?
3. Can you describe your role in relation to the development or implementation of the Primary**Connections** project?
4. When Primary**Connections** was initially conceived there were five objectives which are listed below.

    i.   improved student learning outcomes in science
    ii. improved student learning outcomes in the literacies of science
    iii. enhanced teacher self-efficacy and confidence in teaching science and literacy
    iv. increased teaching time for science
    v.   an enhanced profile for the teaching of science in Australian primary schools

5. From your perspective to what extent has Primary**Connections** Stage 3 achieved these objectives and how do you know?
6. What factors have facilitated Primary**Connections** in achieving these objectives?
7. Can you comment on the quality of the Primary**Connections** curriculum resources?
8. Can you comment on the quality of the Primary**Connections** professional learning programme?
9. From your perspective, what other resources (human or material) are needed to ensure the long term implementation of Primary**Connections** in all schools?
10. From your perspective what are the greatest challenges to the long term success of the Primary**Connections** project?
11. (If relevant) Are you aware of the proposed national science curriculum and other national initiatives? If yes, how can the Primary**Connections** project align itself to support these initiatives?

Appendix 2

Survey for state and territory science curriculum officers

Review of Primary**Connections: linking science with literacy Stage 3**

Australian Academy of Science Primary**Connections** Project

Dear Participant,

Thank you for agreeing to complete this brief anonymous questionnaire for state and territory curriculum officers.

Please return this questionnaire and the signed consent form in the stamped addressed envelope.

Part A

Please circle or write your answer

Location of Current Workplace

1. State/Territory_____

2. Metropolitan   Regional   Rural

Sector of Current Workplace

3. Government   Catholic   Independent

   Other _____

4. Name of workplace in 2009

   _____

5. Name of workplace in 2008 (if different)

   _____

6. Professional role in 2009

   _____

7. Professional role in 2008 (if different).

   _____

Part B

Please write your answer

8. When did you first become involved with the Primary**Connections** project?

_____

_____

9. How did you first become involved with the Primary**Connections** project?

_____

_____

_____

_____

_____

10. Why did you first become involved with the Primary**Connections** project?

_____

_____

_____

_____

_____

11. What training have you participated in regarding the Primary**Connections** project (e.g. Professional Learning Facilitator workshop)?

_____

_____

_____

_____

12. Describe your role in the implementation of Primary**Connections** in your state/territory.

_____

_____

_____

_____

13. When Primary**Connections** was initially developed there were **five objectives/success indicators**. These are listed in the table below.

To what extent has Primary**Connections** Stage 3 achieved the following in your school?

	Not at all 1		Somewhat 3		To a large extent 5
13.1 Improved student learning outcomes in Science	1	2	3	4	5
13.2 Improved student learning outcomes in the literacies of science	1	2	3	4	5
13.3 Enhanced teacher self-efficacy and confidence in teaching science and literacy	1	2	3	4	5
13.3 Increased teaching time for science	1	2	3	4	5
13.4 An enhanced profile for the teaching of science in Australian primary schools	1	2	3	4	5

14. How do you know the above five **objectives** have been achieved? Please explain/write below.

14.1 Improved student learning outcomes in science

_____

_____

14.2 Improved student learning outcomes in the literacies of science

_____

_____

14.3 Enhanced teacher self-efficacy and confidence in teaching science and literacy

_____

_____

14.4 Increased teaching time for science

_____

_____

14.5 An enhanced profile for the teaching of science in Australian primary schools

_____

_____

15. From your perspective, what factors have **helped** the Primary**Connections** project in achieving these five **objectives**?

_____
_____
_____
_____

16. From your perspective, what factors have **inhibited** the Primary**Connections** project from meeting these five **objectives**?

_____
_____
_____
_____

17. What other resources (human or material) are needed to ensure the long term implementation of the Primary**Connections** project in your state/territory?

_____
_____
_____
_____

18. From your perspective, what are the greatest challenges to the long term success of the Primary**Connections** project in your state/territory?

_____
_____
_____
_____

19. How can the Primary**Connections** project position itself to best support the national science curriculum and other national initiatives (e.g. assessment, teacher training)?

_____
_____
_____
_____

Thank you for completing this questionnaire.

Appendix 3

Survey for trial teachers and principals

Review of PrimaryConnections: linking science with literacy Stage 3

Australian Academy of Science Primary**Connections** Project

Dear Participant,

Thank you for agreeing to complete this brief anonymous questionnaire for trial teachers and principals.

Please return this questionnaire and the signed consent form in the stamped addressed envelope.

This research has been approved by the Curtin University of Technology's Human Research Ethics Committee (Approval number SMEC – 02-09).

Part A

Please circle or write your answer

Location of Current Workplace

1. State/Territory_____

2. Metropolitan   Regional   Rural

Sector of Current Workplace

3. Government   Catholic   Independent

   Other _____

4. Name of workplace in 2009

   _____

5. Name of workplace in 2008 (if different)

   _____

6. Professional role in 2009

   _____

7. Professional role in 2008 (if different).

   _____

Part B

Please write your answer

8. When did you first become involved with the Primary**Connections** project?

_____

_____

9. How did you first become involved with the Primary**Connections** project?

_____

_____

_____

_____

_____

10. Why did you first become involved with the Primary**Connections** project?

_____

_____

_____

_____

_____

11. What training have you participated in regarding the Primary**Connections** project
    (e.g. Professional Learning Facilitator workshop)?

_____

_____

_____

_____

12. Describe your role in the implementation of Primary**Connections** in your school.

_____

_____

_____

_____

13. When Primary**Connections** was initially developed there were **five objectives/success indicators**. These are listed in the table below.To what extent has Primary**Connections** Stage 3 achieved the following in your school?

	Not at all 1		Somewhat 3		To a large extent 5
13.1 Improved student learning outcomes in Science	1	2	3	4	5
13.2 Improved student learning outcomes in the literacies of science	1	2	3	4	5
13.3 Enhanced teacher self-efficacy and confidence in teaching science and literacy	1	2	3	4	5
13.3 Increased teaching time for science	1	2	3	4	5
13.4 An enhanced profile for the teaching of science in Australian primary schools	1	2	3	4	5

14. How do you know the above five **objectives** have been achieved? Please explain/write below.

14.1 Improved student learning outcomes in science

_____
_____

14.2 Improved student learning outcomes in the literacies of science

_____
_____

14.3 Enhanced teacher self-efficacy and confidence in teaching science and literacy

_____
_____

14.4 Increased teaching time for science

_____
_____

14.5 An enhanced profile for the teaching of science in Australian primary schools

_____
_____

15. From your perspective, what factors have **helped** the Primary**Connections** project in achieving these five **objectives** in your school?

_____

_____

_____

_____

16. From your perspective, what factors have **inhibited** the Primary**Connections** project from meeting these five **objectives** in your school?

_____

_____

_____

_____

17. What other resources (human or material) are needed to ensure the long term implementation of the Primary**Connections** project in your school?

_____

_____

_____

_____

18. From your perspective, what are the greatest challenges to the long term success of the Primary**Connections** project in your school?

_____

_____

_____

_____

Thank you for completing this questionnaire.

If you require more space for any questions, please attach a separate page.