

Minds-on, hands-on

**Creating
competent
and
confident
teachers
of science
and literacy**

WITH A PROJECTED SKILL SHORTAGE IN TRAINED SCIENCE PROFESSIONALS, THE PUSH IS ON TO INCREASE THE AMOUNT OF SCIENCE TAUGHT IN SCHOOLS. SHELLEY PEERS EXPLAINS HOW THE 'MINDS-ON, HANDS-ON' APPROACH OF THE AUSTRALIAN ACADEMY OF SCIENCE'S INNOVATIVE PROJECT, PRIMARY CONNECTIONS, IS DOING JUST THAT.

THE AUSTRALIAN ACADEMY OF SCIENCE'S Primary Connections: linking science with literacy project aims to establish meaningful connections between science and literacy, to promote effective learning in both domains. With a pedagogy that is 'minds-on' as well as 'hands-on,' Primary Connections has been developed in consultation with educators across all state and territory jurisdictions and sectors, funded through a partnership with the Commonwealth government's Department of Education, Science and Training. The project, now in its third stage, with funding until December 2008, is still growing and maturing.

Primary Investigations grows up

The Australian Academy of Science has been developing resources to help teachers provide quality science education in the classroom for decades. When the Commonwealth government inquiry, the *Discipline Review of Teacher Education in Mathematics and Science*, stated in 1989 that the teaching of science in primary schools was in 'a state of crisis,' the Academy took note. What followed was consultation of both primary school teachers and curriculum advisers from every state and territory, as well as a review of existing materials, after which the Academy developed Primary Investigations during the 1990s.

By 2002, a comprehensive evaluation of Primary Investigations indicated that a revision of the program was due. By 2004, a collaborative reference group was established that brought together representatives from the Commonwealth, state and territory governments, as well as Catholic and independent education systems, alongside education researchers, the Australian Academy of Science, the Australian Academy of Technological Sciences and Engineering, the

Australian Science Teachers Association, the Primary English Teaching Association and the Australian Literacy Educators' Association to ensure the needs and priorities of all sectors were addressed. Primary Connections was born.

A teaching and learning model

To develop an understanding of the nature of science and scientific evidence, students need to be engaged in an inquiry-oriented approach to learning science. For that reason, the Primary Connections teaching and learning model takes an inquiry approach, following the five-phase model of Roger Bybee, namely, Engage, Explore, Explain, Elaborate and Evaluate. (See Table 1)

The Engage phase is designed to spark students' interest, stimulate their curiosity, raise questions for inquiry and elicit students' existing beliefs about the topic. In a unit about natural and processed materials, for example, the teacher might bring into

the classroom a battered postal package. Students then brainstorm to figure out what may have led to the battered state of the package, why that may have happened, and what materials could make a better packet. The approach makes the unit relevant to the students' daily lives and encourages an inquiry-oriented approach.

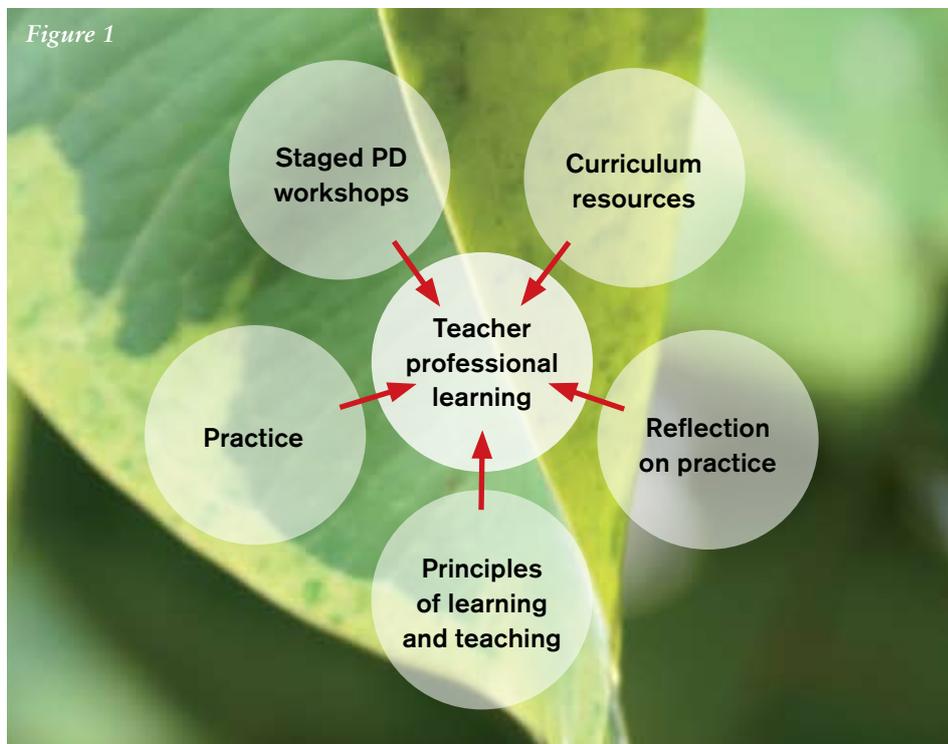
The Explore phase provides students with hands-on experiences of the topic's science phenomena, ensuring all students have a shared experience that can be discussed and explained in the following Explain phase. For example, when investigating plants, students explore seeds, germination, flowers and fruit in order to identify what they think and know, and develop a common base of experience for understanding how plants grow.

In the Explain phase, students identify patterns and relationships drawn from their observations, and develop scientific explanations. For example, students might review their experiments on yeast to explain the

Table 1

Phase	Focus
ENGAGE	Engage students and elicit prior knowledge Diagnostic assessment
EXPLORE	Provide hands-on experience of the phenomenon Formative assessment
EXPLAIN	Develop scientific explanations for observations and represent developing conceptual understanding Consider current scientific explanations Formative assessment
ELABORATE	Extend understanding to a new context or make connections to additional concepts through a student-planned investigation Summative assessment of the investigating outcomes
EVALUATE	Students 're-present' their understanding and reflect on their learning journey and teachers collect evidence about the achievement of outcomes Summative assessment of the conceptual outcomes

Primary Connections is not just a set of curriculum units. A professional learning program lies at its heart. This gives teachers the tools to understand the Primary Connections project, its philosophy and goals.



role it plays in the different stages of bread making. It is at this stage that the current views of scientists are introduced to deepen the students' own understanding.

In the Elaborate phase, students plan and conduct an open investigation to apply and extend their new conceptual understanding in a new context. For example, having understood the processes that cause day and night, students plan their own investigation into the length and direction of shadows during the day.

In the Evaluate phase students reflect on their learning journey and create a literacy product to 're-present' their conceptual understanding.

Because the way students understand new information depends on what they already know, engaging with and exploring students' own ideas precedes the presentations of current explanations of scientists – and that, for many teachers, is a very different way to teach science. The Primary Connections teaching and learning model also embeds diagnostic, formative and summative assessment into the teaching and learning process. (See Table 1)

Primary Connections also emphasises cooperative learning, where students work in small groups to solve problems and to enhance their learning. Most students enjoy this learning style, and it enables them to learn effectively and to become more positive about themselves and each other. In the Primary Connections model, each team member is assigned a specific role within their team, but all share leadership responsibilities. Assigning the roles encourages students to avoid traditional social stereotypes that suppose boys like manipulating materials while girls like recording results.

Not just another resource

To develop Primary Connections, teachers were asked what resources would best meet their needs. The answer was a resource book with a practical, easy-to-use layout, and a background CD with additional science information. The curriculum units were therefore planned around overlapping concepts and processes as identified in state and territory syllabuses. The outcomes are tailored to explore one concept in depth. For example, rather than list all the processes

that affect the surface of the Earth, a unit concentrates on exploring earthquakes. The units are mapped according to each strand, Earth and Beyond, Life and Living, Energy and Change, and Natural and Processed Materials, to ensure that students cover a wide base of conceptual knowledge through their schooling. Primary Connections pays particular attention to developing topics that many teachers felt less confident about teaching, especially forces and materials. By the end of 2008, there will be 19 units published, and they come at a minimal price since the development costs are covered by the project.

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program lies at its heart. This gives teachers the tools to understand the Primary Connections project, its philosophy and goals. (See Figure 1)

A tiered set of professional learning workshops is available, with: three days' training for professional learning facilitators; two days' training for curriculum leaders; a one-day 'Introduction to Primary Connections' workshop for whole-school uptake; workshops of 60 to 90 minutes on the underpinning philosophies of Primary Connections, addressing the literacies of science, investigating, cooperative learning, assessment and questioning, and the five Es; and a principals' information session.

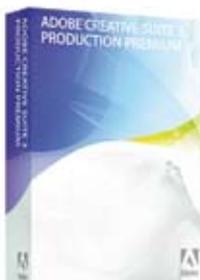
Through interactive workshops that model the teaching and learning philosophy, participants develop their knowledge. Understanding the features and purpose of the curriculum units allows teachers to effectively use, adapt and extend them in constructive ways. Ideally, teachers develop the tools to plan their own units with the same teaching and learning philosophy. A unit-planning template is available on the website.

Feedback from participants means the professional learning program can be constantly revised, and feedback has been very positive. Here's what one participant wrote. 'Thank you for: engaging (us with) a very desirable alternative to teach science; exploring with us where we are at and where we

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The number of primary school teachers with low belief in their capability to teach science effectively decreased from 22 to three after one term using Primary Connections curriculum resources, and dropped to just one after two terms.

can go with Primary Connections; explaining answers to our many questions; elaborating the support networks available to help us; and evaluating all the data to produce a user-friendly package. I would like to add one more E to the list – the sixth E – encouraging us to see that we can make a difference no matter who or where we are!

One school indicated that their students' response to the program was so positive they had started implementing the five Es approach in other areas of the curriculum.

In order for every teacher to have access to the professional learning program, Primary Connections has trained a cadre of professional learning facilitators who can deliver workshops in schools throughout Australia. Each facilitator receives a guide designed for facilitation, with tools and techniques and a suite of comprehensively resourced professional learning modules. Techniques include 'Dialogue for meaning,' 'The Toulmin model of argument,' and the 'DIGA' method – of describing, interpreting, generalising and applying. University science educators from every tertiary institution that trains primary school teachers have also attended an Academy-run two-day workshop.

Integrating science into a broader context

The innovation in Primary Connections is that it explicitly explores the links between science and literacy. Units employ a range of strategies to encourage students to think about and to represent science.

First, everyday literacies such as reading and writing are necessary skills to support the learning of scientific concepts, processes and skills. Science provides authentic contexts and meaningful purposes to explore representations through many different modes, including drawing, gestures and role play.

Secondly, there are the literacies of science. These can be modes of representations, such as tables and graphs, or modes of reasoning, such as evidence-based arguments. There is also a vocabulary and a set

of practices, such as using models to represent the world, that characterise science.

The 'curriculum links' section found at the end of lessons identifies some opportunities for experiences that integrate learning across key learning areas. Primary Connections also identifies links to other projects such as The Learning Federation and the Science Education Assessment Resources Project. By making use of existing resources, Primary Connections provides teachers with a comprehensive science and literacy program with easy access to additional material.

What does the research say?

The Primary Connections Stage 2 trial research report in 2005, conducted by Mark Hackling and Vaughan Prain, provides a comprehensive overview of the program. Primary Connections was trialled by 106 teachers in 56 schools from all jurisdictions and sectors across metropolitan, regional and rural areas in all states and territories, involving over 3,000 students in 2005. Schools were asked to nominate both an experienced teacher of science and an inexperienced teacher of science, both of whom attended a five-day professional learning workshop.

Teachers' confidence with nine science and literacy teaching strategies was assessed on a five-point scale. Their mean confidence scores increased significantly ($p < .05$) from 3.34 at the beginning of the program to 4.04 at the end of second term. The number of primary school teachers with low belief in their capability to teach science effectively decreased from 22 to three after one term using Primary Connections curriculum resources, and dropped to just one after two terms.

An overwhelming 96 of the 97 teachers involved said their teaching had improved. They reported an increase in the teaching of the literacies of science, the use of hands-on activities and the use of diagnostic assessment to determine the existing conceptions of students. The amount of science being taught in the classroom also increased, with 73 per cent of teachers teaching over an hour of science a week compared with 33

per cent before the trial. Almost 90 per cent of teachers considered the units compatible with their jurisdiction's curriculum frameworks and school's science programs.

Almost 90 per cent of teachers indicated that students responded positively or very positively to the learning approach. More than three-quarters of the teachers believed that their students had learned more science than previously and that the quality of science learning was better using Primary Connections. Fifty-nine per cent indicated that literacy learning had also improved, with students using a wider range of forms of representation.

Work samples from Year 5 students were evaluated against the national scientific liter-

acy progress map produced by the Curriculum Corporation for the Ministerial Council on Education, Employment, Training and Youth Affairs. The mean achievement score more than doubled over the course of the Plants in Action unit, and at the end of the unit 78 per cent of the Year 5 students were working at or beyond level 3, which is the national benchmark for Year 6 students.

So much for the research, but consider this telling testimony from a trial teacher who has gone on to run professional learning workshops for Primary Connections: 'In most, if not all, schools I have taught in, there hasn't been a recognition of what science can offer children. I have always dodged teaching science as much as I could.

What a shame that it's the children who have missed out. If only I'd had the experience of (Primary Connections) early in my career.'

And that's what the program is all about, giving teachers the competence and confidence to teach science and literacy effectively. ▀

Shelley Peers is the managing director of the Primary Connections project of the Australian Academy of Science.

LINKS: For more about Primary Connections, visit www.science.org.au/primaryconnections

For references go to www.acer.edu.au/teachermagazine/references.html

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